GaussDB
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# Distributed Developer Guide

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HUAWEI

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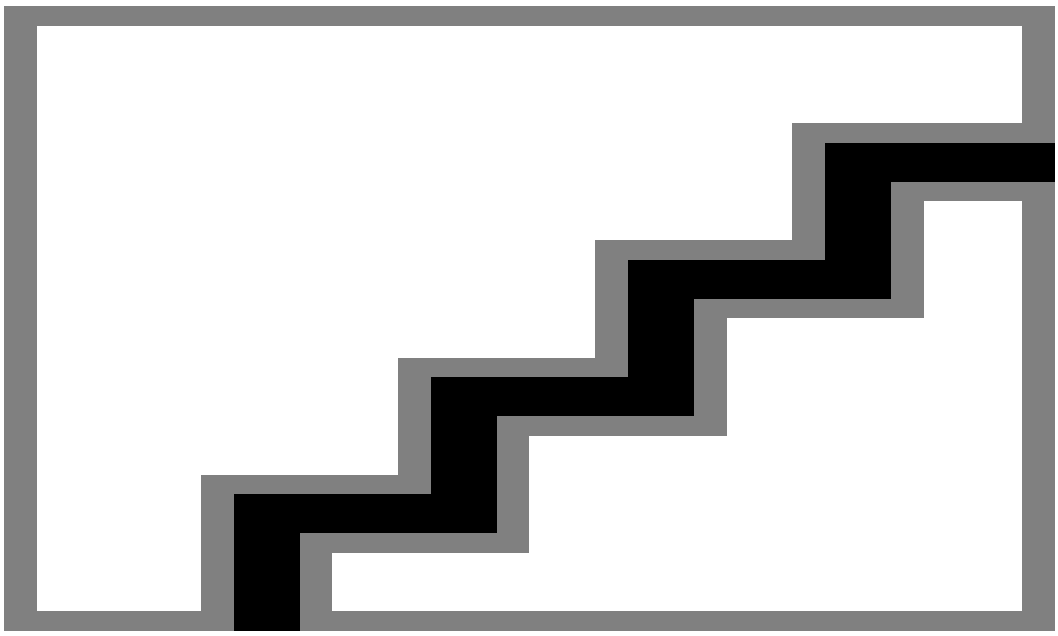
# 1 Overview

## 1.1 Database Logical Architecture

Each DN in a cluster stores data on disks. This section describes the objects on each DN from the logical view, the relationship between these objects, and how data is distributed on different nodes. **Figure 1-1** shows the database logical structure.

**Figure 1-1** Database logical architecture



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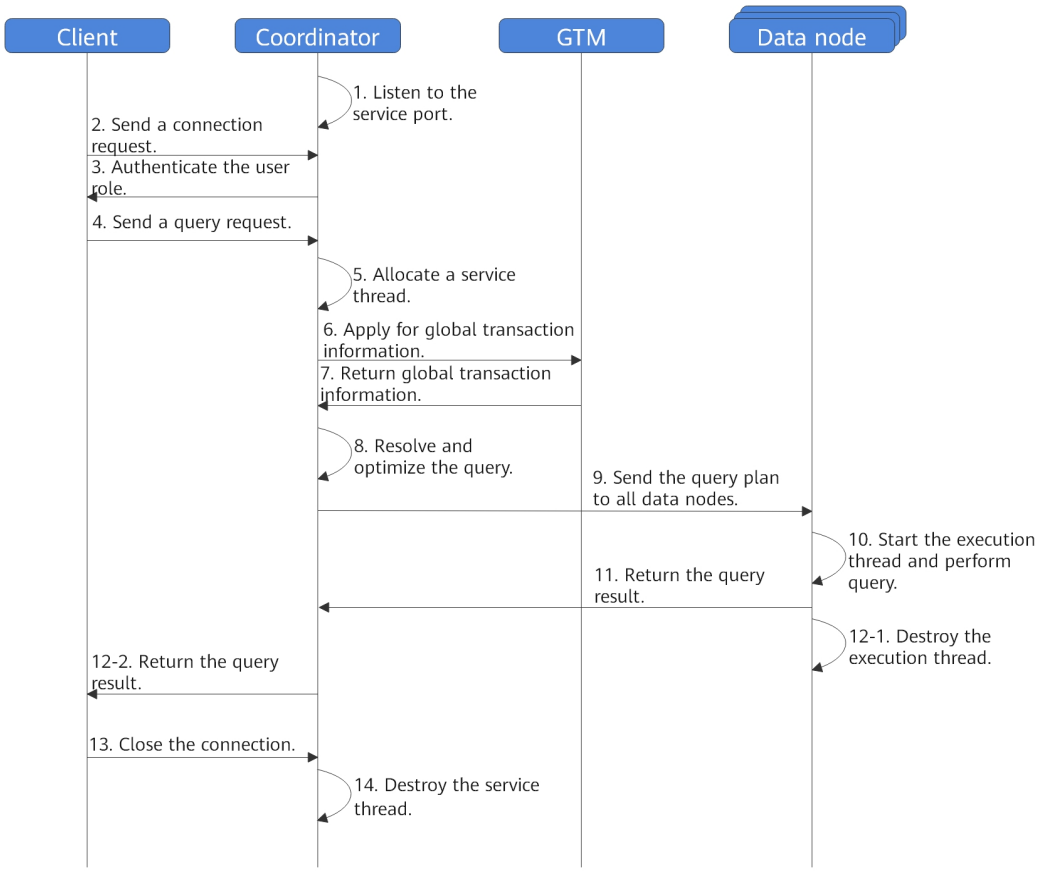
NOTE

- A tablespace is a directory that stores physical files of databases. Multiple tablespaces can coexist. Each tablespace can contain files belonging to different databases.
- Each database manages various data objects and is isolated from each other. Objects managed by a database can be distributed to multiple tablespaces.
- A datafile segment stores data of only one table. A table containing more than 1 GB of data is stored in multiple datafile segments.
- One table belongs to only one database and one tablespace. The data file segments storing the data of the same table must be in the same tablespace.
- Block: Basic unit of database management. Its default size is 8 KB.
- Data can be distributed on DNs in replication, hash, range, or list mode. You can specify a mode when creating a table.

# 1.2 Query Request Handling Process

**Figure 1-2** GaussDB service response process




# 1.3 Managing Transactions

A transaction is a customized sequence of database operations, which form an integral unit of work. In GaussDB, you can start, set, commit, and roll back transactions. A GaussDB database supports the following transaction isolation levels: READ COMMITTED, READ UNCOMMITTED (not recommended),

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REPEATABLE READ, and SERIALIZABLE. SERIALIZABLE is equivalent to REPEATABLE READ.

## Controlling Transactions

The following describes transaction operations supported by the database:

- Starting transactions

  You can use the START TRANSACTION or BEGIN syntax to start a transaction. For details, see **12.14.168 START TRANSACTION** and **12.14.41 BEGIN**.

- Setting transactions

  You can use the SET TRANSACTION or SET LOCAL TRANSACTION syntax to set transactions. For details, see **12.14.165 SET TRANSACTION**.

- Committing transactions

  You can use the COMMIT or END syntax to commit all operations of a transaction. For details, see **12.14.48 COMMIT | END**.

- Rolling back transactions

  Rollback indicates that the system cancels all changes that a transaction has made to a database if the transaction fails to be executed due to a fault. For details, see **12.14.155 ROLLBACK**.

## Transaction Isolation Levels

A transaction isolation level specifies how concurrent transactions process the same object.

NOTE

The isolation level cannot be changed after data is modified using SELECT, INSERT, DELETE, UPDATE, FETCH, or COPY in the transaction.

- **READ COMMITTED**: At this level, a transaction can access only committed data. This is the default level.

  The SELECT statement accesses the snapshot of the database taken when the query begins. It can also access the data updates in its transaction, regardless of whether they have been committed. Note that different database snapshots may be returned to two consecutive SELECT statements for the same transaction, because data may be committed for other transactions while the first SELECT statement is executed.

  At the READ COMMITTED level, the execution of each statement begins with a new snapshot, which contains all the transactions that have been committed by the execution time. Therefore, during a transaction, a statement can access the result of other committed transactions. Pay attention to whether a single statement always accesses completely consistent data in a database.

  Transaction isolation at this level meets the requirements of many applications, and is fast and easy to use. However, applications performing complicated queries and updates may require data that is more consistent than this level can provide.

- **READ UNCOMMITTED**: This level is not recommended, because it may result in data inconsistency. This level can be used for reading data in an emergency,

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such as when a coordinator node (CN) fails to be restored from a fault, to bypass the congestion caused by data inconsistency between the GTM and CN/DN. Do not use this level for data writing transactions, as this may lead to data inconsistency.

- **REPEATABLE READ**: At this level, a transaction can only read data committed before it starts. Uncommitted data or data committed in other concurrent transactions cannot be read. However, a query can read earlier data updates in its transaction, regardless of whether they have been committed. READ COMMITTED differs from this level in that a transaction reads the snapshot taken at the start of the transaction, not at the beginning of the current query within the transaction. Therefore, the SELECT statement within a transaction always reads the same data, and cannot read data committed by other concurrent transactions after the transaction starts. Applications at this level must be able to retry transactions, because serialization failures may occur.
- **SERIALIZABLE**: Currently, this isolation level is not supported in GaussDB. It is equivalent to REPEATABLE READ.

# 1.4 Concepts

## Database

Databases manage various data objects and are isolated from each other. While creating a database, you can specify a tablespace. If you do not specify it, the object will be saved to the **PG_DEFAULT** tablespace by default. Objects managed by a database can be distributed to multiple tablespaces.

## Tablespace

In GaussDB, a tablespace is a directory storing physical files of the databases the tablespace contains. Multiple tablespaces can coexist. Files are physically isolated using tablespaces and managed by a file system.

## Schema

GaussDB schemas logically separate databases. All database objects are created under certain schemas. In GaussDB, schemas and users are loosely bound. When you create a user, a schema with the same name as the user will be created automatically. You can also create a schema or specify another schema.

## User and Role

GaussDB uses users and roles to control the access to databases. A role can be a database user or a group of database users, depending on role settings. In GaussDB, the difference between roles and users is that a role does not have the **LOGIN** permission by default. In GaussDB, one user can have only one role, but you can put a user's role under a parent role to grant multiple permissions to the user.

## Transaction

In GaussDB, transactions are managed by multi-version concurrency control (MVCC) and two-phase locking (2PL). This enables smooth data reads and writes.

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In GaussDB, MVCC saves historical version data together with the current tuple version. GaussDB uses the VACUUM thread instead of rollback segments to routinely delete historical version data. Generally, you do not need to pay special attention to the VACUUM thread unless you need to optimize the performance. In addition, GaussDB automatically commits transactions for single-statement queries (without using statements such as **BEGIN** to explicitly start a transaction block).

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# 2 Working with Databases

## 2.1 Connecting to a Database

Client tools for connecting to a database include DAS, gsql, and APIs (such as ODBC and JDBC).

- DAS enables you to manage databases on a web-based console and supports SQL execution, advanced database management, and intelligent O&M, simplifying database management and improving working efficiency and data security. The permissions required for connecting to a GaussDB instance through DAS are enabled by default. Using DAS to connect to your DB instance is recommended, which is more secure and convenient. For details about how to connect to GaussDB, see **Data Admin Service User Guide**.
- gsql is a client tool provided by GaussDB. You can use gsql to connect to the database and then enter, edit, and execute SQL statements in an interactive manner. For details about the connection modes, see **Connecting to a DB Instance**.
- You can use standard database APIs, such as ODBC and JDBC, to develop GaussDB-based applications.

**NOTICE**

- For distributed instances, you can use a client tool to connect to a database through any CN. Before connection, you must obtain the IP address and port number of the server where the CN is deployed. The client tool can access the database by connecting to any CN. Do not connect to a database through a DN when services are running properly.

### 2.1.1 APIs

You can use standard database APIs, such as **ODBC** and **JDBC**, to develop GaussDB-based applications.

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### Supported APIs

Each application is an independent GaussDB development project. APIs alleviate applications from directly operating in databases, and enhance the database portability, extensibility, and maintainability. **Table 2-1** lists the APIs supported by GaussDB and the download addresses.

**Table 2-1** Database APIs

| API | How to Obtain |
| --- | --- |
| ODBC | • Linux:<br>Driver: **GaussDB-Kernel-*VxxxRxxxCxx*-xxxxx-64bit-Odbc.tar.gz**<br>unixODBC source code package: **http://sourceforge.net/projects/unixodbc/files/unixODBC/2.3.0/unixODBC-2.3.0.tar.gz/download**<br>• Windows:<br>Driver: **GaussDB-Kernel-*VxxxRxxxCxx*-Windows-Odbc.tar.gz** |
| JDBC | • Driver: **GaussDB-Kernel-*VxxxRxxxCxx*-xxxxx-64bit-Jdbc.tar.gz**<br>• Driver: **org.postgresql.Driver** |

For details about more APIs, see **6 Application Development Guide**.

## 2.2 Before You Start

This section explains how to use databases, including creating databases and tables, inserting data to tables, and querying data in tables.

### Prerequisites

GaussDB runs properly.

### Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** Create a database user.

Only administrators that are created during the cluster installation can access the initial database by default. You can also create other database users.

```
openGauss=# CREATE USER joe WITH PASSWORD "xxxxxxxxx";
```

If the following information is displayed, the user has been created:

```
CREATE ROLE
```

In this case, you have created a user named **joe**, and the user password is **xxxxxxxxxx**. Run the following command to set user **joe** as the system administrator:

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```
openGauss=# GRANT ALL PRIVILEGES TO joe;
```

Run the **GRANT** command to set related permissions. For details, see **12.14.140 GRANT**.

**Note**: For details about how to create users, see **7.2 Managing Users and Their Permissions**.

**Step 3** Create a database.

```
openGauss=# CREATE DATABASE db_tpcds;
```

If the following information is displayed, the database has been created:

```
CREATE DATABASE
```

After creating the **db_tpcds** database, you can run the following command to exit the **postgres** database and log in to the **db_tpcds** database as the user you created. You can also continue using the default **postgres** database for more operations.

```
openGauss=# \q
gsql -d db_tpcds -p 8000 -U joe
Password for user joe:
gsql((GaussDB Kernel VxxxRxxxCxx build f521c606) compiled at 2021-09-16 14:55:22 commit 2935 last mr 6385 release)
Non-SSL connection (SSL connection is recommended when requiring high-security)
Type "help" for help.

db_tpcds=>
```

**Note:**

New databases are created in the **pg_default** tablespace by default. To specify another tablespace, run the following statement:

```
openGauss=# CREATE DATABASE db_tpcds WITH TABLESPACE = hr_local;
CREATE DATABASE
```

*hr_local* indicates the tablespace name. For details about how to create a tablespace, see **2.5 Creating and Managing Tablespaces**.

**Step 4** Create a table.

- Create a table named **mytable** that has only one column. The column name is **firstcol** and the column type is **integer**.

  ```
  db_tpcds=>  CREATE TABLE mytable (firstcol int);
  ```

  If the **DISTRIBUTE BY** statement is not used to specify distribution columns, the system automatically specifies the first column as a hash distribution column and prompts you to confirm the operation. If **CREATE TABLE** is displayed at the end of the returned information, the table has been created.

  ```
  NOTICE: The 'DISTRIBUTE BY' clause is not specified. Using 'firstcol' as the distribution column by default.
  HINT: Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
  CREATE TABLE
  ```

- Run the following command to insert data to the table:

  ```
  db_tpcds=> INSERT INTO mytable values (100);
  ```

  If the following information is displayed, the data has been inserted:

  ```
  INSERT 0 1
  ```

- Run the following command to view data in the table:

  ```
  db_tpcds=> SELECT * from mytable;
   firstcol
  ----------
  ```

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```
  100
(1 row)
```

**Note:**

- By default, new database objects, such as the **mytable** table, are created in the **$user** schema. For more details about schemas, see **2.8.1 Creating and Managing Schemas**.
- For more details about how to create a table, see **2.6 Creating and Managing Tables**.
- In addition to the created tables, a database contains many system catalogs. These system catalogs contain cluster installation, GaussDB queries and processes. You can collect information about the database by querying system catalogs. For details, see **2.7 Querying a System Catalog**.

  GaussDB supports hybrid row-column store, providing high query performance for interaction analysis in complex scenarios. For details about how to select a storage method, see **2.4 Planning a Storage Model**.

**----End**

# 2.3 Creating and Managing Databases

## Prerequisites

Only the database system administrator or users granted with database creation permissions can create a database. For details about how to grant database creation permissions to a user, see **7.2 Managing Users and Their Permissions**.

## Background

- GaussDB has two default template databases **template0** and **template1** and a default user database **postgres**.
- **CREATE DATABASE** creates a database by copying a template database. Only **template0** can be copied. Do not use a client or any other tools to connect to or to perform operations on the template databases.

  NOTE

  - The template database does not contain any user table. You can view the attributes of the template database in the **PG_DATABASE** system catalog.
  - The **template0** template database does not allow user connections. Only the initial user and the system administrator of the database can connect to **template1**.
- A database system consists of multiple databases. A client can connect to only one database at a time. Currently, cross-database query or cross-database transaction is not supported.
- If multiple databases exist in the database cluster, you can use the **-d** parameter of the client tool to specify the target database for login. Alternatively, you can run the **\c** command to switch the database after the client program logs in to the database.

## Precautions

Assume that the database encoding is SQL_ASCII. (You can run the **show server_encoding** command to query the encoding used for storing data in the

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current database.) If the database object name contains multi-byte characters (such as Chinese) or if the object name length exceeds the allowed maximum (63 bytes), the database truncates the last byte (not the last character) of the object name. In this case, half characters may appear.

To resolve this problem, you need to:

- Ensure that the name of the data object does not exceed the maximum length.
- Use a proper coded character set, such as UTF-8, as the default database storage code set (server_encoding).
- Exclude multi-byte characters from object names.
- If you fail to delete an object by specifying its name after truncation, specify its original name to delete it, or manually delete it from the system catalogs on each node.

## Procedure

**Step 1** Run the following command to create a database named **db_tpcds**:

```
openGauss=# CREATE DATABASE db_tpcds;
CREATE DATABASE
```

NOTE

- Database names must comply with the general naming convention rules of SQL identifiers. The current role automatically becomes the owner of this new database.
- If a database system is used to support independent users and projects, store them in different databases.
- If the projects or users are associated with each other and share resources, store them in one database. However, you can divide them into different schemas. A schema is a logical structure, and the access permission for a schema is controlled by the permission system module.
- A database name contains a maximum of 63 bytes and the excessive bytes at the end of the name will be truncated by the server. You are advised to specify a database name no longer than 63 bytes when you create a database.

**Step 2** View databases.

- Run the **\l** meta-command to view the database list of the database system.
  ```
  openGauss=# \l
  ```
- Run the following command to query the database list in the **pg_database** system catalog:
  ```
  openGauss=# SELECT datname FROM pg_database;
  ```

**Step 3** Modify the database.

You can modify database configuration such as the database owner, name, and default settings.

- Run the following command to rename the database:
  ```
  openGauss=# ALTER DATABASE db_tpcds RENAME TO human_tpcds;
  ALTER DATABASE
  ```

NOTE

After setting the parameters, you need to manually run the **CLEAN CONNECTION** command to clear the old connections. Otherwise, the parameter values between nodes may be inconsistent.

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**Step 4** Delete a database.

You can run the **DROP DATABASE** command to delete a database. This command deletes the system directory in the database, as well as the database directory on the disk that stores data. Only the database owner or system administrator can delete a database. A database accessed by users cannot be deleted. You need to connect to another database before deleting this database.

Run the following command to delete the database:

```
openGauss=# DROP DATABASE human_tpcds;
DROP DATABASE
```

**----End**

# 2.4 Planning a Storage Model

GaussDB supports hybrid row storage and column storage. Each storage model applies to specific scenarios. Select an appropriate model when creating a table.

Row-store stores tables to disk partitions by row, and column-store stores tables to disk partitions by column. By default, a row-store table is created. For details about differences between row storage and column storage, see **Figure 2-1**.

**Figure 2-1** Differences between row storage and column storage

In the preceding figure, the upper left part is a row-store table, and the upper right part shows how the row-store table is stored on a disk; the lower left part is a column-store table, and the lower right part shows how the column-store table is stored on a disk.

Both storage models have benefits and drawbacks.

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| Storage Model | Benefit | Drawback |
| --- | --- | --- |
| Row storage | Record data is stored together. Data can be easily inserted and updated. | All the columns of a record are read after the **SELECT** statement is executed even if only certain columns are required. |
| Column storage | • Only the columns involved in a query are read.<br>• Projections are efficient.<br>• Any column can serve as an index. | • The selected columns need to be reconstructed after the **SELECT** statement is executed.<br>• Data cannot be easily inserted or updated. |

Generally, if a table contains many columns (called a wide table) and its query involves only a few columns, column storage is recommended. Row storage is recommended if a table contains only a few columns and a query involves most of the fields.

| Storage Model | Application Scenario |
| --- | --- |
| Row storage | • Point queries (simple index-based queries that only return a few records)<br>• Scenarios requiring frequent addition, deletion, and modification |
| Column storage | • Statistical analysis queries (requiring a large number of association and grouping operations)<br>• Ad hoc queries (using uncertain query conditions and unable to utilize indexes to scan row-store tables) |

## Row-Store Tables

Row-store tables are created by default. In a row-store table, data is stored by row, that is, data in each row is stored continuously. Therefore, this storage model applies to scenarios where data needs to be updated frequently.

```
openGauss=# CREATE TABLE customer_t1
(
  state_ID   CHAR(2),
  state_NAME VARCHAR2(40),
  area_ID    NUMBER
);

--Delete the table.
openGauss=# DROP TABLE customer_t1;
```

## Column-Store Tables

In a column-store table, data is stored by column, that is, data in each column is stored continuously. The I/O of data query in a single column is small, and

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column-store tables occupy less storage space than row-store tables. This storage model applies to scenarios where data is inserted in batches, less updated, and queried for statistical analysis. A column-store table cannot be used for point queries.

```
openGauss=# CREATE TABLE customer_t2
(
  state_ID   CHAR(2),
  state_NAME VARCHAR2(40),
  area_ID    NUMBER
)
WITH (ORIENTATION = COLUMN);

--Delete the table.
openGauss=# DROP TABLE customer_t2;
```

### Selecting a Storage Model

- Update frequency

  If data is frequently updated, use a row-store table.

- Data insertion frequency

  If a small amount of data is frequently inserted each time, use a row-store table. If a large amount of data is inserted at a time, use column storage.

- Number of columns

  If a table is to contain many columns, use a column-store table.

- Number of columns to be queried

  If only a small number of columns (less than 50% of the total) is queried each time, use a column-store table.

- Compression ratio

  The compression ratio of a column-store table is higher than that of a row-store table. High compression ratio consumes more CPU resources.

## 2.5 Creating and Managing Tablespaces

### Background

The administrator can use tablespaces to control the layout of disks where a database is installed. This has the following advantages:

- If the initial disk partition or volume allocated to the database is full and the space cannot be logically increased, you can create and use tablespaces in other partitions until the space is reconfigured.
- Tablespaces allow the administrator to distribute data based on the schema of database objects, improving system performance.
  - A frequently used index can be placed in a disk having stable performance and high computing speed, such as a solid device.
  - A table that stores archived data and is rarely used or has low performance requirements can be placed in a disk with a slow computing speed.
- The administrator can use tablespaces to set the maximum available disk space. In this way, when a partition is shared with other data, tablespaces will not occupy excessive space in the partition.

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- You can use tablespaces to control the disk space occupied by data in a database. If the usage of a disk where a tablespace resides reaches 90%, the database switches to the read-only mode. It switches back to read/write mode when the disk usage becomes less than 90%.

  The automatic disk check of the cluster manager (CM) is enabled by default. To enable it, run the following command:

  ```
  gs_guc set -Z cmserver -N all -I all -c " enable_transaction_read_only = on "
  ```

  Restart the database to make the parameter settings take effect.

- Each tablespace corresponds to a file system directory. Run the following command to create a tablespace corresponding to **/pg_location/mount1/path1** and specify the maximum available space to 500 GB.

  ```
  -- Create a tablespace.
  openGauss=# CREATE TABLESPACE ds_location1 RELATIVE LOCATION '/pg_location/mount1/path1' MAXSIZE '500G';
  ```

  If **MAXSIZE** is used to manage tablespace quotas, the concurrent insertion performance may deteriorate by about 30%. **MAXSIZE** specifies the maximum quota for each each DN. The difference between the actual tablespace capacity of each DN and the specified quota should be within 500 MB. Determine whether to set a tablespace to its maximum size as required.

GaussDB provides two tablespaces: **pg_default** and **pg_global**.

- Default tablespace **pg_default**: stores non-shared system catalogs, user tables, user table indexes, temporary tables, temporary table indexes, and internal temporary tables. The corresponding storage directory is the base directory in the instance data directory.
- Shared tablespace **pg_global**: stores shared system tables. The corresponding storage directory is the base directory in the global data directory.

**Precautions**:

- You are not advised to use user-defined tablespaces.

  This is because user-defined tablespaces are usually used with storage media other than the main storage (storage device where the default tablespace is located, such as a disk) to isolate I/O resources that can be used by different services. Storage devices use standard configurations and do not have other available storage media in scenarios such as Huawei Cloud. If the user-defined tablespace is not properly used, the system cannot run stably for a long time and the overall performance is affected. Therefore, you are advised to use the default tablespace.

## Procedure

- Create a tablespace.

  a. Run the following command to create user **jack**:

  ```
  openGauss=# CREATE USER jack IDENTIFIED BY 'xxxxxxxxx';
  ```

  If the following information is displayed, the user has been created:

  ```
  CREATE ROLE
  ```

  b. Run the following command to create a tablespace:

  ```
  openGauss=# CREATE TABLESPACE fastspace RELATIVE LOCATION 'my_tablespace/tablespace1';
  ```

  If the following information is displayed, the tablespace has been created:

  ```
  CREATE TABLESPACE
  ```

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**fastspace** is the new tablespace, and *CN/DN data directory*/**pg_location/my_tablespace/tablespace1** is an empty directory on which users have read and write permissions.

c. A database system administrator can run the following command to grant the permission of accessing the **fastspace** tablespace to user **jack**:

```
openGauss=# GRANT CREATE ON TABLESPACE fastspace TO jack;
```

If the following information is displayed, the permission has been assigned:

```
GRANT
```

- Create an object in a tablespace.

  If you have the CREATE permission on the tablespace, you can create database objects in the tablespace, such as tables and indexes.

  Take creating a table as an example:

  – Method 1: Run the following command to create a table in a specified tablespace:

  ```
  openGauss=# CREATE TABLE foo(i int) TABLESPACE fastspace;
  ```

  If the following information is displayed, the table has been created:

  ```
  NOTICE: The 'DISTRIBUTE BY' clause is not specified. Using 'i' as the distribution column by default.
  HINT: Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
  CREATE TABLE
  ```

  – Method 2: Use **set default_tablespace** to set the default tablespace and then create a table:

  ```
  openGauss=# SET default_tablespace = 'fastspace';
  SET
  openGauss=# CREATE TABLE foo2(i int);
  NOTICE: The 'DISTRIBUTE BY' clause is not specified. Using 'i' as the distribution column by default.
  HINT: Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
  CREATE TABLE
  ```

  In this example, **fastspace** is the default tablespace, and **foo2** is the created table.

- Use one of the following methods to query a tablespace:

  – Method 1: Check the **pg_tablespace** system catalog. Run the following command to view all the tablespaces defined by the system and users:

  ```
  openGauss=# SELECT spcname FROM pg_tablespace;
  ```

  – Method 2: Run the following meta-command of the gsql program to query the tablespaces:

  ```
  openGauss=# \db
  ```

- Query the tablespace usage.

  a. Query the current usage of the tablespace.

  ```
  openGauss=# SELECT PG_TABLESPACE_SIZE('fastspace');
  ```

  Information similar to the following is displayed:

  ```
   pg_tablespace_size
  --------------------
             2146304
  (1 row)
  ```

  **2146304** is the size of the tablespace, and its unit is byte.

  b. Calculate the tablespace usage.

  Tablespace usage = Value of **PG_TABLESPACE_SIZE**/Size of the disk where the tablespace resides

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- Modify a tablespace.

  Run the following command to rename tablespace **fastspace** to **fspace**:

  ```
  openGauss=# ALTER TABLESPACE fastspace RENAME TO fspace;
  ALTER TABLESPACE
  ```

- Delete a tablespace and related data.
  - Run the following command to delete user **jack**:

    ```
    openGauss=# DROP USER jack CASCADE;
    DROP ROLE
    ```

  - Run the following commands to delete tables **foo** and **foo2**:

    ```
    openGauss=# DROP TABLE foo;
    openGauss=# DROP TABLE foo2;
    ```

    If the following information is displayed, the tables have been deleted:

    ```
    DROP TABLE
    ```

  - Run the following command to delete tablespace **fspace**:

    ```
    openGauss=# DROP TABLESPACE fspace;
    DROP TABLESPACE
    ```

    NOTE

    Only the tablespace owner or system administrator can delete a tablespace.

# 2.6 Creating and Managing Tables

## 2.6.1 Creating a Table

### Background

A table is created in a database and can be saved in different databases. Tables under different schemas in a database can have the same name. Before creating a table, refer to **2.4 Planning a Storage Model**.

For details about how to design a table suitable for services, see **4.1 Best Practices of Table Design**.

### Creating a Table

Run the following command to create a table:

```
openGauss=# CREATE TABLE customer_t1
(
    c_customer_sk           integer,
    c_customer_id           char(5),
    c_first_name            char(6),
    c_last_name             char(8)
)
with (orientation = column,compression=middle)
distribute by hash (c_last_name);
```

If the following information is displayed, the table has been created:

```
CREATE TABLE
```

**c_customer_sk**, **c_customer_id**, **c_first_name**, and **c_last_name** are the column names of the table. **integer**, **char(5)**, **char(6)**, and **char(8)** are column name types.

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# 2.6.2 Inserting Data to a Table

A new table contains no data. You need to insert data to the table before using it. This section describes how to insert a row or multiple rows of data using the **INSERT** command and to insert data from a specified table. For details about how to insert a large amount of data to a table in batches, see **8 Importing Data**.

## Background

The length of a character on the server and client may vary by the character sets they use. A string entered on the client will be processed based on the server's character set, so the result may differ from expected.

**Table 2-2** Comparison of character set output between the client and server

| Operation Procedure | Server and Client Use Same Encoding | Server and Client Use Different Encoding |
| --- | --- | --- |
| No operations are performed to the string while it is saved and read. | Your expected result is returned. | If the encoding for input and output on the client is the same, your expected result is returned. |
| Operations (such as executing string functions) are performed to the string while it is saved and read. | Your expected result is returned. | The result may differ from expected, depending on the operations performed to the string. |
| A long string is truncated while it is saved. | Your expected result is returned. | If the character sets used on the client and server have different character length, the result may differ from expected. |

More than one of the preceding operations can be performed to a string. For example, if the character sets of the client and server are different, a string may be processed and then truncated. In this case, the result will also be unexpected. For details, see **Table 2-3**.

NOTE

Long strings are truncated only if **DBCOMPATIBILITY** is set to **TD** (compatible with Teradata) and **td_compatible_truncation** is set to **on**.

Run the following commands to create **table1** and **table2** to be used in the example:

```
openGauss=# CREATE TABLE table1(id int, a char(6), b varchar(6),c varchar(6));
openGauss=# CREATE TABLE table2(id int, a char(20), b varchar(20),c varchar(20));
```

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**Table 2-3** Example

| No. | Server Character Set | Client Character Set | Automatic Truncation Enabled | Example | Result | Description |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | SQL_ASCII | UTF8 | Yes | openGauss=# **INSERT INTO** *table1* **VALUES**(*1,reverse('123AA78'),reverse(''123AA78''),reverse('123AA78')*); | id \|a\|b\|c<br>----+------+------+------<br>1 \| 87\| 87\| 87 | A string is reversed on the server and then truncated. Because character sets used by the server and client are different, character A is displayed in multiple bytes on the server and the result is incorrect. |
| 2 | SQL_ASCII | UTF8 | Yes | openGauss=# **INSERT INTO** *table1* **VALUES**(*2,reverse('123A78'),reverse('123A78'),reverse('123A78')*); | id \|a\|b\|c<br>----+------+------+------<br>2 \| 873\| 873\| 873 | A string is reversed and then automatically truncated. Therefore, the result is unexpected. |
| 3 | SQL_ASCII | UTF8 | Yes | openGauss=# **INSERT INTO** *table1* **VALUES**(*3,'87A123','87A123','87A123'*); | id \| a \| b \| c<br>----+-------+-------+-------<br>3 \| 87A1 \| 87A1 \| 87A1 | The column length in the string type is an integer multiple of the length in client character encoding. Therefore, the result is correct after truncation. |

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| No. | Server Character Set | Client Character Set | Automatic Truncation Enabled | Example | Result | Description |
| --- | --- | --- | --- | --- | --- | --- |
| 4 | SQL_ASCII | UTF8 | No | openGauss=# **INSERT INTO** *table2* **VALUES**(*1,reverse('123AA78'),reverse('123AA78'),reverse('123AA78')*);<br>openGauss=# **INSERT INTO** *table2* **VALUES**(*2,reverse('123A78'),reverse('123A78'),reverse('123A78')*);<br> | id \|a\|b\|c<br>----<br>+----------<br>--+--------<br>+--------<br>1 \| 87 321\| 87 321 \| 87 321<br>2 \| 87321\| 87321\| 87321 | Similar to the first example, multi-byte characters no longer indicate the original characters after being reversed. |

## Procedure

You need to create a table before inserting data to it. For details about how to create a table, see **2.6 Creating and Managing Tables**.

- Insert a row to table **customer_t1**:

  Data values are arranged in the same order as the columns in the table and are separated by commas (,). Generally, column values are text values (constants). But column values can also be scalar expressions.

  ```
  openGauss=# INSERT INTO customer_t1(c_customer_sk, c_customer_id, c_first_name) VALUES (3769, 'hello', 'Grace');
  ```

  If you know the sequence of the columns in the table, you can obtain the same result without listing these columns. For example, the following command generates the same result as the preceding command:

  ```
  openGauss=# INSERT INTO customer_t1 VALUES (3769, 'hello', 'Grace');
  ```

  If you do not know some of the column values, you can omit them. If no value is specified for a column, the column is set to the default value. For example:

  ```
  openGauss=# INSERT INTO customer_t1 (c_customer_sk, c_first_name) VALUES (3769, 'Grace');

  openGauss=# INSERT INTO customer_t1 VALUES (3769, 'hello');
  ```

  You can also specify the default value of a column or row:

  ```
  openGauss=# INSERT INTO customer_t1 (c_customer_sk, c_customer_id, c_first_name) VALUES (3769, 'hello', DEFAULT);

  openGauss=# INSERT INTO customer_t1 DEFAULT VALUES;
  ```

- To insert multiple rows to a table, run the following command:

  ```
  openGauss=# INSERT INTO customer_t1 (c_customer_sk, c_customer_id, c_first_name) VALUES
      (6885, 'maps', 'Joes'),
      (4321, 'tpcds', 'Lily'),
      (9527, 'world', 'James');
  ```

  You can also insert multiple rows by running the command for inserting one row for multiple times. However, you are advised to run this command to improve efficiency.

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- Assume that you have created a backup table **customer_t2** for table **customer_t1**. To insert data from **customer_t1** to **customer_t2**, run the following commands:

```
openGauss=# CREATE TABLE customer_t2
(
    c_customer_sk             integer,
    c_customer_id             char(5),
    c_first_name              char(6),
    c_last_name               char(8)
);

openGauss=# INSERT INTO customer_t2 SELECT * FROM customer_t1;
```

  NOTE

  If implicit conversion is not implemented between the column data types of the specified table and those of the current table, the two tables must have the same column data types when data is inserted from the specified table to the current table.

- To delete a backup file, run the following command:

```
openGauss=# DROP TABLE customer_t2 CASCADE;
```

  NOTE

  If the table to be deleted is dependent on other tables, you need to delete its dependent tables first.

## 2.6.3 Updating Data in a Table

Existing data in a database can be updated. You can update one row, all rows, or specified rows of data, or update data in a single column without affecting the data in the other columns.

The following types of information are required when the **UPDATE** statement is used to update a row:

- Table name and column name of the data to be updated
- New column value
- Rows of the data to be updated

Generally, the SQL language does not provide a unique ID for a row of data. Therefore, it is impossible to directly specify the rows of the data to be updated. However, you can specify the rows by declaring the conditions that must be met by the updated row. If a table contains primary keys, you can specify a row using the primary keys.

For details about how to create a table and insert data to it, see **2.6.1 Creating a Table** and **2.6.2 Inserting Data to a Table**.

**c_customer_sk** in the table **customer_t1** must be changed from **9527** to **9876**:

```
openGauss=# UPDATE customer_t1 SET c_customer_sk = 9876 WHERE c_customer_sk = 9527;
```

You can use a schema to modify the table name. If no such modifier is specified, the table is located based on the default schema path. In the statement, **SET** is followed by the target column and the new column value. The new value can be a constant or an expression.

For example, run the following statement to increase all the values in the **c_customer_sk** column by 100:

```
openGauss=# UPDATE customer_t1 SET c_customer_sk = c_customer_sk + 100;
```

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This statement does not include the **WHERE** clause, so all rows are updated. If the statement includes the **WHERE** clause, only the rows matching the clause are updated.

In the **SET** clause, the equal sign (=) indicates value setting. In the **WHERE** clause, the equal sign indicates comparison. **WHERE** may not represent an equation and can be replaced by other operators.

You can run an **UPDATE** statement to update multiple columns by specifying multiple values in the **SET** clause. For example:

```
openGauss=# UPDATE customer_t1 SET  c_customer_id = 'Admin', c_first_name = 'Local' WHERE c_customer_sk = 4421;
```

After data has been updated or deleted in batches, a large number of deletion markers are generated in the data file. During query, data with these deletion markers needs to be scanned as well. In this case, a large amount of data with deletion marks can greatly affect the query performance after batch updates or deletions. If data needs to be updated or deleted in batches frequently, you are advised to periodically run the **VACUUM FULL** statement to maintain the query performance.

## 2.6.4 Viewing Data

- Run the following command to query information about all tables in a database in the system catalog **pg_tables**:
  ```
  openGauss=# SELECT * FROM pg_tables;
  ```
- Run the **\d+** command of the **gsql** tool to query table attributes:
  ```
  openGauss=# \d+ customer_t1;
  ```
- Run the following command to query the data volume of table **customer_t1**:
  ```
  openGauss=# SELECT count(*) FROM customer_t1;
  ```
- Run the following command to query all data in the table **customer_t1**:
  ```
  openGauss=# SELECT * FROM customer_t1;
  ```
- Run the following command to query only the data in the column **c_customer_sk**:
  ```
  openGauss=# SELECT c_customer_sk FROM customer_t1;
  ```
- Run the following command to filter repeated data in the column **c_customer_sk**:
  ```
  openGauss=# SELECT DISTINCT( c_customer_sk ) FROM customer_t1;
  ```
- Run the following command to query all data whose column **c_customer_sk** is **3869**:
  ```
  openGauss=# SELECT * FROM customer_t1 WHERE c_customer_sk = 3869;
  ```
- Run the following command to collate data based on the column **c_customer_sk**:
  ```
  openGauss=# SELECT * FROM customer_t1 ORDER BY c_customer_sk;
  ```

## 2.6.5 Deleting Data from a Table

Outdated data may need to be deleted when tables are used. Data can be deleted from tables only by row.

SQL statements can only access and delete an independent row by declaring conditions that match the row. If a table has a primary key, you can use it to specify a row. You can delete several rows that match the specified condition or delete all the rows from a table.

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For example, to delete all the rows whose **c_customer_sk** column is **3869** from the table **customer_t1**, run the following command:

```
openGauss=# DELETE FROM customer_t1 WHERE c_customer_sk = 3869;
```

To delete all rows from the table, run either of the following commands:

```
openGauss=# DELETE FROM customer_t1;
or
openGauss=# TRUNCATE TABLE customer_t1;
```

NOTE

If you need to delete an entire table, you are advised to use the **TRUNCATE** statement rather than **DELETE**.

To delete a table, run the following command:

```
openGauss=# DROP TABLE customer_t1;
```

# 2.7 Querying a System Catalog

In addition to the created tables, a database contains many system catalogs. These system catalogs contain cluster installation, GaussDB queries and processes. You can collect information about the database by querying system catalogs.

In **16 Schemas**, the description about each table indicates whether the table is visible to all users or only the initial user. To query tables that are visible only to the initial user, log in as the user.

GaussDB provides the following types of system catalogs and views:

- System catalogs and views inherited from PG and PGXC

  These system catalogs and views have the prefix **PG** or **PGXC**.
- New system catalogs and views of GaussDB

  These system catalogs and views have the prefix **GS**.
- System catalogs and views that are compatible with Oracle

  These system catalogs and views have the prefix **ALL**, **DBA**, **USER**, or **PV**.

## Querying Database Tables

For example, you can run the following command to query the **PG_TABLES** system catalog for all tables in the **public** schema:

```
SELECT distinct(tablename) FROM pg_tables WHERE SCHEMANAME = 'public';
```

Information similar to the following is displayed:

```
    tablename
------------------
 err_hr_staffs
 test
 err_hr_staffs_ft3
 web_returns_p1
 mig_seq_table
 films4
(6 rows)
```

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## Viewing Database Users

You can run the **PG_USER** command to view the list of all users in the database, and view the user ID (**USESYSID**) and permissions.

```
SELECT * FROM pg_user;
 usename | usesysid | usecreatedb | usesuper | usecatupd | userepl |  passwd  | valbegin | valuntil |
respool    | parent | spacelimit | useconfig | nodegroup | tempspacelimit | spillspacelimit
---------+----------+-------------+----------+-----------+---------+----------+----------+----------+--------------
+------
-------+------------+-----------+-----------+----------------+-----------------
 roach   |       10 | t          | t        | t         | t       | ******** |          |          | default_pool |
0      |          |          |          |              |
(1 row)
```

## Viewing and Stopping the Running Query Statements

You can view the running query statements in the **15.3.146 PG_STAT_ACTIVITY** view. You can use the following methods:

**Step 1** Set the parameter **track_activities** to **on**.

```
SET track_activities = on;
```

The database collects the running information about active queries only if the parameter is set to **on**.

**Step 2** View the running query statements. Run the following command to view the database names, users performing queries, query status, and the corresponding PID which are connected to the running query statements:

```
SELECT datname, usename, state,pid FROM pg_stat_activity;
 datname  | usename | state  |       pid
----------+---------+--------+-----------------
 postgres | Ruby    | active | 140298793514752
 postgres | Ruby    | active | 140298718004992
 postgres | Ruby    | idle   | 140298650908416
 postgres | Ruby    | idle   | 140298625742592
 postgres | omm | active | 140298575406848
(5 rows)
```

If the **state** column is **idle**, the connection is idle and requires a user to enter a command.

To identify only active query statements, run the following command:

```
SELECT datname, usename, state pid FROM pg_stat_activity WHERE state != 'idle';
```

**Step 3** To cancel queries that have been running for a long time, use the **PG_TERMINATE_BACKEND** function to end sessions based on the thread ID (corresponding to the PID in **Step 2**).

```
SELECT PG_TERMINATE_BACKEND(140298793514752);
```

If information similar to the following is displayed, the session is successfully terminated:

```
PG_TERMINATE_BACKEND
----------------------
 t
(1 row)
```

If information similar to the following is displayed, a user has terminated the current session:

```
FATAL:  terminating connection due to administrator command
FATAL:  terminating connection due to administrator command
```

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NOTE

If the **PG_TERMINATE_BACKEND** function is used to terminate the backend threads of the current session and the user is an initial user, the **gsql** client is reconnected automatically rather than be logged out. The message "The connection to the server was lost. Attempting reset: Succeeded." is returned. Otherwise, the client fails to be reconnected and the error message "The connection to the server was lost. Attempting reset: Failed." is returned because only the initial user can use password-free login.

2. If the **PG_TERMINATE_BACKEND** function is used to terminate inactive backend threads and the thread pool is opened, idle sessions do not have thread IDs and cannot be ended. In non-thread pool mode, ended sessions are not automatically reconnected.

**----End**

# 2.8 Other Operations

## 2.8.1 Creating and Managing Schemas

### Background

Schemas function as models. Schema management allows multiple users to use the same database without mutual impacts, to organize database objects as manageable logical groups, and to add third-party applications to the same schema without causing conflicts. Schema management involves creating a schema, using a schema, deleting a schema, setting a search path for a schema, and setting schema permissions.

### Precautions

- A database cluster can have one or more databases. Users and user groups are shared within entire cluster, but their data is exclusive. Any user who has connected to a server can access only the database specified in the connection request.
- A database can have one or more schemas, and a schema can contain tables and other data objects, such as data types, functions, and operators. One object name can be used in different schemas. For example, both **schema1** and **schema2** can have a table named **mytable**.
- Different from databases, schemas are not isolated. You can access the objects in a schema of the connected database if you have schema permissions. To manage schema permissions, you need to have knowledge about database permissions.
- A schema named with the **PG_** prefix cannot be created because this type of schema is reserved for the database system.
- Each time a new user is created, the system creates a schema with the same name for the new user in the current database. In other databases, such a schema needs to be manually created.
- To reference a table that is not modified with a schema name, the system uses **search_path** to find the schema that the table belongs to. **pg_temp** and **pg_catalog** are always the first two schemas to be searched no matter whether or how they are specified in **search_path**. **search_path** is a schema name list, and the first table detected in it is the target table. If no target

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table is found, an error will be reported. (If a table exists but the schema it belongs to is not listed in **search_path**, the search fails as well.) The first schema in **search_path** is called "current schema". This schema is the first one to be searched. If no schema name is declared, newly created database objects are saved in this schema by default.

- Each database has a **pg_catalog** schema, which contains system catalogs and all embedded data types, functions, and operators. **pg_catalog** is a part of the search path and has the second highest search priority. It is searched after the schema of temporary tables and before other schemas specified in **search_path**. This search order ensures that database built-in objects can be found. To use a custom object that has the same name as a built-in object, you can specify the schema of the custom object.

## Procedure

- Create a schema.
  - Run the following command to create a schema:
    ```
    openGauss=# CREATE SCHEMA myschema;
    ```
    If the following information is displayed, the schema named **myschema** is successfully created:
    ```
    CREATE SCHEMA
    ```
    To create or access an object in the schema, the object name in the command should consist of the schema name and the object name, which are separated by a dot (.), for example, **myschema.table**.
  - Run the following command to create a schema and specify the owner:
    ```
    openGauss=# CREATE SCHEMA myschema AUTHORIZATION omm;
    ```
    If the following information is displayed, the **myschema** schema that belongs to **omm** is created successfully:
    ```
    CREATE SCHEMA
    ```
- Use a schema.

  If you want to create or access an object in a specified schema, the object name must contain the schema name. To be specific, the name consists of a schema name and an object name, which are separated by a dot (.).
  - Run the following command to create the **mytable** table in **myschema**:
    ```
    openGauss=# CREATE TABLE myschema.mytable(id int, name varchar(20));
    CREATE TABLE
    ```
    To specify the location of an object, the object name must contain the schema name.
  - Run the following command to query all data of the **mytable** table in **myschema**:
    ```
    openGauss=# SELECT * FROM myschema.mytable;
    id | name
    ----+------
    (0 rows)
    ```
- View **search_path** of a schema.

  You can set **search_path** to specify the sequence of schemas in which objects are searched. The first schema listed in **search_path** will become the default schema. If no schema is specified during object creation, the object will be created in the default schema.
  - Run the following command to view **search_path**:
    ```
    openGauss=# SHOW SEARCH_PATH;
     search_path
    ```

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```
----------------
 "$user",public
(1 row)
```

  - Run the following command to set **search_path** to **myschema** and **public** (**myschema** will be searched first):

```
openGauss=# SET SEARCH_PATH TO myschema, public;
SET
```

- Set permissions for a schema.

  By default, a user can only access database objects in their own schema. Only after a user is granted with the usage permission for a schema by the schema owner, the user can access the objects in the schema.

  By granting the **CREATE** permission for a schema to a user, the user can create objects in this schema. By default, all roles have the **USAGE** permission in the **public** schema, but common users do not have the **CREATE** permission in the **public** schema. It is insecure for a common user to connect to a specified database and create objects in its **public** schema. If the common user has the **CREATE** permission on the **public** schema, it is advised to:

  - Run the following command to revoke **PUBLIC**'s permission to create objects in the **public** schema. **public** indicates the schema and **PUBLIC** indicates all roles.

```
openGauss=# REVOKE CREATE ON SCHEMA public FROM PUBLIC;
REVOKE
```

  - Run the following command to view the current schema:

```
openGauss=# SELECT current_schema();
 current_schema
----------------
 myschema
(1 row)
```

  - Run the following commands to create user **jack** and grant the **usage** permission for **myschema** to the user:

```
openGauss=# CREATE USER jack IDENTIFIED BY 'xxxxxxxxxx';
CREATE ROLE
openGauss=# GRANT USAGE ON schema myschema TO jack;
GRANT
```

  - Run the following command to revoke the usage permission for **myschema** from **jack**:

```
openGauss=# REVOKE USAGE ON schema myschema FROM jack;
REVOKE
```

- Delete a schema.

  - If a schema is empty, that is, it contains no database objects, you can execute the **DROP SCHEMA** command to delete it. For example, run the following command to delete an empty schema named **nullschema**:

```
openGauss=# DROP SCHEMA IF EXISTS nullschema;
DROP SCHEMA
```

  - To delete a schema that is not null, use the keyword **CASCADE** to delete it and all its objects. For example, run the following command to delete **myschema** and all its objects in it:

```
openGauss=# DROP SCHEMA myschema CASCADE;
DROP SCHEMA
```

  - Run the following command to delete user **jack**:

```
openGauss=# DROP USER jack;
DROP ROLE
```

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# 2.8.2 Creating and Managing Partitioned Tables

## Background

GaussDB supports range partitioned tables.

In a range partitioned table, data within a certain range is mapped to each partition. The range is determined by the partition key specified when the partitioned table is created. This partitioning mode is most commonly used. The partition key is usually a date. For example, sales data is partitioned by month.

A partitioned table has the following advantages over an ordinary table:

- High query performance: You can specify partitions when querying partitioned tables, improving query efficiency.
- High availability: If a certain partition in a partitioned table is faulty, data in the other partitions is still available.
- Easy maintenance: To fix a partitioned table having a faulty partition, you only need to fix the partition.

To convert an ordinary table to a partitioned table, you need to create a partitioned table and import data to it from the ordinary table. When you design tables, plan whether to use partitioned tables based on service requirements.

## Procedure

Example 1: using the default tablespace

- Creating a partitioned table (assuming that the **tpcds** schema has been created)

```
openGauss=# CREATE TABLE tpcds.customer_address
(
    ca_address_sk       integer                 NOT NULL   ,
    ca_address_id       character(16)           NOT NULL   ,
    ca_street_number    character(10)                      ,
    ca_street_name      character varying(60)              ,
    ca_street_type      character(15)                      ,
    ca_suite_number     character(10)                      ,
    ca_city             character varying(60)              ,
    ca_county           character varying(30)              ,
    ca_state            character(2)                       ,
    ca_zip              character(10)                      ,
    ca_country          character varying(20)              ,
    ca_gmt_offset       numeric(5,2)                       ,
    ca_location_type    character(20)
)
DISTRIBUTE BY HASH (ca_address_sk)
PARTITION BY RANGE (ca_address_sk)
(
        PARTITION P1 VALUES LESS THAN(5000),
        PARTITION P2 VALUES LESS THAN(10000),
        PARTITION P3 VALUES LESS THAN(15000),
        PARTITION P4 VALUES LESS THAN(20000),
        PARTITION P5 VALUES LESS THAN(25000),
        PARTITION P6 VALUES LESS THAN(30000),
        PARTITION P7 VALUES LESS THAN(40000),
        PARTITION P8 VALUES LESS THAN(MAXVALUE)
)
ENABLE ROW MOVEMENT;
```

  If the following information is displayed, the partitioned table has been created:

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```
CREATE TABLE
```

**NOTE**

You are advised to create a maximum of 1000 column-store partitioned tables.

- Inserting data

  Insert data from the **tpcds.customer_address** table to the **tpcds.web_returns_p2** table.

  Suppose a backup table **tpcds.web_returns_p2** of the **tpcds.customer_address** table has been created in the database. You can run the following command to insert the data of the **tpcds.customer_address** table into the backup table **tpcds.web_returns_p2**:

```
openGauss=# CREATE TABLE tpcds.web_returns_p2
(
    ca_address_sk       integer                 NOT NULL   ,
    ca_address_id       character(16)           NOT NULL   ,
    ca_street_number    character(10)                      ,
    ca_street_name      character varying(60)              ,
    ca_street_type      character(15)                      ,
    ca_suite_number     character(10)                      ,
    ca_city             character varying(60)              ,
    ca_county           character varying(30)              ,
    ca_state            character(2)                       ,
    ca_zip              character(10)                      ,
    ca_country          character varying(20)              ,
    ca_gmt_offset       numeric(5,2)                       ,
    ca_location_type    character(20)
)
DISTRIBUTE BY HASH (ca_address_sk)
PARTITION BY RANGE (ca_address_sk)
(
        PARTITION P1 VALUES LESS THAN(5000),
        PARTITION P2 VALUES LESS THAN(10000),
        PARTITION P3 VALUES LESS THAN(15000),
        PARTITION P4 VALUES LESS THAN(20000),
        PARTITION P5 VALUES LESS THAN(25000),
        PARTITION P6 VALUES LESS THAN(30000),
        PARTITION P7 VALUES LESS THAN(40000),
        PARTITION P8 VALUES LESS THAN(MAXVALUE)
)
ENABLE ROW MOVEMENT;
CREATE TABLE
openGauss=# INSERT INTO tpcds.web_returns_p2 SELECT * FROM tpcds.customer_address;
INSERT 0 0
```

- Modifying the row movement attributes of the partitioned table

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 DISABLE ROW MOVEMENT;
ALTER TABLE
```

- Deleting a partition

  Run the following command to delete partition **P8**:

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 DROP PARTITION P8;
ALTER TABLE
```

- Adding a partition

  Run the following command to add partition **P8** and set its range to [40000,MAXVALUE]:

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 ADD PARTITION P8 VALUES LESS THAN
(MAXVALUE);
ALTER TABLE
```

- Renaming a partition
  - Run the following command to rename partition **P8** to **P_9**:

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 RENAME PARTITION P8 TO P_9;
ALTER TABLE
```

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  - Run the following command to rename partition **P_9** to **P8**:
    ```
    openGauss=# ALTER TABLE tpcds.web_returns_p2 RENAME PARTITION FOR (40000) TO P8;
    ALTER TABLE
    ```

- Querying a partition

  Run the following command to query partition **P6**:
  ```
  openGauss=# SELECT * FROM tpcds.web_returns_p2 PARTITION (P6);
  openGauss=# SELECT * FROM tpcds.web_returns_p2 PARTITION FOR (35888);
  ```

- Deleting a partitioned table and its tablespaces
  ```
  openGauss=# DROP TABLE tpcds.customer_address;
  DROP TABLE
  openGauss=# DROP TABLE tpcds.web_returns_p2;
  DROP TABLE
  ```

Example 2: using a user-defined tablespace

Perform the following operations on the range partitioned table (the **tpcds** namespace in the example must be created in advance):

- Creating tablespaces
  ```
  openGauss=# CREATE TABLESPACE example1 RELATIVE LOCATION 'tablespace1/tablespace_1';
  openGauss=# CREATE TABLESPACE example2 RELATIVE LOCATION 'tablespace2/tablespace_2';
  openGauss=# CREATE TABLESPACE example3 RELATIVE LOCATION 'tablespace3/tablespace_3';
  openGauss=# CREATE TABLESPACE example4 RELATIVE LOCATION 'tablespace4/tablespace_4';
  ```

  If the following information is displayed, the tablespaces have been created:
  ```
  CREATE TABLESPACE
  ```

- Creating a partitioned table
  ```
  openGauss=# CREATE TABLE tpcds.customer_address
  (
      ca_address_sk       integer                 NOT NULL   ,
      ca_address_id       character(16)           NOT NULL   ,
      ca_street_number    character(10)                      ,
      ca_street_name      character varying(60)              ,
      ca_street_type      character(15)                      ,
      ca_suite_number     character(10)                      ,
      ca_city             character varying(60)              ,
      ca_county           character varying(30)              ,
      ca_state            character(2)                       ,
      ca_zip              character(10)                      ,
      ca_country          character varying(20)              ,
      ca_gmt_offset       numeric(5,2)                       ,
      ca_location_type    character(20)
  )
  TABLESPACE example1
  DISTRIBUTE BY HASH (ca_address_sk)
  PARTITION BY RANGE (ca_address_sk)
  (
      PARTITION P1 VALUES LESS THAN(5000),
      PARTITION P2 VALUES LESS THAN(10000),
      PARTITION P3 VALUES LESS THAN(15000),
      PARTITION P4 VALUES LESS THAN(20000),
      PARTITION P5 VALUES LESS THAN(25000),
      PARTITION P6 VALUES LESS THAN(30000),
      PARTITION P7 VALUES LESS THAN(40000),
      PARTITION P8 VALUES LESS THAN(MAXVALUE) TABLESPACE example2
  )
  ENABLE ROW MOVEMENT;
  ```

  If the following information is displayed, the partitioned table has been created:
  ```
  CREATE TABLE
  ```

  **NOTE**

  You are advised to create a maximum of 1000 column-store partitioned tables.

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- Inserting data

  Insert data from the **tpcds.customer_address** table to the **tpcds.web_returns_p2** table.

  Suppose a backup table **tpcds.web_returns_p2** of the **tpcds.customer_address** table has been created in the database. You can run the following command to insert the data of the **tpcds.customer_address** table into the backup table **tpcds.web_returns_p2**:

```
openGauss=# CREATE TABLE tpcds.web_returns_p2
(
    ca_address_sk       integer                 NOT NULL   ,
    ca_address_id       character(16)           NOT NULL   ,
    ca_street_number    character(10)                      ,
    ca_street_name      character varying(60)              ,
    ca_street_type      character(15)                      ,
    ca_suite_number     character(10)                      ,
    ca_city             character varying(60)              ,
    ca_county           character varying(30)              ,
    ca_state            character(2)                       ,
    ca_zip              character(10)                      ,
    ca_country          character varying(20)              ,
    ca_gmt_offset       numeric(5,2)                       ,
    ca_location_type    character(20)
)
TABLESPACE example1
DISTRIBUTE BY HASH (ca_address_sk)
PARTITION BY RANGE (ca_address_sk)
(
        PARTITION P1 VALUES LESS THAN(5000),
        PARTITION P2 VALUES LESS THAN(10000),
        PARTITION P3 VALUES LESS THAN(15000),
        PARTITION P4 VALUES LESS THAN(20000),
        PARTITION P5 VALUES LESS THAN(25000),
        PARTITION P6 VALUES LESS THAN(30000),
        PARTITION P7 VALUES LESS THAN(40000),
        PARTITION P8 VALUES LESS THAN(MAXVALUE) TABLESPACE example2
)
ENABLE ROW MOVEMENT;
CREATE TABLE
openGauss=# INSERT INTO tpcds.web_returns_p2 SELECT * FROM tpcds.customer_address;
INSERT 0 0
```

- Modifying the row movement attributes of the partitioned table

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 DISABLE ROW MOVEMENT;
ALTER TABLE
```

- Deleting a partition

  Run the following command to delete partition **P8**:

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 DROP PARTITION P8;
ALTER TABLE
```

- Adding a partition

  Run the following command to add partition **P8** and set its range to [40000,MAXVALUE]:

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 ADD PARTITION P8 VALUES LESS THAN
(MAXVALUE);
ALTER TABLE
```

- Renaming a partition
  - Run the following command to rename partition **P8** to **P_9**:

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 RENAME PARTITION P8 TO P_9;
ALTER TABLE
```

  - Run the following command to rename partition **P_9** to **P8**:

```
openGauss=# ALTER TABLE tpcds.web_returns_p2 RENAME PARTITION FOR (40000) TO P8;
ALTER TABLE
```

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- Modifying the tablespace of a partition
  - Run the following command to change the tablespace of partition **P6** to **example3**:
    ```
    openGauss=# ALTER TABLE tpcds.web_returns_p2 MOVE PARTITION P6 TABLESPACE example3;
    ALTER TABLE
    ```
  - Run the following command to change the tablespace of partition **P4** to **example4**:
    ```
    openGauss=# ALTER TABLE tpcds.web_returns_p2 MOVE PARTITION P4 TABLESPACE example4;
    ALTER TABLE
    ```
- Querying a partition

  Run the following command to query partition **P6**:
  ```
  openGauss=# SELECT * FROM tpcds.web_returns_p2 PARTITION (P6);
  openGauss=# SELECT * FROM tpcds.web_returns_p2 PARTITION FOR (35888);
  ```
- Deleting a partitioned table and its tablespaces
  ```
  openGauss=# DROP TABLE tpcds.customer_address;
  DROP TABLE
  openGauss=# DROP TABLE tpcds.web_returns_p2;
  DROP TABLE
  openGauss=# DROP TABLESPACE example1;
  openGauss=# DROP TABLESPACE example2;
  openGauss=# DROP TABLESPACE example3;
  openGauss=# DROP TABLESPACE example4;
  DROP TABLESPACE
  ```

# 2.8.3 Creating and Managing Indexes

## Background

Indexes accelerate data access but increase the processing time of insertion, update, and deletion operations. Therefore, before creating an index, consider whether it is necessary and select the columns where indexes are to be created. You can determine whether to add an index for a table by analyzing the service processing and data use of applications, as well as columns that are frequently used as search criteria or need to be collated.

Indexes are created based on columns in database tables. Therefore, you must correctly identify which columns require indexes. You are advised to create indexes for any of the following columns:

- Columns that are often searched and queried. This speeds up searches.
- Columns that function as primary keys. This enforces the uniqueness of the columns and the data collation structures in organized tables.
- Columns that are often joined and function as foreign keys. This increases the join efficiency.
- Columns that are often searched by range. The index helps collate data, and therefore the specified ranges are contiguous.
- Columns that often need to be collated. The index helps collate data, reducing the time for a collation query.
- Columns where the WHERE clause is executed frequently. This speeds up condition judgment.
- Columns that often appear after the keywords ORDER BY, GROUP BY, and DISTINCT.

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NOTE

- After an index is created, the system automatically determines when to reference it. If the system determines that indexing is faster than sequenced scanning, the index will be used.
- After an index is successfully created, it must be synchronized with the associated table to ensure new data can be accurately located, which increases the data operation load. Therefore, delete unnecessary indexes periodically.

- When logical replication is enabled, if you need to create a primary key index that contains system columns, you must set the **REPLICA IDENTITY** attribute of the table to **FULL** or use USING INDEX to specify a unique, non-local, non-deferrable index that does not contain system columns and contains only columns marked **NOT NULL**.

## Procedure

For details about how to create a partitioned table, see **2.8.2 Creating and Managing Partitioned Tables**.

- Creating an index
  - Create the partitioned table index **tpcds_web_returns_p2_index1** without specifying the partition name.

    ```
    openGauss=# CREATE INDEX tpcds_web_returns_p2_index1 ON tpcds.web_returns_p2 (ca_address_id) LOCAL;
    ```

    If the following information is displayed, the index has been created:

    ```
    CREATE INDEX
    ```

  - Create the partitioned table index **tpcds_web_returns_p2_index2** with the partition name specified.

    ```
    openGauss=# CREATE INDEX tpcds_web_returns_p2_index2 ON tpcds.web_returns_p2 (ca_address_sk) LOCAL
    (
        PARTITION web_returns_p2_P1_index,
        PARTITION web_returns_p2_P2_index TABLESPACE example3,
        PARTITION web_returns_p2_P3_index TABLESPACE example4,
        PARTITION web_returns_p2_P4_index,
        PARTITION web_returns_p2_P5_index,
        PARTITION web_returns_p2_P6_index,
        PARTITION web_returns_p2_P7_index,
        PARTITION web_returns_p2_P8_index
    ) TABLESPACE example2;
    ```

    If the following information is displayed, the index has been created:

    ```
    CREATE INDEX
    ```

- Modifying the tablespace of an index partition
  - Change the tablespace of index partition **web_returns_p2_P2_index** to **example1**.

    ```
    openGauss=# ALTER INDEX tpcds.tpcds_web_returns_p2_index2 MOVE PARTITION web_returns_p2_P2_index TABLESPACE example1;
    ```

    If the following information is displayed, the tablespace of the index partition has been modified:

    ```
    ALTER INDEX
    ```

  - Change the tablespace of index partition **web_returns_p2_P3_index** to **example2**.

    ```
    openGauss=# ALTER INDEX tpcds.tpcds_web_returns_p2_index2 MOVE PARTITION web_returns_p2_P3_index TABLESPACE example2;
    ```

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If the following information is displayed, the tablespace of the index partition has been modified:

```
ALTER INDEX
```

- Renaming an index partition

  Rename the name of index partition **web_returns_p2_P8_index** to **web_returns_p2_P8_index_new**.

  ```
  openGauss=# ALTER INDEX tpcds.tpcds_web_returns_p2_index2 RENAME PARTITION web_returns_p2_P8_index TO web_returns_p2_P8_index_new;
  ```

  If the following information is displayed, the index partition has been renamed:

  ```
  ALTER INDEX
  ```

- Querying indexes
  - Run the following command to query all indexes defined by the system and users:

    ```
    openGauss=# SELECT RELNAME FROM PG_CLASS WHERE RELKIND='i';
    ```

  - Run the following command to query information about a specified index:

    ```
    openGauss=# \di+ tpcds.tpcds_web_returns_p2_index2
    ```

- Deleting indexes

  ```
  openGauss=# DROP INDEX tpcds.tpcds_web_returns_p2_index1;
  openGauss=# DROP INDEX tpcds.tpcds_web_returns_p2_index2;
  ```

  If the following information is displayed, the indexes have been deleted:

  ```
  DROP INDEX
  ```

GaussDB supports four methods for creating indexes. For details, see **Table 2-4**.

NOTE

- After an index is created, the system automatically determines when to reference it. If the system determines that indexing is faster than sequenced scanning, the index will be used.
- After an index is successfully created, it must be synchronized with the associated table to ensure new data can be accurately located, which increases the data operation load. Therefore, delete unnecessary indexes periodically.

**Table 2-4** Indexing method

| Indexing Method | Description |
| --- | --- |
| Unique index | An index that requires the uniqueness of an index attribute or an attribute group. If a table declares unique constraints or primary keys, GaussDB automatically creates unique indexes (or composite indexes) for columns that form the primary keys or unique constraints. Currently, unique indexes can be created only for the B-tree and UB-tree in GaussDB. |
| Composite index | An index that can be defined for multiple attributes of a table. Currently, composite indexes can be created only for B-tree in GaussDB and up to 32 columns can share a composite index. |

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| Indexing Method | Description |
| --- | --- |
| Partial index | An index that can be created for subsets of a table. This indexing method contains only tuples that meet condition expressions. |
| Expression index | An index that is built on a function or expression calculated based on one or more attributes of a table. An expression index works only when the queried expression is the same as the created expression. |

- Create an ordinary table.
  ```
  openGauss=# CREATE TABLE tpcds.customer_address_bak AS TABLE tpcds.customer_address;
  INSERT 0 0
  ```
- Create an ordinary index.

  For the **tpcds.customer_address_bak** table, you need to perform the following operations frequently:
  ```
  openGauss=# SELECT ca_address_sk FROM tpcds.customer_address_bak WHERE ca_address_sk=14888;
  ```

  Generally, the database system needs to scan the **tpcds.customer_address_bak** table row by row to find all matched tuples. If the size of the **tpcds.customer_address_bak** table is large but only a few (possibly zero or one) of the WHERE conditions are met, the performance of this sequential scan is low. If the database system uses an index to maintain the **ca_address_sk** attribute, the database system only needs to search a few tree layers for the matched tuples. This greatly improves data query performance. Furthermore, indexes can improve the update and deletion operation performance in the database.

  Run the following command to create an index:

  ```
  openGauss=# CREATE INDEX index_wr_returned_date_sk ON tpcds.customer_address_bak (ca_address_sk);
  CREATE INDEX
  ```
- Create a unique index.

  Create a unique index on the **SM_SHIP_MODE_SK** column in the **tpcds.ship_mode_t1** table.

  ```
  openGauss=# CREATE UNIQUE INDEX ds_ship_mode_t1_index1 ON tpcds.ship_mode_t1(SM_SHIP_MODE_SK);
  ```
- Create a multi-column index.

  Assume you need to frequently query records with **ca_address_sk** being **5050** and **ca_street_number** smaller than **1000** in the **tpcds.customer_address_bak** table. Run the following commands:
  ```
  openGauss=# SELECT ca_address_sk,ca_address_id FROM tpcds.customer_address_bak WHERE ca_address_sk = 5050 AND ca_street_number < 1000;
  ```

  Run the following command to define a composite index on **ca_address_sk** and **ca_street_number** columns:
  ```
  openGauss=# CREATE INDEX more_column_index ON tpcds.customer_address_bak(ca_address_sk ,ca_street_number );
  CREATE INDEX
  ```
- Create a partial index.

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If you only want to find records whose **ca_address_sk** is **5050**, you can create a partial index to facilitate your query.

```
openGauss=# CREATE INDEX part_index ON tpcds.customer_address_bak(ca_address_sk) WHERE ca_address_sk = 5050;
CREATE INDEX
```

- Create an expression index.

  Assume that you need to frequently query records with **ca_street_number** smaller than **1000**, run the following command:

  ```
  openGauss=# SELECT * FROM tpcds.customer_address_bak WHERE trunc(ca_street_number) < 1000;
  ```

  The following expression index can be created for this query task:

  ```
  openGauss=# CREATE INDEX para_index ON tpcds.customer_address_bak (trunc(ca_street_number));
  CREATE INDEX
  ```

- Delete the **tpcds.customer_address_bak** table.

  ```
  openGauss=# DROP TABLE tpcds.customer_address_bak;
  DROP TABLE
  ```

# 2.8.4 Creating and Managing Views

## Background

If some columns in one or more tables in a database are frequently searched for, an administrator can define a view for these columns, and then users can directly access these columns in the view without entering search criteria.

A view is different from a base table. It is only a virtual object rather than a physical one. Only view definition is stored in the database and view data is not. The data is stored in a base table. If data in the base table changes, the data in the view changes accordingly. In this sense, a view is like a window through which users can know their interested data and data changes in the database. A view is triggered every time it is referenced.

## Managing Views

- Creating a view

  Run the following command to create the **MyView** view. In the command, **tpcds.***web_returns* indicates the created user table that contains the *wr_refunded_cash* integer field.

  ```
  openGauss=# CREATE OR REPLACE VIEW MyView AS SELECT * FROM tpcds.web_returns WHERE trunc(wr_refunded_cash) > 10000;
  CREATE VIEW
  ```

  NOTE

  The **OR REPLACE** parameter in this command is optional. It indicates that if the view exists, the new view will replace the existing view.

- Querying a view

  Run the following command to query **MyView**:

  ```
  openGauss=# SELECT * FROM MyView;
  ```

- Querying views of the current user

  ```
  openGauss=# SELECT * FROM my_views;
  ```

- Querying all views

  ```
  openGauss=# SELECT * FROM adm_views;
  ```

- Viewing details about a specified view

  Run the following command to view details about **MyView**:

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```
openGauss=# \d+ MyView
                    View "PG_CATALOG.MyView"
 Column  |          Type          | Modifiers | Storage  | Description
----------+------------------------+-----------+----------+-------------
 USERNAME | CHARACTER VARYING(64) |           | extended |
View definition:
 SELECT PG_AUTHID.ROLNAME::CHARACTER VARYING(64) AS USERNAME
   FROM PG_AUTHID;
```

- Deleting a view

  Run the following command to delete **MyView**:

  ```
  openGauss=# DROP VIEW MyView;
  DROP VIEW
  ```

# 2.8.5 Creating and Managing Sequences

## Background

A sequence is a database object that generates unique integers. Sequence numbers are generated according to a certain rule. Sequences are unique because they increase automatically. This is why they are often used as primary keys.

You can create a sequence for a column in either of the following methods:

- Set the data type of a column to **sequence integer**. A sequence will be automatically created by the database for this column.
- Run the **CREATE SEQUENCE** statement to create a sequence. Set the initial value of the **nextval**('*sequence_name*') function to the default value of a column.

## Procedure

Method 1: Set the data type of a column to a sequence integer. For example:

```
openGauss=# CREATE TABLE T1
(
    id    serial,
    name  text
);
```

If the following information is displayed, the table has been created:

```
CREATE TABLE
```

Method 2: Create a sequence and set the initial value of the **nextval**('*sequence_name*') function to the default value of a column. You can cache a specific number of sequence values to reduce the requests to the GTM, improving the performance.

1. Create a sequence.

   ```
   openGauss=# CREATE SEQUENCE seq1 cache 100;
   ```

   If the following information is displayed, the sequence has been created:

   ```
   CREATE SEQUENCE
   ```

2. Set the initial value of the **nextval**('*sequence_name*') function to the default value of a column.

   ```
   openGauss=# CREATE TABLE T2
   (
      id   int not null default nextval('seq1'),
      name text
   );
   ```

   If the following information is displayed, the default value has been specified:

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```
CREATE TABLE
```

3. Associate the sequence with a column.

   Associate a sequence with a specified column included in a table. In this way, the sequence will be deleted when you delete its associated field or the table where the field belongs.

   ```
   openGauss=# ALTER SEQUENCE seq1 OWNED BY T2.id;
   ```

   If the following information is displayed, the column has been specified:

   ```
   ALTER SEQUENCE
   ```

**NOTE**

The preceding methods are similar, except that the second method specifies cache for the sequence. A sequence having cache defined has inconsecutive values (such as 1, 4, and 5) and cannot maintain the order of its values. After the dependent column of a sequence has been specified, once the sequence is deleted, the sequence of the dependent will be deleted. A sequence shared by multiple columns is not forbidden in a database, but you are not advised to do that.

In the current version, you can specify the auto-increment column or set the default value of a column to **nextval('seqname')** when defining a table. You cannot add an auto-increment column or a column whose default value is **nextval('seqname')** to an existing table.

## Precautions

Sequence values are generated by the GTM. By default, each request for a sequence value is sent to the GTM. The GTM calculates the result of the current value plus the step and then returns the result. The GTM is a globally unique node and is the performance bottleneck. Therefore, you are not advised to generate sequence values frequently and numerously, such as to use BulkLoad to import data. For example, the **INSERT FROM SELECT** statement has poor performance in the following scenario:

```
openGauss=# CREATE SEQUENCE newSeq1;
openGauss=# CREATE TABLE newT1
        (
          id   int not null default nextval('newSeq1'),
          name text
        );
openGauss=# INSERT INTO newT1(name) SELECT name from T1;
```

Assume that data imported from table **T1** to table **newT1** has 10,000 rows. The following statements achieve better performance:

```
openGauss=# INSERT INTO newT1(id, name) SELECT id,name from T1;
openGauss=# SELECT SETVAL('newSeq1',10000);
```

**NOTE**

Rollback is not supported by sequence functions, including **nextval()** and **setval()**. The value of the **setval** function immediately takes effect on **nextval** in the current session in any cases and take effect in other sessions only when no cache is specified for them. If cache is specified for a session, it takes effect only after all the cached values have been used. To avoid duplicate values, use **setval** only when necessary. Do not set it to an existing sequence value or a cached sequence value.

To generate the default sequence value using BulkLoad, set sufficient cache for **newSeq1** and do not set **Maxvalue** or **Minvalue**. The database will push down the calling of **nextval('sequence_name')** to DNs to improve performance. Currently, the concurrent connection requests that can be processed by the GTM

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are limited. If there are too many DNs, a large number of concurrent connection requests will be sent to the GTM. In this case, you need to limit the bulk loading concurrency, so that DNs do not fully occupy GTM connections. If the target table is a duplicate table (DISTRIBUTE BY REPLICATION), pushdown cannot be performed. A large amount of data would be a disaster to the database. Also, the occupied space may dramatically expand. After the import is completed, you need to run **VACUUM FULL** to free space. The best way is not to use BulkLoad to generate the default sequence value.

After a sequence is created, one single-row table is maintained on each node to store the sequence definition and value, which is obtained from the last interaction with the GTM rather than updated in real time. The single-row table on a node does not update when other nodes request a new value from the GTM or when the sequence is modified using **setval**.

## 2.8.6 Creating and Managing Scheduled Jobs

### Background

Time-consuming jobs, such as summarizing statistics or synchronizing data from another database, affect service performance if they are performed during the daytime and incur overtime hours if performed at night. To solve this problem, the database is compatible with the scheduled job function in Oracle. You can create scheduled jobs that are automatically triggered to reduce O&M workload.

This function calls interfaces provided by the **DBE_TASK** package to create scheduled jobs, execute jobs automatically, delete jobs, and modify job attributes (including job ID, the enabled/disabled status of a job, job triggering time, triggering interval, and job contents).

### Managing Scheduled Jobs

**Step 1** Create a test table.

```
openGauss=# CREATE TABLE test(id int, time date);
```

If the following information is displayed, the test table has been created:

```
CREATE TABLE
```

**Step 2** Create a customized storage procedure.

```
openGauss=# CREATE OR REPLACE PROCEDURE PRC_JOB_1()
AS
N_NUM integer :=1;
BEGIN
FOR I IN 1..1000 LOOP
INSERT INTO test VALUES(I,SYSDATE);
END LOOP;
END;
/
```

If the following information is displayed, the procedure has been created:

```
CREATE PROCEDURE
```

**Step 3** Create a job.

- Create a job with unspecified **job_id** and execute the **PRC_JOB_1** stored procedure every minute.

  ```
  openGauss=# call dbe_task.submit('call public.prc_job_1(); ', sysdate, 'interval ''1 minute''', :a);
  job
  ```

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```
-----
1
(1 row)
```

- Specify **job_id** to create a job. The value of **job_id** ranges from 1 to 32767.

```
openGauss=# call dbe_task.id_submit(2,'call public.prc_job_1(); ', sysdate, 'interval ''1 minute''');
isubmit
---------

(1 row)
```

**Step 4** View details of jobs created by the current user.

```
openGauss=# select job,dbname,start_date,last_date,this_date,next_date,broken,status,interval,failures,what
from my_jobs;
job | dbname |     start_date      |         last_date          |         this_date          |      next_date      | broken |
status |      interval       | failures |           what
-----+--------+---------------------+----------------------------+----------------------------+---------------------
+--------+--------+---------------------+----------+----------------------------
1 | postgres   | 2017-07-18 11:38:03 | 2017-07-18 13:53:03.607838 | 2017-07-18 13:53:03.607838 |
2017-07-18 13:54:03 | n      | s      | interval '1 minute' |        0 | call public.prc_job_1();
(1 row)
```

**Step 5** Stop a job.

```
openGauss=# call dbe_task.finish(1,true);
broken
--------

(1 row)
```

**Step 6** Start a job.

```
openGauss=# call dbe_task.finish(1,false);
broken
--------

(1 row)
```

**Step 7** Modify job attributes.

- Modify the **Next_date** parameter information about a job.

  -- Set **Next_date** of **Job1** to 1 hour so that **Job1** will be executed in one hour.

```
openGauss=# call dbe_task.next_time(1, sysdate+1.0/24);
next_date
-----------

(1 row)
```

- Modify the **Interval** parameter about a job.

  -- Set **Interval** of **Job1** to **1**.

```
openGauss=# call dbe_task.interval(1,'sysdate + 1.0/24');
interval
----------

(1 row)
```

- Modify the **What** parameter about a job.

  -- Set **What** to the SQL statement **insert into public.test values(333, sysdate+5);** for **Job1**.

```
openGauss=# call dbe_task.content(1,'insert into public.test values(333, sysdate+5);');
what
------

(1 row)
```

- Modify **Next_date**, **Interval**, and **What** parameters about a job.

```
openGauss=# call dbe_task.update(1, 'call public.prc_job_1();', sysdate, 'interval ''1 minute''');
change
--------
```

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```
(1 row)
```

**Step 8** Delete a job.

```
openGauss=# call dbe_task.cancel(1);
remove
--------

(1 row)
```

**Step 9** View the job execution status.

If a job fails to execute automatically, (the status of **job_status** is **f**), you can query the failure information by visiting the **pg_log** subdirectory of the CN data directory where the job belongs to.

From **detail error msg**, you can see the failure causes.

```
LOG:  Execute Job Detail:
        job_id: 1
        what: call public.test();
        start_date: 2017-07-19 23:30:47.401818
        job_status: failed
        detail error msg: relation "test" does not exist
        end_date: 2017-07-19 23:30:47.401818
        next_run_date: 2017-07-19 23:30:56.855827
```

**Step 10** Set job permissions.

- During the creation of a job, the job is bound to the user and database that created the job. Accordingly, the user and database are added to **dbname** and **log_user** columns in the **pg_job** system catalog, respectively.
- If the current user is a database administrator, system administrator, or the user who created the job, (**log_user** of **pg_job**), the user has permissions to delete or modify job parameters using the **Remove**, **Change**, **Next_date**, **What**, or **Interval** parameter. Otherwise, the system displays a message indicating that the user has no permissions to perform operations on this job.
- If the current database is the one that created a job, (that is, **dbname** in **pg_job**), you can delete or modify parameter settings of the job using the **cancel**, **update**, **next_data**, **content**, or **interval** parameter.
- When deleting the database that created a job, (that is, **dbname** in **pg_job**), the system automatically deletes the job records of the database.
- When deleting the user who created a job, (that is, **log_user** in **pg_job**), the system automatically deletes the job records of the user.

**Step 11** Manage job concurrency. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

You can configure parameter **job_queue_processes** to adjust the number of jobs running at the same time.

- Setting **job_queue_processes** to **0** indicates that the scheduled job function is disabled and all jobs will not be executed.
- Setting **job_queue_processes** to a value that is greater than **0** indicates that the scheduled job function is enabled and this value is the maximum number of jobs that can be concurrently processed.

Too many concurrent jobs consume many system resources, so you need to set the number of concurrent jobs to be processed. If the current number of concurrent jobs reaches the value of **job_queue_processes** and some of them expire, these

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jobs will be postponed to the next polling period. Therefore, you are advised to set the polling interval (the **Interval** parameter of the **submit** interface) based on the execution duration of each job to avoid the problem that jobs in the next polling period cannot be properly processed because of overlong job execution time.

Note: For clusters that do not use jobs, set **job_queue_processes** to **0** to disable job functions to reduce the resource consumption.

**----End**

# 2.9 gsql Client Reference

**gsql** is a database connection tool provided by GaussDB and runs in the command-line interface. You can use **gsql** to connect to the server and perform operations and maintenance. In addition to basic functions for performing operations on a database, **gsql** provides multiple advanced features. For details, see **Advanced Features**.

## 2.9.1 Overview

### Basic Features

- **Connect to a database**: By default, only remote connection to the database is supported.

  NOTE

  If **gsql** is used to connect to a database, the connection timeout period will be 5 minutes. If the database has not correctly set up a connection and authenticated the identity of the client within this period, **gsql** will time out and exit.

  To resolve this problem, see **2.9.6 Troubleshooting**.
- **Run SQL statements**: Interactively entered SQL statements and specified SQL statements in a file can be run.
- **Run meta-commands**: Meta-commands help the administrator view database object information, query cache information, format SQL output, and connect to a new database. For details about meta-commands, see **2.9.5 Meta-Command Reference**.

### Advanced Features

**Table 2-5** lists the advanced features of **gsql**.

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**Table 2-5** Advanced features of **gsql**

| Feature Name | Description |
| --- | --- |
| Variable | **gsql** provides a variable feature that is similar to the **shell** command of Linux. The following **\set** meta-command of **gsql** can be used to set a variable:<br>**\set** *varname value*<br>To delete the variables set by the **\set** command, run the following command:<br>**\unset** *varname*<br>**NOTE**<br>• A variable is a simple name-value pair. The value can be any characters in any length.<br>• Variable names must consist of case-sensitive letters (including non-Latin letters), digits, and underscores (_).<br>• If the **\set** *varname* meta-command (without the second parameter) is used, the variable is set without a value specified.<br>• If the **\set** meta-command without parameters is used, values of all variables are displayed.<br>For details about variable examples and descriptions, see **Variables**. |
| SQL substitution | Common SQL statements can be set to variables using the variable feature of **gsql** to simplify operations.<br>For details about SQL substitution examples and descriptions, see **SQL substitution**. |
| Customized prompt | Prompts of **gsql** can be customized. Prompts can be modified by changing the reserved three variables of **gsql**: *PROMPT1*, *PROMPT2*, and *PROMPT3*.<br>These variables can be set to customized values or the values predefined by **gsql**. For details, see **Prompt**. |
| Historical client operation records | **gsql** can record historical client operations. This function is enabled by specifying the **-r** parameter when a client is connected. The number of historical records can be set using the **\set** command. For example, **\set HISTSIZE 50** indicates that the number of historical records is set to **50**. **\set HISTSIZE 0** indicates that the operation history is not recorded.<br>**NOTE**<br>• The default number of historical records is **32**. The maximum number of historical records is **500**. If interactively entered SQL commands contain Chinese characters, only the UTF-8 encoding environment is supported.<br>• For security purposes, the records containing character strings such as PASSWORD, IDENTIFIED, GS_ENCRYPT_AES128, GS_DECRYPT_AES128, GS_ENCRYPT, GS_DECRYPT, PG_CREATE_PHYSICAL_REPLICATION_SLOT_EXTERN, SECRET_ACCESS_KEY, SECRETKEY and CREATE_CREDENTIAL (case-insensitive) are considered as sensitive information and will not be recorded in historical information. This indicates that you cannot view these records in command output histories. |

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- Variables

  To set a variable, run the **\set** meta-command of **gsql**. For example, to set variable *foo* to **bar**, run the following command:

  ```
  openGauss=# \set foo bar
  ```

  To reference the value of a variable, add a colon (:) before the variable. For example, to view the value of variable *foo*, run the following command:

  ```
  openGauss=# \echo :foo
  bar
  ```

  The variable reference method is suitable for regular SQL statements and meta-commands.

  **gsql** pre-defines some special variables and plans the values of these variables. To ensure compatibility with later versions, do not use these variables for other purposes. For details about special variables, see **Table 2-6**.

  NOTE

  - All the special variables consist of upper-case letters, digits, and underscores (_).
  - To view the default value of a special variable, run the **\echo :***varname* meta-command, for example, **\echo :***DBNAME*.

  **Table 2-6** Settings of special variables

| Variable | Setting Method | Description |
| --- | --- | --- |
| DBNAME | \set DBNAME *dbname* | Name of the connected database. This variable is set again when a database is connected. |
| ECHO | \set ECHO all \| queries | • If this variable is set to **all**, only the query information is displayed. This has the same effect as specifying the **-a** parameter when **gsql** is used to connect to a database.<br>• If this variable is set to **queries**, the command line and query information are displayed. This has the same effect as specifying the **-e** parameter when **gsql** is used to connect to a database. |

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| Variable | Setting Method | Description |
| --- | --- | --- |
| ECHO_HIDDEN | \set ECHO_HIDDEN on \| off \| noexec | When a meta-command (such as **\dg**) is used to query database information, the value of this variable determines the query behavior.<br>● If this variable is set to **on**, the query statements that are called by the meta-command are displayed, and then the query result is displayed. This has the same effect as specifying the **-E** parameter when **gsql** is used to connect to a database.<br>● If this variable is set to **off**, only the query result is displayed.<br>● If this variable is set to **noexec**, only the query information is displayed, and the query is not run. |
| ENCODING | \set ENCODING *encoding* | Character set encoding of the current client. |
| FETCH_COUNT | \set FETCH_COUNT *variable* | ● If the value is an integer greater than **0**, for example, *n*, *n* lines will be selected from the result set to the cache and displayed on the screen when the **SELECT** statement is run.<br>● If this variable is not set or set to a value less than or equal to **0**, all results are selected at a time to the cache when the **SELECT** statement is run.<br>**NOTE**<br>A proper variable value helps reduce the memory usage. The recommended value range is from 100 to 1000. |
| HISTCONTROL | \set HISTCONTROL ignorespace \| ignoredups \| ignoreboth \| none | ● **ignorespace**: A line started with a space is not written to the historical record.<br>● **ignoredups**: A line that exists in the historical record is not written to the historical record.<br>● **ignoreboth**, **none**, or other values: All the lines read in interaction mode are saved in the historical record.<br>**NOTE**<br>**none** indicates that **HISTCONTROL** is not set. |
| HISTFILE | \set HISTFILE *filename* | Specifies the file for storing historical records. The default value is **~/.bash_history**. |

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| Variable | Setting Method | Description |
| --- | --- | --- |
| HISTSIZE | \set HISTSIZE *size* | Specifies the number of commands to store in the command history. The default value is **500**. |
| HOST | \set HOST *hostname* | Specifies the name of a connected host. |
| IGNOREEOF | \set IGNOREEOF *variable* | • If this variable is set to a number, for example, **10**, the first nine EOF characters (generally **Ctrl**+**C**) entered in **gsql** are neglected and the **gsql** program exits when the tenth **Ctrl**+**C** is entered.<br>• If this variable is set to a non-numeric value, the default value is **10**.<br>• If this variable is deleted, **gsql** exits when an EOF is entered. |
| LASTOID | \set LASTOID *oid* | Specifies the last OID, which is the value returned by an **INSERT** or **lo_import** command. This variable is valid only before the output of the next SQL statement is displayed. |
| ON_ERROR_ROLLBACK | \set ON_ERROR_ROLLBACK on \| interactive \| off | • If the value is **on**, an error that may occur in a statement in a transaction block is ignored and the transaction continues.<br>• If the value is **interactive**, the error is ignored only in an interactive session.<br>• If the value is **off** (default value), the error triggers the rollback of the transaction block. In **on_error_rollback-on** mode, a **SAVEPOINT** is set before each statement of a transaction block, and an error triggers the rollback of the transaction block. |
| ON_ERROR_STOP | \set ON_ERROR_STOP on \| off | • **on**: specifies that the execution stops if an error occurs. In interactive mode, **gsql** returns the output of executed commands immediately.<br>• **off** (default value): specifies that an error, if occurring during the execution, is ignored, and the execution continues. |
| PORT | \set PORT *port* | Specifies the port number of a connected database. |

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| Variable | Setting Method | Description |
| --- | --- | --- |
| USER | \set USER *username* | Specifies the database user you are currently connected as. |
| VERBOSITY | \set VERBOSITY terse \| default \| verbose | This variable can be set to **terse**, **default**, or **verbose** to control redundant lines of error reports.<br>• **terse**: Only critical and major error texts and text locations are returned (which is generally suitable for single-line error information).<br>• **default**: Critical and major error texts and text locations, error details, and error messages (possibly involving multiple lines) are all returned.<br>• **verbose**: All error information is returned. |

- SQL substitution

  **gsql**, like a parameter of a meta-command, provides a key feature that enables you to substitute a standard SQL statement for a **gsql** variable. **gsql** also provides a new alias or identifier for the variable. To replace the value of a variable using the SQL substitution method, add a colon (:) before the variable. For example:

```
openGauss=# \set foo 'HR.areaS'
openGauss=# select * from :foo;
 area_id |       area_name
---------+------------------------
       4 | Middle East and Africa
       3 | Asia
       1 | Europe
       2 | Americas
(4 rows)
```

  The above command queries the HR.areaS table.

  **NOTICE**

  The value of the variable is copied literally, so it can even contain unbalanced quotation marks or backslash commands. Therefore, the input content must be meaningful.

- Prompt

  The **gsql** prompt can be set using the three variables in **Table 2-7**. These variables consist of characters and special escape characters.

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**Table 2-7** Prompt variables

| Variable | Description | Example |
| --- | --- | --- |
| PROMPT1 | Specifies the normal prompt used when **gsql** requests a new command.<br>The default value of *PROMPT1* is:<br>`%/%R%#` | *PROMPT1* can be used to change the prompt.<br>• Change the prompt to **[local]**:<br>`openGauss=> \set PROMPT1 %M`<br>`[local:/tmp/gaussdba_mppdb]`<br>• Change the prompt to **name**:<br>`openGauss=> \set PROMPT1 name`<br>`name`<br>• Change the prompt to **=**:<br>`openGauss=> \set PROMPT1 %R`<br>`=` |
| PROMPT2 | Specifies the prompt displayed when more input is expected because the command that is not terminated with a semicolon (;) or a quote (') is not closed. | *PROMPT2* can be used to display the prompt.<br>`openGauss=# \set PROMPT2 TEST`<br>`openGauss=# select * from HR.areaS TEST;`<br>` area_id \|  area_name`<br>`---------+--------------------`<br>`  1 \| Europe`<br>`  2 \| Americas`<br>`  4 \| Middle East and Africa`<br>`  3 \| Asia`<br>`(4 rows))` |
| PROMPT3 | Specifies the prompt displayed when the **COPY** statement (such as **COPY FROM STDIN**) is run and data input is expected. | *PROMPT3* can be used to display the **COPY** prompt.<br>`openGauss=# \set PROMPT3 '>>>>'`<br>`openGauss=# copy HR.areaS from STDIN;`<br>`Enter data to be copied followed by a newline.`<br>`End with a backslash and a period on a line by itself.`<br>`>>>>1 aa`<br>`>>>>2 bb`<br>`>>>>\.` |

The value of the selected prompt variable is printed literally. However, a value containing a percent sign (%) is replaced by the predefined contents depending on the character following the percent sign (%). For details about the defined substitutions, see **Table 2-8**.

**Table 2-8** Defined substitutions

| Symbol | Description |
| --- | --- |
| %M | Replaced with the full host name (with domain name). The full name is **[local]** if the connection is over a Unix domain socket, or **[local:/dir/name]** if the Unix domain socket is not at the compiled default location. |
| %m | Replaced with the host name truncated at the first dot. It is **[local]** if the connection is over a Unix domain socket. |

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| Symbol | Description |
| --- | --- |
| %> | Replaced with the number of the port that the host is listening on. |
| %n | Replaced with the database session username. |
| %/ | Replaced with the name of the current database. |
| %~ | Similar to **%/**. However, the output is tilde (~) if the database is your default database. |
| %# | Uses **#** if the session user is the database administrator. Otherwise, uses **>**. |
| %R | • In *PROMPT1* normally **=**, but **^** if in single-line mode, or **!** if the session is disconnected from the database (which can happen if **\connect** fails).<br>• In *PROMPT2* %R is replaced with a hyphen (-), an asterisk (*), a single or double quotation mark, or a dollar sign ($), depending on whether **gsql** expects more input because the query is inside a /*...*/ comment or inside a quoted or dollar-escaped string. |
| %x | Replaced with the transaction status.<br>• An empty string when it is not in a transaction block<br>• An asterisk (*) when it is in a transaction block<br>• An exclamation mark (!) when it is in a failed transaction block<br>• A question mark (?) when the transaction status is indefinite (for example, because there is no connection). |
| %digits | Replaced with the character with the specified byte. |
| %:name | Replaced with the value of the *name* variable of **gsql**. |
| %command | Replaced with the command output, similar to substitution with the "^" symbol. |
| %[ . . . %] | Prompts may contain terminal control characters which, for example, change the color, background, or style of the prompt text, or change the title of the terminal window. For example:<br>potgres=> \set PROMPT1 '%[%033[1;33;40m%]%n@%/%R%[%033[0m%]%#'<br>The output is a boldfaced (1;) yellow-on-black (33;40) prompt on VT100-compatible, color-capable terminals. |

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## Environment Variables

**Table 2-9** Environment variables related to **gsql**

| Name | Description |
| --- | --- |
| COLUMNS | If **\set columns** is set to **0**, this parameter controls the width of the wrapped format. This width determines whether to change the wide output mode into the vertical output mode if automatic expansion is enabled. |
| PAGER | If the query results do not fit on the screen, they are redirected through this command. You can use the **\pset** command to disable the pager. Typically, the **more** or **less** command is used for viewing the query result page by page. The default is platform-dependent.<br>**NOTE**<br>Display of the **less** command is affected by the *LC_CTYPE* environment variable. |
| PSQL_EDITOR | The **\e** and **\ef** commands use the editor specified by the environment variables. The variables are examined in the order listed. The default editor on Unix is vi. |
| EDITOR | |
| VISUAL | |
| PSQL_EDITOR_LINENUMBER_ARG | When the **\e** or **\ef** command is used with a line number parameter, this variable specifies the command-line parameter used to pass the starting line number to the editor. For editors, such as Emacs or vi, this is a plus sign. Include a space in the value of the variable if space is needed between the option name and the line number. For example:<br>`PSQL_EDITOR_LINENUMBER_ARG = '+'`<br>`PSQL_EDITOR_LINENUMBER_ARG='--line '`<br>A plus sign (+) is used by default on Unix. |
| PSQLRC | Specifies the location of the user's .gsqlrc file. |
| SHELL | Has the same effect as the **\!** command. |
| TMPDIR | Specifies the directory for storing temporary files. The default value is **/tmp**. |

# 2.9.2 How to Use gsql

## Prerequisites

The user using **gsql** must have the permission to access the database.

## Procedure

**Step 1** Use **gsql** to connect to a GaussDB instance.

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The **gsql** tool uses the **-d** parameter to specify the target database name, the **-U** parameter to specify the database username, the **-h** parameter to specify the host name, and the **-p** parameter to specify the port number.

NOTE

If the database name is not specified, the default database name generated during initialization will be used. If the database username is not specified, the current OS username will be used by default. If a variable does not belong to any parameter (such as **-d** and **-U**), and **-d** is not specified, the variable will be used as the database name. If **-d** is specified but **-U** is not specified, the variable will be used as the database username.

Example 2: Connect to the 8000 port of the remote postgres database as user **jack**.

```
gsql -h 10.180.123.163 -d postgres -U jack -p 8000
```

For details about the **gsql** parameters, see **2.9.4 Command Reference**.

**Step 2** Run a SQL statement.

The following takes creating database **human_staff** as an example:

```
CREATE DATABASE human_staff;
CREATE DATABASE
```

Ordinarily, input lines end when a command-terminating semicolon is reached. If the command is sent and executed without any error, the command output is displayed on the screen.

**Step 3** Execute gsql meta-commands.

The following takes all GaussDB databases and description information as an example:

```
openGauss=# \l
                             List of databases
     Name      |  Owner   | Encoding  | Collate | Ctype |   Access privileges
---------------+----------+-----------+---------+-------+-----------------------
 human_resource | root | SQL_ASCII | C       | C     |
 postgres       | root | SQL_ASCII | C       | C     |
 template0      | root | SQL_ASCII | C       | C     | =c/root          +
                |      |           |         |       | root=CTc/root
 template1      | root | SQL_ASCII | C       | C     | =c/root          +
                |      |           |         |       | root=CTc/root
 human_staff    | root | SQL_ASCII | C       | C     |
(5 rows)
```

For details about **gsql** meta-commands, see **2.9.5 Meta-Command Reference**.

**----End**

## Example

The example shows how to spread a command over several lines of input. Note the prompt change:

```
openGauss=# CREATE TABLE HR.areaS(
postgres(# area_ID   NUMBER,
openGauss(# area_NAME VARCHAR2(25)
openGauss-# )tablespace EXAMPLE;
CREATE TABLE
```

Query the table definition:

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```
openGauss=# \d HR.areaS
              Table "hr.areas"
  Column   |         Type          | Modifiers
-----------+-----------------------+-----------
 area_id   | numeric               | not null
 area_name | character varying(25) |
```

Insert four lines of data into **HR.areaS**.

```
openGauss=# INSERT INTO HR.areaS (area_ID, area_NAME) VALUES (1, 'Europe');
INSERT 0 1
openGauss=# INSERT INTO HR.areaS (area_ID, area_NAME) VALUES (2, 'Americas');
INSERT 0 1
openGauss=# INSERT INTO HR.areaS (area_ID, area_NAME) VALUES (3, 'Asia');
INSERT 0 1
openGauss=# INSERT INTO HR.areaS (area_ID, area_NAME) VALUES (4, 'Middle East and Africa');
INSERT 0 1
```

Change the prompt.

```
openGauss=# \set PROMPT1 '%n@%m %~%R%#'
```

Query the table:

```
openGauss=#SELECT * FROM HR.areaS;
 area_id |       area_name
---------+------------------------
       1 | Europe
       4 | Middle East and Africa
       2 | Americas
       3 | Asia
(4 rows)
```

Use the **\pset** command to display the table in different ways:

```
openGauss=#\pset border 2
Border style is 2.
openGauss=#SELECT * FROM HR.areaS;
+---------+------------------------+
| area_id |       area_name        |
+---------+------------------------+
|       1 | Europe                 |
|       2 | Americas               |
|       3 | Asia                   |
|       4 | Middle East and Africa |
+---------+------------------------+
(4 rows)
openGauss=#\pset border 0
Border style is 0.
openGauss=#SELECT * FROM HR.areaS;
area_id       area_name
------- ----------------------
      1 Europe
      2 Americas
      3 Asia
      4 Middle East and Africa
(4 rows)
```

Use the meta-command:

```
openGauss=#\a \t \x
Output format is unaligned.
Showing only tuples.
Expanded display is on.
openGauss=#SELECT * FROM HR.areaS;
area_id|2
area_name|Americas

area_id|1
area_name|Europe
```

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```
area_id|4
area_name|Middle East and Africa

area_id|3
area_name|Asia
```

# 2.9.3 Obtaining Help Information

## Procedure

- When connecting to the database, run the following command to obtain the help information:
  ```
  gsql --help
  ```
  The following help information is displayed:
  ```
  ......
  Usage:
    gsql [OPTION]... [DBNAME [USERNAME]]

  General options:
    -c, --command=COMMAND    run only single command (SQL or internal) and exit
    -d, --dbname=DBNAME      database name to connect to (default: "omm")
    -f, --file=FILENAME      execute commands from file, then exit
  ......
  ```
- When connecting to the database, run the following command to obtain the help information:
  ```
  help
  ```
  The following help information is displayed:
  ```
  You are using gsql, the command-line interface to gaussdb.
  Type:  \copyright for distribution terms
         \h for help with SQL commands
         \? for help with gsql commands
         \g or terminate with semicolon to execute query
         \q to quit
  ```

## Examples

**Step 1** View the **gsql** help information. For details, see **Table 2-10**.

**Table 2-10 gsql** online help

| Description | Example |
| --- | --- |
| Query the copyright. | \copyright |

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| Description | Example |
| --- | --- |
| View help information about SQL statements supported by GaussDB. | View help information about SQL statements supported by GaussDB.<br>For example, view all SQL statements supported by GaussDB.<br>openGauss=# \h<br>Available help:<br>ABORT<br>ALTER AGGREGATE<br>ALTER APP WORKLOAD GROUP<br>... ...<br>For example, view parameters of the **CREATE DATABASE** command:<br>openGauss=# \help CREATE DATABASE<br>Command: CREATE DATABASE<br>Description: create a new database<br>Syntax:<br>CREATE DATABASE database_name<br>[ [ WITH ] {[ OWNER [=] user_name ]\|<br>[ TEMPLATE [=] template ]\|<br>[ ENCODING [=] encoding ]\|<br>[ LC_COLLATE [=] lc_collate ]\|<br>[ LC_CTYPE [=] lc_ctype ]\|<br>[ DBCOMPATIBILITY [=] compatibility_type ]\|<br>[ TABLESPACE [=] tablespace_name ]\|<br>[ CONNECTION LIMIT [=] connlimit ]}[...] ]; |
| View the help information about **gsql** commands. | For example, view commands supported by **gsql**.<br>openGauss=# \?<br>General<br>\copyright show openGauss usage and distribution terms<br>\g [FILE] or ; execute query (and send results to file or \|pipe)<br>\h(\help) [NAME] help on syntax of SQL commands, * for all commands<br>\q quit gsql<br>... ... |

**----End**

## 2.9.4 Command Reference

Table 2-11, Table 2-12, Table 2-13 and Table 2-14 list the **gsql** parameters.

**Table 2-11** Common parameters

| Parameter | Description | Value Range |
| --- | --- | --- |
| -c, --command=COMMAND | Specifies that **gsql** is to run a string command and then exit. | - |

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| Parameter | Description | Value Range |
| --- | --- | --- |
| -d, --dbname=DBNAME | Specifies the name of the database to connect to.<br>In addition, gsql allows you to use extended database names, that is, connection strings in the format of **'postgres[ql]://[user[:password]@][netloc][:port][, ...][/dbname][?param1=value1&...]'** or **'[key=value][...]'** as database names. gsql parses connection information from the connection strings and preferentially uses the information. | String |
| -f, --file=FILENAME | Specifies that files are used as the command source instead of interactively-entered commands. After the files are processed, **gsql** exits. If *FILENAME* is - (hyphen), then standard input is read. | An absolute path or relative path that meets the OS path naming convention |
| -l, --list | Lists all available databases and then exits. | - |
| -v, --set, --variable=NAME=VALUE | Sets **gsql** variable *NAME* to *VALUE*.<br>For details about variable examples and descriptions, see **Variables**. | - |
| -X, --no-gsqlrc | Does not read the startup file (neither the system-wide **gsqlrc** file nor the user's **~/.gsqlrc** file).<br>**NOTE**<br>The startup file is **~/.gsqlrc** by default or it can be specified by the environment variable *PSQLRC*. | - |
| -1 ("one"), --single-transaction | When **gsql** uses the **-f** parameter to execute a script, **START TRANSACTION**/**COMMIT** are added to the start and end of the script, respectively, so that the script is executed as one transaction. This ensures that the script is executed successfully. If the script cannot be executed, the script is invalid.<br>**NOTE**<br>If the script has used **START TRANSACTION**, **COMMIT**, or **ROLLBACK**, this parameter is invalid. | - |
| -?, --help | Displays help information about **gsql** command parameters, and exits. | - |
| -V, --version | Prints the **gsql** version information and exits. | - |

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**Table 2-12** Input and output parameters

| Parameter | Description | Value Range |
| --- | --- | --- |
| -a, --echo-all | Prints all input lines to standard output as they are read.<br>**CAUTION**<br>When this parameter is used in some SQL statements, the sensitive information, such as user password, may be disclosed. Use this parameter with caution. | - |
| -e, --echo-queries | Displays all SQL commands sent to the server to the standard output as well.<br>**CAUTION**<br>When this parameter is used in some SQL statements, the sensitive information, such as user password, may be disclosed. Use this parameter with caution. | - |
| -E, --echo-hidden | Echoes the actual queries generated by **\d** and other backslash commands. | - |
| -k, --with-key=KEY | Uses **gsql** to decrypt imported encrypted files.<br>**NOTICE**<br>• For key characters, such as the single quotation mark (') or double quotation mark (") in shell commands, Linux shell checks whether the input single quotation mark (') or double quotation mark (") matches. If no match is found, Linux shell does not enter the **gsql** program until input is complete.<br>• Stored procedures and functions cannot be decrypted and imported. | - |
| -L, --log-file=FILENAME | Writes normal output source and all query output into the **FILENAME** file.<br>**CAUTION**<br>• When this parameter is used in some SQL statements, the sensitive information, such as user password, may be disclosed. Use this parameter with caution.<br>• This parameter retains only the query result in the corresponding file, so that the result can be easily found and parsed by other invokers (for example, automatic O&M scripts). Logs about **gsql** operations are not retained. | An absolute path or relative path that meets the OS path naming convention |
| -m, --maintenance | Allows a cluster to be connected when a two-phase transaction is being restored.<br>**NOTE**<br>The parameter is for engineers only. When this parameter is used, **gsql** can be connected to the standby server to check data consistency between the primary and standby server. | - |

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| Parameter | Description | Value Range |
| --- | --- | --- |
| -n, --no-libedit | Closes command line editing. | - |
| -o, --output=FILENAME | Puts all query output into the **FILENAME** file. | An absolute path or relative path that meets the OS path naming convention |
| -q, --quiet | Indicates the quiet mode and no additional information will be printed. | By default, **gsql** displays various information. |
| -s, --single-step | Runs in single-step mode. It indicates that the user is prompted before each command is sent to the server. This option can be also used for canceling execution. Use this option to debug scripts.<br>**CAUTION**<br>When this parameter is used in some SQL statements, the sensitive information, such as user password, may be disclosed. Use this parameter with caution. | - |
| -S, --single-line | Runs in single-line mode where a line break terminates an SQL command, as a semicolon does. | - |
| -C, --enable-client-encryption | When **-C** is used to connect to a local or remote database, you can use this option to enable the encrypted database function. | - |

**Table 2-13** Output format parameters

| Parameter | Description | Value Range |
| --- | --- | --- |
| -A, --no-align | Switches to unaligned output mode. | The default output mode is aligned. |
| -F, --field-separator=STRING | Specifies the field separator. The default is the vertical bar (\|). | - |
| -H, --html | Turns on the HTML tabular output. | - |

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| Parameter | Description | Value Range |
| --- | --- | --- |
| -P, --pset=VAR[=ARG] | Specifies the print option in the **\pset** format in the command line.<br>**NOTE**<br>The equal sign (=), instead of the space, is used here to separate the name and value. For example, enter **-P format=latex** to set the output format to **LaTeX**. | - |
| -R, --record-separator=STRING | Sets the record separator. | - |
| -r | Enables the editing mode on the client. | This function is disabled by default. |
| -t, --tuples-only | Prints only tuples. | - |
| -T, --table-attr=TEXT | Specifies options to be placed within the HTML table tag.<br>Use this parameter with the **-H,--html** parameter to specify the output to the HTML format. | - |
| -x, --expanded | Turns on the expanded table formatting mode. | - |
| -z, --field-separator-zero | Sets the field separator in the unaligned output mode to be blank.<br>Use this parameter with the **-A, --no-align** parameter to switch to unaligned output mode. | - |
| -0, --record-separator-zero | Sets the record separator in the unaligned output mode to be blank.<br>Use this parameter with the **-A, --no-align** parameter to switch to unaligned output mode. | - |
| -2, --pipeline | Uses a pipe to transmit the password. This parameter cannot be used on devices and must be used together with the **-c** or **-f** parameter. | - |
| -g, | Prints all SQL statements from a file. | - |

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**Table 2-14** Connection parameters

| Parameter | Description | Value Range |
| --- | --- | --- |
| -h, --host=HOSTNAME | Specifies the host name of the machine on which the server is running or the directory for the Unix-domain socket. | If the host name is omitted, **gsql** connects to the server of the local host over the Unix domain socket or over TCP/IP to connect to local host without the Unix domain socket. |
| -p, --port=PORT | Specifies the port number of the database server.<br>You can modify the default port number using the **-p, --port=PORT** parameter. | The default value is **8000**. |
| -U, --username=USERNAME | Specifies the user that connects to the database.<br>**NOTE**<br>• If this parameter is specified, you also need to enter your password for identity authentication when connecting to the database. You can enter the password interactively or use the **-W** parameter to specify a password.<br>• To connect to a database, add an escape character before any dollar sign ($) in the username. | String. The default user is the current user that operates the system. |
| -W, --password=PASSWORD | Specifies a password when the **-U** parameter is used to connect to the local database or a remote database.<br>**NOTE**<br>• When you attempt to connect to the CN after you have logged in to the server where the CN resides, the trust connection is used by default, and this parameter does not need to be set.<br>• To connect to a database, add an escape character before any backslash (\) or back quote (`) in the password.<br>• If this parameter is not specified but database connection requires your password, you will be prompted to enter your password in interactive mode. The maximum length of the password is 999 bytes, which is restricted by the maximum value of the GUC parameter **password_max_length**. | String |

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# 2.9.5 Meta-Command Reference

This section describes meta-commands provided by **gsql** after the GaussDB database CLI tool is used to connect to a database. A **gsql** meta-command can be anything that you enter in **gsql** and begins with an unquoted backslash.

## Precautions

- The format of the **gsql** meta-command is a backslash (\) followed by a command verb, and then a parameter. The parameters are separated from the command verb and from each other by any number of whitespace characters.
- To include whitespace characters into an argument, you must quote them with a single straight quotation mark. To include a single straight quotation mark into such an argument, precede it by a backslash. Anything contained in single quotation marks is furthermore subject to C-like substitutions for \n (new line), \t (tab), \b (backspace), \r (carriage return), \f (form feed), \digits (octal), and \xdigits (hexadecimal).
- Within a parameter, text enclosed in double quotation marks ("") is taken as a command line input to the shell. The output of the command (with any trailing newline removed) is taken as the argument value.
- If an unquoted argument begins with a colon (:), the argument is taken as a **gsql** variable and the value of the variable is used as the argument value instead.
- Some commands take an SQL identifier (such as a table name) as a parameter. These parameters follow the SQL syntax rules: Unquoted letters are forced to lowercase, while double quotation marks ("") protect letters from case conversion and allow incorporation of whitespace into the identifier. Within double quotation marks, paired double quotation marks reduce to a single double quotation mark in the result name. For example, **FOO"BAR"BAZ** is interpreted as **fooBARbaz**, and **"Aweird""name"** becomes **A weird"name**.
- Parsing for arguments stops when another unquoted backslash is found. This is taken as the beginning of a new meta-command. The special sequence \\ (two backslashes) marks the end of parameters and continues parsing SQL statements if any. In this way, SQL and **gsql** commands can be freely mixed in a line. But in any case, the arguments of a meta-command cannot continue beyond the end of the line.

## Meta-command

For details about meta-commands, see **Table 2-15**, **Table 2-16**, **Table 2-17**, **Table 2-18**, **Table 2-20**, **Table 2-22**, **Table 2-23**, **Table 2-24** and **Table 2-26**.

**NOTICE**

*FILE* mentioned in the following commands indicates a file path. This path can be an absolute path such as **/home/gauss/file.txt** or a relative path, such as **file.txt**. By default, a **file.txt** is created in the path where the user runs **gsql** commands.

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**Table 2-15** Common meta-commands

| Parameter | Description | Value Range |
| --- | --- | --- |
| \copyright | Displays version and copyright information about GaussDB. | - |
| \g [FILE] or ; | Performs a query operation and sends the result to a file or pipe. | - |
| \h(\help) [NAME] | Provides syntax help on the specified SQL statement. | If the name is not specified, then **gsql** will list all the commands for which syntax help is available. If the name is an asterisk (*), syntax help on all SQL statements is displayed. |
| \parallel [on [num]\|off] | Controls the parallel execution function.<br>• **on**: The switch is enabled and the maximum number of concurrently executed tasks is **num**.<br>• **off**: This switch is disabled.<br>**NOTE**<br>• Parallel execution is not allowed in a running transaction and a transaction is not allowed to be started during parallel execution.<br>• Parallel execution of **\d** meta-commands is not allowed.<br>• If **SELECT** statements are run concurrently, customers can accept the problem that the return results are displayed randomly but they cannot accept it if a core dump or process response failure occurs.<br>• **SET** statements are not allowed in concurrent tasks because they may cause unexpected results.<br>• Temporary tables cannot be created in parallel. If temporary tables are required, create them before parallel execution is enabled, and use them only in the parallel execution. Temporary tables cannot be created in parallel execution.<br>• When **\parallel** is executed, *num* independent gsql processes can be connected to the database server.<br>• The total duration of all **\parallel** tasks cannot exceed **session_timeout**. Otherwise, the connection may fail during concurrent execution. | The default value of *num* is **1024**.<br>**NOTICE**<br>• The maximum number of connections allowed by the server is determined based on **max_connection** and the number of current connections.<br>• Set the value of *num* based on the allowed number of connections. |

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| Parameter | Description | Value Range |
| --- | --- | --- |
| \q | Exits the gsql program. This command is executed only when a script terminates in a script file. | - |

**Table 2-16** Query buffer meta-commands

| Parameter | Description |
| --- | --- |
| \e [FILE] [LINE] | Uses an external editor to edit the query buffer or file. |
| \ef [FUNCNAME [LINE]] | Edits the function definition using an external editor. If **LINE** is specified, the cursor will point to the specified line of the function body. |
| \p | Prints the current query buffer to the standard output. |
| \r | Resets or clears the query buffer. |
| \w FILE | Outputs the current query buffer to a file. |

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**Table 2-17** Input/Output commands

| Parameter | Description |
| --- | --- |
| \copy { table [ ( column_list ) ] \| ( query ) } { from \| to } { filename \| stdin \| stdout \| pstdin \| pstdout } [ with ] [ binary ] [ oids ] [ delimiter [ as ] 'character' ] [ null [ as ] 'string' ] [ csv [ header ] [ quote [ as ] 'character' ] [ escape [ as ] 'character' ] [ force quote column_list \| * ] [ force not null column_list ] ] [parallel integer] | After logging in to the database on any **gsql** client, you can import and export data. This is an operation of running the **SQL COPY** command, but not the server that reads or writes data to a specified file. Instead, data is transferred between the server and the local file system. In this way, local user permissions instead of server permissions are required for file access, and the user permissions do not need to be initialized.<br>**NOTE**<br>• **\COPY** is applicable only to small-batch data import in a good format. It does not preprocess invalid characters and does not have the error tolerance capability. GDS or **COPY** is preferred for data import.<br>• \COPY specifies the number of clients to import data to implement parallel import of data files. Currently, the value ranges from 1 to 8.<br>• The parallel import using \COPY has the following constraints:<br>Parallel import of temporary tables is not supported. Parallel import within transactions is not supported. Parallel import of binary files is not supported. Parallel import of data encrypted using AES-128 is not supported. The COPY option contains EOL. In these cases, even if the parallel parameter is specified, a non-parallel process is performed. |
| \echo [STRING] | Writes character strings to the standard output. |
| \i FILE | Reads content from *FILE* and uses them as the input for a query. |
| \i+ FILE KEY | Runs commands in an encrypted file. |
| \ir FILE | Similar to **\i**, but resolves relative path names differently. |
| \ir+ FILE KEY | Similar to **\i+**, but resolves relative path names differently. |
| \o [FILE] | Saves all query results to a file. |
| \qecho [STRING] | Writes character strings to the query output flow. |

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NOTE

In Table 2-18, **S** indicates that the system object is displayed, and **+** indicates that additional object descriptions are displayed. **PATTERN** specifies the name of an object to be displayed.

**Table 2-18** Information display meta-commands

| Parameter | Description | Value Range | Example |
| --- | --- | --- | --- |
| \d[S+] | Lists all tables, views, and sequences of all schemas in the search_path. When objects with the same name exist in different schemas in **search_path**, only the object in the schema that ranks first in **search_path** is displayed. | - | Lists all tables, views, and sequences of all schemas in the search_path.<br>`openGauss=# \d` |
| \d[S+] NAME | Lists the structure of specified tables, views, and indexes. | - | Lists the structure of table **a**.<br>`openGauss=# \dtable+ a` |
| \d+ [PATTERN] | Lists all tables, views, and indexes. | If **PATTERN** is specified, only tables, views, and indexes whose names match **PATTERN** are displayed. | Lists all tables, views, and indexes whose names start with **f**.<br>`openGauss=# \d+ f*` |
| \da[S] [PATTERN] | Lists all available aggregate functions, together with the data type they perform operations on and the return value types. | If **PATTERN** is specified, only aggregate functions whose names match **PATTERN** are displayed. | Lists all available aggregate functions whose names start with **f**, together with their return value types and the data types.<br>`openGauss=# \da f*` |
| \db[+] [PATTERN] | Lists all available tablespaces. | If **PATTERN** is specified, only tablespaces whose names match **PATTERN** are displayed. | Lists all available tablespaces whose names start with **p**.<br>`openGauss=# \db p*` |

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| Parameter | Description | Value Range | Example |
| --- | --- | --- | --- |
| \dc[S+] [PATTERN] | Lists all available conversions between character-set encodings. | If **PATTERN** is specified, only conversions whose names match **PATTERN** are displayed. | Lists all available conversions between character-set encodings.<br>openGauss=# \dc * |
| \dC[+] [PATTERN] | Lists all available type conversions.<br>PATTERN must be the actual type name and cannot be an alias. | If **PATTERN** is specified, only conversions whose names match **PATTERN** are displayed. | Lists all type conversions whose pattern names start with **c**.<br>openGauss=# \dC c* |
| \dd[S] [PATTERN] | Lists descriptions about objects matching **PATTERN**. | If **PATTERN** is not specified, all visible objects are displayed. The objects include aggregations, functions, operators, types, relations (tables, views, indexes, sequences, and large objects), and rules. | Lists all visible objects.<br>openGauss=# \dd |
| \ddp [PATTERN] | Lists all default permissions. | If **PATTERN** is specified, only permissions whose names match **PATTERN** are displayed. | Lists all default permissions.<br>openGauss=# \ddp |
| \dD[S+] [PATTERN] | Lists all available domains. | If **PATTERN** is specified, only domains whose names match **PATTERN** are displayed. | Lists all available domains.<br>openGauss=# \dD |
| \ded[+] [PATTERN] | Lists all Data Source objects. | If **PATTERN** is specified, only objects whose names match **PATTERN** are displayed. | Lists all Data Source objects.<br>openGauss=# \ded |

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| Parameter | Description | Value Range | Example |
| --- | --- | --- | --- |
| \det[+] [PATTERN] | Lists all external tables. | If **PATTERN** is specified, only tables whose names match **PATTERN** are displayed. | Lists all external tables.<br>openGauss=# \det |
| \des[+] [PATTERN] | Lists all external servers. | If **PATTERN** is specified, only servers whose names match **PATTERN** are displayed. | Lists all external servers.<br>openGauss=# \des |
| \deu[+] [PATTERN] | Lists all user mappings. | If **PATTERN** is specified, only information whose name matches **PATTERN** is displayed. | Lists all user mappings.<br>openGauss=# \deu |
| \dew[+] [PATTERN] | Lists all encapsulated external data. | If **PATTERN** is specified, only data whose name matches **PATTERN** is displayed. | Lists all encapsulated external data.<br>openGauss=# \dew |
| \df[antw][S+] [PATTERN] | Lists all available functions, together with their parameters and return types. **a** indicates an aggregate function, **n** indicates a common function, **t** indicates a trigger, and **w** indicates a window function. | If **PATTERN** is specified, only functions whose names match **PATTERN** are displayed. | Lists all available functions, together with their parameters and return types.<br>openGauss=# \df |
| \dF[+] [PATTERN] | Lists all text search configuration information. | If **PATTERN** is specified, only configurations whose names match **PATTERN** are displayed. | Lists all text search configuration information.<br>openGauss=# \dF+ |

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| Parameter | Description | Value Range | Example |
| --- | --- | --- | --- |
| \dFd[+] [PATTERN] | Lists all text search dictionaries. | If **PATTERN** is specified, only dictionaries whose names match **PATTERN** are displayed. | Lists all text search dictionaries.<br>openGauss=# \dFd |
| \dFp[+] [PATTERN] | Lists all text search analyzers. | If **PATTERN** is specified, only analyzers whose names match **PATTERN** are displayed. | Lists all text search analyzers.<br>openGauss=# \dFp |
| \dFt[+] [PATTERN] | Lists all text search templates. | If **PATTERN** is specified, only templates whose names match **PATTERN** are displayed. | Lists all text search templates.<br>openGauss=# \dFt |
| \dg[+] [PATTERN] | Lists all database roles.<br>**NOTE**<br>Since the concepts of "users" and "groups" have been unified into "roles", this command is now equivalent to **\du**. Both commands are retained to ensure compatibility with earlier versions. | If **PATTERN** is specified, only roles whose names match **PATTERN** are displayed. | Lists all database roles whose names start with **j** and end with **e**.<br>openGauss=# \dg j?e |
| \dl | This is an alias for **\lo_list**, which shows a list of large objects. | - | Lists all large objects.<br>openGauss=# \dl |
| \dL[S+] [PATTERN] | Lists all available program languages. | If **PATTERN** is specified, only languages whose names match **PATTERN** are displayed. | Lists all available program languages.<br>openGauss=# \dL |
| \dm[S+] [PATTERN] | Lists materialized views. | If **PATTERN** is specified, only materialized views whose names match **PATTERN** are displayed. | Lists materialized views.<br>openGauss=# \dm |

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| Parameter | Description | Value Range | Example |
| --- | --- | --- | --- |
| \dn[S+] [PATTERN] | Lists all schemas (namespace). If **+** is added to the command, the permission and description of each schema are listed. | If **PATTERN** is specified, only schemas whose names match the pattern are shown. By default, only schemas you created are displayed. | Lists information about all schemas whose names start with **d**.<br>openGauss=# \dn+ d* |
| \do[S] [PATTERN] | Lists available operators with their operand and return types. | If **PATTERN** is specified, only operators whose names match **PATTERN** are displayed. By default, only the operators created by the user are listed. | Lists available operators with their operand and return types.<br>openGauss=# \do |
| \dO[S+] [PATTERN] | Lists collation rules. | If **PATTERN** is specified, only rules whose names match **PATTERN** are displayed. By default, only user-created rules are shown. | Lists collation rules.<br>openGauss=# \dO |
| \dp [PATTERN] | Lists tables, views, and related permissions.<br>The following result about **\dp** is displayed:<br>rolename=xxxx/yyyy --Assigns permissions to a role.<br>=xxxx/yyyy --Assigns permissions to public.<br>*xxxx* indicates the assigned permissions, and *yyyy* indicates the roles with the assigned permissions. For details about permission descriptions, see **Table 2-19**. | If **PATTERN** is specified, only tables and views whose names match the pattern are shown. | Lists tables, views, and related permissions.<br>openGauss=# \dp |

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| Parameter | Description | Value Range | Example |
| --- | --- | --- | --- |
| \drds [PATTERN1 [PATTERN2]] | Lists all parameters that have been modified. These settings can be for roles, for databases, or for both. **PATTERN1** and **PATTERN2** indicate a role pattern and a database pattern, respectively. | If **PATTERN** is specified, only collations rules whose names match **PATTERN** are displayed. If the default value is used or ***** is specified, all settings are listed. | Lists all modified configuration parameters of the **postgres** database.<br>`openGauss=# \drds * postgres` |
| \dT[S+] [PATTERN] | Lists all data types. | If **PATTERN** is specified, only types whose names match **PATTERN** are displayed. | Lists all data types.<br>`openGauss=# \dT` |
| \du[+] [PATTERN] | Lists all database roles.<br>**NOTE**<br>Since the concepts of "users" and "groups" have been unified into "roles", this command is now equivalent to **\dg**. Both commands are retained to ensure compatibility with earlier versions. | If **PATTERN** is specified, only roles whose names match **PATTERN** are displayed. | Lists all database roles.<br>`openGauss=# \du` |
| \dE[S+] [PATTERN]<br>\di[S+] [PATTERN]<br>\ds[S+] [PATTERN]<br>\dt[S+] [PATTERN]<br>\dv[S+] [PATTERN] | In this group of commands, the letters E, i, s, t, and v stand for foreign table, index, sequence, table, and view, respectively. You can specify any or a combination of these letters sequenced in any order to obtain an object list. For example, **\dit** lists all indexes and tables. If + is added to the end of a command name, the physical size and related description of each object are also listed. | If **PATTERN** is specified, only objects whose names match **PATTERN** are displayed. By default, only objects you created are displayed. You can specify **PATTERN** or **S** to view other system objects. | Lists all indexes and views.<br>`openGauss=# \div` |

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| Parameter | Description | Value Range | Example |
| --- | --- | --- | --- |
| \dx[+] [PATTERN] | Lists installed extensions. | If **PATTERN** is specified, only extensions whose names match **PATTERN** are displayed. | Lists installed extensions.<br>openGauss=# \dx |
| \l[+] | Lists the names, owners, character set encodings, and permissions of all the databases in the server. | - | List the names, owners, character set encodings, and permissions of all the databases in the server.<br>openGauss=# \l |
| \sf[+] FUNCNAME | Displays the definition of a function.<br>**NOTE**<br>If the function name contains parentheses, enclose the function name with double quotation marks and add the parameter type list following the double quotation marks. Also enclose the list with parentheses. | - | Assume a function **function_a** and a function **func()name**. This parameter will be as follows:<br>openGauss=# \sf function_a<br>openGauss=# \sf "func()name"(argtype1, argtype2) |
| \z [PATTERN] | Lists all tables, views, and sequences in the database and their access permissions. | If a pattern is given, it is a regular expression, and only matched tables, views, and sequences are shown. | Lists all tables, views, and sequences in the database and their access permissions.<br>openGauss=# \z |

**Table 2-19** Description of permissions

| Parameter | Description |
| --- | --- |
| r | **SELECT**: allows users to read data from specified tables and views. |
| w | **UPDATE**: allows users to update columns for specified tables. |
| a | **INSERT**: allows users to insert data to specified tables. |
| d | **DELETE**: allows users to delete data from specified tables. |

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| Parameter | Description |
| --- | --- |
| D | **TRUNCATE**: allows users to delete all data from specified tables. |
| x | **REFERENCES**: allows users to create foreign key constraints. |
| t | **TRIGGER**: allows users to create a trigger on specified tables. |
| X | **EXECUTE**: allows users to use specified functions and the operators that are realized by the functions. |
| U | **USAGE**:<br>● For procedural languages, allows users to specify a procedural language when creating a function.<br>● For schemas, allows users to access objects included in specified schemas.<br>● For sequences, allows users to use the nextval function. |
| C | **CREATE**:<br>● For databases, allows new schemas to be created within the database.<br>● For schemas, allows users to create objects in a schema.<br>● For tablespaces, allows users to create tables in a tablespace and set the tablespace to default one when creating databases and schemas. |
| c | **CONNECT**: allows users to connect to specified databases. |
| T | **TEMPORARY**: allows users to create temporary tables. |
| A | **ALTER**: allows users to modify the attributes of a specified object. |
| P | **DROP**: allows users to delete specified objects. |
| m | **COMMENT**: allows users to define or modify comments of a specified object. |
| i | **INDEX**: allows users to create indexes on specified tables. |
| v | **VACUUM**: allows users to perform ANALYZE and VACUUM operations on specified tables. |
| * | Authorization options for preceding permissions. |

**Table 2-20** Formatting meta-commands

| Parameter | Description |
| --- | --- |
| \a | Switches between aligned and unaligned table output formats. |

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| Parameter | Description |
| --- | --- |
| \C [STRING] | Sets the title of any table being printed as the result of a query or unsets any such title. |
| \f [STRING] | Sets the field separator for unaligned query outputs. |
| \H | • If the text format schema is used, switches to the HTML format.<br>• If the HTML format schema is used, switches to the text format. |
| \pset NAME [VALUE] | Sets options affecting the output of query result tables. For details about the value of **NAME**, see **Table 2-21**. |
| \t [on\|off] | Switches the display of output name information and row count footer. |
| \T [STRING] | Specifies attributes to be placed within the table tag in HTML output format. If this parameter is empty, no attribute is specified. |
| \x [on\|off\|auto] | Switches expanded table formatting mode. |

**Table 2-21** Adjustable printing options

| Option | Description | Value Range |
| --- | --- | --- |
| border | The value must be a number. In general, the larger the number, the more borders and lines the tables will have, but this depends on the particular format. | • The value is an integer greater than 0 in HTML format.<br>• The value range in other formats is as follows:<br>– 0: no border<br>– 1: internal dividing line<br>– 2: table frame |

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| Option | Description | Value Range |
| --- | --- | --- |
| expanded (or x) | Switches between regular and expanded formats. | • When the expanded format is enabled, query results are displayed in two columns, with the column name on the left and the data on the right. This mode is useful if the data does not fit on the screen in the normal "horizontal" mode.<br>• Use the expanded format when the query output format is wider than the screen in regular format. The regular format is effective only in the aligned and wrapped formats. |
| fieldsep | Specifies the field separator to be used in unaligned output mode. In this way, you can create tab- or comma-separated output required by other programs. To set a tab as field separator, type **\pset fieldsep '\t'**. The default field separator is a vertical bar ('\|'). | - |
| fieldsep_zero | Sets the field separator to use in unaligned output format to a zero byte. | - |
| footer | Switches the display of the default footer. | - |

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| Option | Description | Value Range |
| --- | --- | --- |
| format | Selects the output format. Unique abbreviations are allowed (this indicates that one letter is enough). | Value range:<br>• **unaligned**: Write all columns of a row on one line, separated by the currently active column separator.<br>• **aligned**: This format is standard and human-readable.<br>• **wrapped**: This format is similar to **aligned**, but includes the packaging cross-line width data value to suit the width of the target field output.<br>• **html**: This format outputs tables to the markup language for a document. The output is not a complete document.<br>• **latex**: This format outputs tables to the markup language for a document. The output is not a complete document.<br>• **troff-ms:** This format outputs tables to the markup language for a document. The output is not a complete document. |
| null | Sets a character string to be printed in place of a null value. | The default is to print nothing, which can be easily mistaken for an empty string. |
| numericlocale | Switches the display of a locale-aware character to separate groups of digits to the left of the decimal marker. | • **on**: The specified separator is displayed.<br>• **off**: The specified separator is not displayed<br>If this parameter is ignored, the default separator is displayed. |

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| Option | Description | Value Range |
| --- | --- | --- |
| pager | Controls the use of a pager for query and **gsql** help outputs. If the **PAGER** environment variable is set, the output is redirected to the specified program. Otherwise, the platform-dependent default value is used. | • **on**: The pager is used for terminal output that does not fit the screen.<br>• **off**: The pager is not used.<br>• **always**: The pager is used for all terminal output regardless of whether it fits the screen. |
| recordsep | Specifies the record separator to use in unaligned output mode. | - |
| recordsep_zero | Sets the record separator to use in unaligned output format to a zero byte. | - |
| tableattr (or T) | Specifies attributes to be placed inside the HTML table tag in HTML output format (such as cellpadding or bgcolor). Note that you do not need to specify **border** here because it has been used by **\pset border**. If no value is given, the table attributes do not need to be set. | - |
| title | Sets the table title for any subsequently printed tables. This can be used to give your output descriptive tags. If no value is given, the title does not need to be set. | - |
| tuples_only (or t) | Enables or disables the tuples-only mode. Full display may show extra information, such as column headers, titles, and various footers. In tuples_only mode, only the table data is displayed. | - |
| feedback | Specifies whether to output the number of result lines. | - |

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**Table 2-22** Connection meta-commands

| Parameter | Description | Value Range |
| --- | --- | --- |
| \c[onnect] [DBNAME\|- USER\|- HOST\|- PORT\|-] | Connects to a new database. (The current database is postgres.) If a database name contains more than 63 bytes, only the first 63 bytes are valid and are used for connection. However, the database name displayed in the command line of **gsql** is still the name before the truncation.<br>**NOTE**<br>If the database login user is changed during reconnection, you need to enter the password of the new user. The maximum length of the password is 999 bytes, which is restricted by the maximum value of the GUC parameter **password_max_length**. | - |
| \encoding [ENCODING] | Sets the client character set encoding. | Without an argument, this command shows the current encoding. |
| \conninfo | Prints information about the current connected database. | - |

**Table 2-23** OS meta-commands

| Parameter | Description | Value Range |
| --- | --- | --- |
| \cd [DIR] | Changes the current working directory. | An absolute path or relative path that meets the OS path naming convention |
| \setenv NAME [VALUE] | Sets the **NAME** environment variable to **VALUE**. If **VALUE** is not provided, do not set the environment variable. | - |
| \timing [on\|off] | Displays how long each SQL statement takes, in milliseconds. | • **on**: specifies that the display is enabled.<br>• **off**: indicates that the display is disabled. |
| \! [COMMAND] | Escapes to a separate Unix shell or runs a Unix command. | - |

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**Table 2-24** Variable meta-commands

| Parameter | Description |
| --- | --- |
| \prompt [TEXT] NAME | Prompts the user to use texts to specify a variable name. |
| \set [NAME [VALUE]] | Sets the *NAME* internal variable to **VALUE**. If more than one value is provided, *NAME* is set to the concatenation of all of them. If no second argument is given, the variable is just set with no value.<br>Some common variables are processed differently in **gsql** and they are combinations of uppercase letters, numbers and underscores. **Table 2-25** describes a list of variables that are processed in a way different from other variables. |
| \unset NAME | Deletes the variable name of **gsql**. |

**Table 2-25** Common **\set** commands

| Command | Command Description | Value Range |
| --- | --- | --- |
| \set VERBOSITY value | This variable can be set to **default**, **verbose**, or **terse** to control redundant lines of error reports. | Value range: **default**, **verbose**, **terse** |
| \set ON_ERROR_STOP value | If this variable is set, the script execution stops immediately. If this script is invoked from another script, that script will be stopped immediately as well. If the primary script is invoked using the **-f** option rather than from one **gsql** session, **gsql** will return error code **3**, indicating the difference between the current error and critical errors. (The error code for critical errors is **1**.) | Value range: **on/off**, **true/false**, **yes/no**, and **1/0** |

**Table 2-26** Large object meta-commands

| Parameter | Description |
| --- | --- |
| \lo_list | Shows a list of all GaussDB large objects stored in the database, along with the comments provided for them. |

## PATTERN

The various **\d** commands accept a **PATTERN** parameter to specify the object name to be displayed. In the simplest case, PATTERN is the exact name of the object. Characters in **PATTERN** are usually converted to lowercase (as in SQL

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names), for example, **\dt FOO** will display a table named **foo**. As in SQL names, placing double quotation marks (") around a pattern prevents them being folded to lower case. If you need to include a double quotation mark (") in a pattern, write it as a pair of double quotation marks ("") within a double-quote sequence, which is in accordance with the rules for SQL quoted identifiers. For example, **\dt "FOO""BAR"** will be displayed as a table named **FOO"BAR** instead of **foo"bar**. You cannot put double quotation marks around just part of a pattern, which is different from the normal rules for SQL names. For example, **\dt FOO"FOO"BAR** will be displayed as a table named **fooFOObar** if just part of a pattern is quoted.

Whenever the **PATTERN** parameter is omitted completely, the **\d** commands display all objects that are visible in the current schema search path, which is equivalent to using an asterisk (*) as the pattern. An object is regarded to be visible if it can be referenced by name without explicit schema qualification. To see all objects in the database regardless of their visibility, use a dot within double quotation marks (*.*) as the pattern.

Within a pattern, the asterisk (*) matches any sequence of characters (including no characters) and a question mark (?) matches any single character. This notation is comparable to Unix shell file name patterns. For example, **\dt int*** displays tables whose names start with **int**. But within double quotation marks, the asterisk (*) and the question mark (?) lose these special meanings and are just matched literally.

A pattern that contains a dot (.) is interpreted as a schema name pattern followed by an object name pattern. For example, **\dt foo*.*bar*** displays all tables (whose names include **bar**) in schemas starting with **foo**. If no dot appears, then the pattern matches only visible objects in the current schema search path. Likewise, the dot within double quotation marks loses its special meaning and becomes an ordinary character.

Senior users can use regular-expression notations, such as character classes. For example [0-9] can be used to match any digit. All regular-expression special characters work as specified in POSIX. The following characters are excluded:

- A dot (.) is used as a separator.
- An asterisk (*) is translated into an asterisk prefixed with a dot (.*), which is a regular-expression marking.
- A question mark (?) is translated into a dot (.).
- A dollar sign ($) is matched literally.

You can write ?, (*R*+|), (*R*|), and *R* to the following pattern characters: ., *R**, and *R*?. The dollar sign ($) does not need to be used as a regular expression character because **PATTERN** must match the entire name instead of being interpreted as a regular expression (in other words, $ is automatically appended to **PATTERN**). If you do not expect a pattern to be anchored, write an asterisk (*) at its beginning or end. All regular-expression special characters within double quotation marks lose their special meanings and are matched literally. Regular-expression special characters in operator name patterns (such as the **\do** parameter) are also matched literally.

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# 2.9.6 Troubleshooting

## Low Connection Performance

- **log_hostname** is enabled, but DNS is incorrect.

  Connect to the database, and run **show log_hostname** to check whether **log_hostname** is enabled in the database.

  If it is enabled, the database kernel will use DNS to check the name of the host where the client is deployed. If the database of the host where the CN resides is configured with an incorrect or unreachable DNS server, the database connection will take a long time to set up.

- The database kernel slowly runs the initialization statement.

  Problems are difficult to locate in this scenario. Try using the **strace** Linux trace command.

  ```
  strace gsql -U MyUserName -d postgres -h 127.0.0.1 -p 23508 -r -c '\q'
  Password for MyUserName:
  ```

  The database connection process will be printed on the screen. If the following statement takes a long time to run:

  ```
  sendto(3, "Q\0\0\0\25SELECT VERSION()\0", 22, MSG_NOSIGNAL, NULL, 0) = 22
  poll([{fd=3, events=POLLIN|POLLERR}], 1, -1) = 1 ([{fd=3, revents=POLLIN}])
  ```

  It indicates that the **SELECT VERSION()** statement was run slowly.

  After the database is connected, you can run the **explain performance select version()** statement to find the reason why the initialization statement was run slowly.

  An uncommon scenario is that the disk of the machine where the database CN resides is full or faulty, affecting queries and leading to user authentication failures. As a result, the connection process is suspended. To solve this problem, contact customer service to clear the data disk of the database CN.

- TCP connection is set up slowly.

  Adapt the steps of troubleshooting slow initialization statement execution. Use **strace**. If the following statement is run slowly:

  ```
  connect(3, {sa_family=AF_FILE, path="/home/test/tmp/gaussdb_llt1/.s.PGSQL.61052"}, 110) = 0
  ```

  Or,

  ```
  connect(3, {sa_family=AF_INET, sin_port=htons(61052), sin_addr=inet_addr("127.0.0.1")}, 16) = -1
  EINPROGRESS (Operation now in progress)
  ```

  It indicates that the physical connection between the client and the database is set up slowly. In this case, check whether the network is unstable or has high throughput.

## Problems in Setting Up Connections

- gsql: could not connect to server: No route to host

  This problem occurs generally because an unreachable IP address or port number was specified. Check whether the values of **-h** and **-p** parameters are correct.

- gsql: FATAL: Invalid username/password,login denied.

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This problem occurs generally because an incorrect username or password was entered. Contact the database administrator to check whether the username and password are correct.

- The "libpq.so" loaded mismatch the version of gsql, please check it.

  This problem occurs because the version of **libpq.so** used in the environment does not match that of **gsql**. Run the **ldd gsql** command to check the version of the loaded **libpq.so**, and then load correct **libpq.so** by modifying the environment variable **LD_LIBRARY_PATH**.

- gsql: symbol lookup error: xxx/gsql: undefined symbol: libpqVersionString

  This problem occurs because the version of **libpq.so** used in the environment does not match that of **gsql** (or the PostgreSQL **libpq.so** exists in the environment). Run the **ldd gsql** command to check the version of the loaded **libpq.so**, and then load correct **libpq.so** by modifying the environment variable **LD_LIBRARY_PATH**.

- gsql: connect to server failed: Connection timed out

  Is the server running on host "xx.xxx.xxx.xxx" and accepting TCP/IP connections on port xxxx?

  This problem is caused by network connection faults. Check the network connection between the client and the database server. If you cannot ping from the client to the database server, the network connection is abnormal. Contact network management personnel for troubleshooting.

  ```
  ping -c 4 10.10.10.1
  PING 10.10.10.1 (10.10.10.1) 56(84) bytes of data.
  From 10.10.10.1: icmp_seq=2 Destination Host Unreachable
  From 10.10.10.1 icmp_seq=2 Destination Host Unreachable
  From 10.10.10.1 icmp_seq=3 Destination Host Unreachable
  From 10.10.10.1 icmp_seq=4 Destination Host Unreachable
  --- 10.10.10.1 ping statistics ---
  4 packets transmitted, 0 received, +4 errors, 100% packet loss, time 2999ms
  ```

- gsql: FATAL: permission denied for database "postgres"

  DETAIL: User does not have CONNECT privilege.

  This problem occurs because the user does not have the permission to access the database. To solve this problem, perform the following steps:

  a. Connect to the database as the database administrator.
  b. Grant the user with the permission to access the database.

     GRANT CONNECT ON DATABASE postgres TO user1;

     **NOTE**

     Actually, some common misoperations may also cause a database connection failure, for example, entering an incorrect database name, username, or password. In this case, the client tool will display the corresponding error messages.

- gsql: FATAL: sorry, too many clients already, active/non-active: 197/3.

  This problem occurs because the number of system connections exceeds the allowed maximum. Contact the DBA database administrator to release unnecessary sessions.

  You can check the number of connections as described in **Table 2-27**.

  You can view the session status in the **PG_STAT_ACTIVITY** view. To release unnecessary sessions, use the **pg_terminate_backend** function.

  ```
  select datid,pid,state from pg_stat_activity;
  ```

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```
 datid |       pid       | state
-------+-----------------+--------
 13205 | 139834762094352 | active
 13205 | 139834759993104 | idle
(2 rows)
```

The value of **pid** is the thread ID of the session. Terminate the session using its thread ID.

```
SELECT PG_TERMINATE_BACKEND(139834759993104);
```

If a command output similar to the following is displayed, the session is successfully terminated.

```
PG_TERMINATE_BACKEND
----------------------
 t
(1 row)
```

**Table 2-27** Viewing the number of session connections

| Description | Command |
| --- | --- |
| View the maximum number of sessions connected to a specific user. | Run the following command to view the upper limit of the number of **USER1**'s session connections. **-1** indicates that no upper limit is set for the number of **USER1**'s session connections.<br>`SELECT ROLNAME,ROLCONNLIMIT FROM PG_ROLES WHERE ROLNAME='user1';`<br>`rolname \| rolconnlimit`<br>`---------+--------------`<br>`user1 \| -1`<br>`(1 row)` |
| View the number of session connections that have been used by a specified user. | Run the following command to view the number of session connections that have been used by **USER1**. **1** indicates the number of session connections that have been used by **USER1**.<br>`SELECT COUNT(*) FROM dv_sessions WHERE USERNAME='user1';`<br>`count`<br>`-------`<br>`1`<br>`(1 row)` |
| View the maximum number of sessions connected to a specific database. | Run the following command to view the upper limit of the number of **postgres**'s session connections. **-1** indicates that no upper limit is set for the number of **postgres**'s session connections.<br>`SELECT DATNAME,DATCONNLIMIT FROM PG_DATABASE WHERE DATNAME='postgres';`<br>`datname \| datconnlimit`<br>`----------+--------------`<br>`postgres \| -1`<br>`(1 row)` |

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| Description | Command |
| --- | --- |
| View the number of session connections that have been used by a specific database. | Run the following command to view the number of session connections that have been used by **postgres**. **1** indicates the number of session connections that have been used by **postgres**.<br>SELECT COUNT(*) FROM PG_STAT_ACTIVITY WHERE DATNAME='postgres';<br> count<br>-------<br> 1<br>(1 row) |
| View the number of session connections that have been used by all users. | Run the following command to view the number of session connections that have been used by all users:<br>SELECT COUNT(*) FROM dv_sessions;<br><br> count<br>-------<br> 10<br>(1 row) |

- gsql: wait xxx.xxx.xxx.xxx:xxxx timeout expired

  When **gsql** initiates a connection request to the database, a 5-minute timeout period is used. If the database cannot correctly authenticate the client request and client identity within this period, **gsql** will exit the connection process for the current session, and will report the above error.

  Generally, this problem is caused by the incorrect host and port (that is, the *xxx* part in the error information) specified by the **-h** and **-p** parameters. As a result, the communication fails. Occasionally, this problem is caused by network faults. To resolve this problem, check whether the host name and port number of the database are correct.

## Other Faults

- There is a core dump or abnormal exit due to the bus error.

  Generally, this problem is caused by changes in loading the shared dynamic library (.so file in Linux) during process running. Alternatively, if the process binary file changes, the execution code for the OS to load machines or the entry for loading a dependent library will change accordingly. In this case, the OS kills the process for protection purposes, generating a core dump file.

  To resolve this problem, try again. In addition, do not run service programs in a cluster during O&M operations, such as an upgrade, preventing such a problem caused by file replacement during the upgrade.

  **NOTE**

  A possible stack of the core dump file contains dl_main and its function calling. The file is used by the OS to initialize a process and load the shared dynamic library. If the process has been initialized but the shared dynamic library has not been loaded, the process cannot be considered completely started.

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# 3 Development and Design Proposal

## 3.1 Overview

This chapter describes the design specifications for database modeling and application development. Modeling compliant with these specifications fits the distributed processing architecture of GaussDB and provides efficient SQL code.

The meaning of "Proposal" and "Notice" in this chapter is as follows:

- **Proposal**: Design rules. Services compliant with the rules can run efficiently, and those violating the rules may have low performance or logic errors.
- **Notice**: Details requiring attention during service development. This term identifies SQL behavior that complies with SQL standards but users may have misconceptions about, and default behavior that users may be unaware of in a program.

## 3.2 Database Object Naming Conventions

The name of a database object must meet the following requirements: The name of a non-time series table ranges from 1 to 63 bytes and that of a time series table ranges from 1 to 53 characters. The name must start with a letter or underscore (_), and can contain letters, digits, underscores (_), dollar signs ($), and number signs (#).

- [Proposal] Do not use reserved or non-reserved keywords to name database objects.

  NOTE

  To query the keywords of GaussDB, run **select * from pg_get_keywords()** or refer to **12.2 Keywords**.

- [Proposal] Do not use a string enclosed in double quotation marks ("") to define the database object name, unless you need to specify its capitalization. Case sensitivity of database object names makes problem location difficult.
- [Proposal] Use the same naming format for database objects.
  - In a system undergoing incremental development or service migration, you are advised to comply with its historical naming conventions.

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  - You are advised to use multiple words separated with underscores (_).
  - You are advised to use intelligible names and common acronyms or abbreviations for database objects. Acronyms or abbreviations that are generally understood are recommended. For example, you can use English words or Chinese pinyin indicating actual business terms. The naming format should be consistent within a cluster.
  - A variable name must be descriptive and meaningful. It must have a prefix indicating its type.
- [Proposal] The name of a table object should indicate its main characteristics, for example, whether it is an ordinary, temporary, or unlogged table.
  - An ordinary table name should indicate the business relevant to a dataset.
  - Temporary tables are named in the format of **tmp**_*Suffix*.
  - Unlogged tables are named in the format of **ul**_*Suffix*.
  - Foreign tables are named in the format of **f**_*Suffix*.
  - Do not create database objects whose names start with **redis**_.
  - Do not create database objects whose names start with **mlog**_ or **matviewmap**_.
- [Proposal] The name of a non-time series table object shall not exceed 63 bytes. If the length of a table name exceeds this value, the kernel truncates the table name. As a result, the actual name is inconsistent with the configured value. In addition, characters may be truncated in different character sets and unexpected characters may appear.

# 3.3 Database Object Design

## 3.3.1 Database and Schema Design

In GaussDB, services can be isolated by databases and schemas. Databases share little resources and cannot directly access each other. Connections to and permissions on them are also isolated. Schemas share more resources than databases do. User permissions on schemas and subordinate objects can be controlled using the **GRANT** and **REVOKE** syntax.

- You are advised to use schemas to isolate services for convenience and resource sharing.
- It is recommended that system administrators create schemas and databases and then assign required permissions to users.

### Database Design

- [Rule] Create databases as required by your business. Do not use the default **postgres** database of a cluster.
- [Proposal] Create up to three customized databases in a cluster.
- [Proposal] To make your database compatible with most characters, you are advised to use the UTF-8 encoding when creating a database.
- [Notice] When you create a database, exercise caution when you set **ENCODING** and **DBCOMPATIBILITY** configuration items. GaussDB supports

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the Teradata, Oracle, MySQL, and PostgreSQL compatibility modes which are partially compatible with the Teradata syntax, Oracle syntax, MySQL syntax, and PostgreSQL syntax, respectively. The syntax behavior varies according to the compatibility mode. By default, the MySQL compatibility mode is used.

- [Notice] By default, a database owner has all permissions for all objects in the database, including the deletion permission. Exercise caution when using the deletion permission.

### Schema Design

- [Notice] To let a user access an object in a schema, assign the usage permission and the permissions for the object to the user, unless the user has the **sysadmin** permission or is the schema owner.
- [Notice] To let a user create an object in the schema, grant the create permission for the schema to the user.
- [Notice] By default, a schema owner has all permissions for all objects in the schema, including the deletion permission. Exercise caution when using the deletion permission.

## 3.3.2 Table Design

GaussDB uses a distributed architecture. Data is distributed on DNs. Generally, well-designed table must comply with the following rules:

- [Notice] Evenly distribute data on each DN to prevent data skew. If most data is stored on several DNs, the effective capacity of a cluster decreases. Select a proper distribution key to avoid data skew.
- [Notice] Evenly scan each DN when querying tables. Otherwise, DNs most frequently scanned will become the performance bottleneck. For example, when you use equivalent filter conditions on a fact table, the nodes are not evenly scanned.
- [Notice] Reduce the amount of data to be scanned. You can use the pruning mechanism of a partitioned table.
- [Notice] Minimize random I/O. By clustering or local clustering, you can sequentially store hot data, converting random I/O to sequential I/O to reduce the cost of I/O scanning.
- [Notice] Try to avoid data shuffling. To shuffle data is to physically transfer it from one node to another. This unnecessarily occupies many network resources. To reduce network pressure, locally process data, and to improve cluster performance and concurrency, you can minimize data shuffling by using proper association and grouping conditions.

### Selecting a Storage Model

[Proposal] Selecting a storage model is the first step in defining a table. The storage model mainly depends on the customer's service type. For details, see **Table 3-1**.

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**Table 3-1** Table storage models and scenarios

| Storage Model | Application Scenario |
| --- | --- |
| Row storage | • Point queries (simple index-based queries that only return a few records)<br>• Scenarios requiring frequent addition, deletion, and modification |
| Column storage | • Statistical analysis queries (requiring a large number of association and grouping operations)<br>• Ad hoc queries (using uncertain query conditions and unable to utilize indexes to scan row-store tables) |

## Selecting a Distribution Mode

[Proposal] Comply with the following rules to distribute table data.

**Table 3-2** Table distribution modes and scenarios

| Distribution Mode | Description | Application Scenario |
| --- | --- | --- |
| Hash | Table data is distributed on all DNs in a cluster by hash. | Fact tables containing a large amount of data |
| Replication | Full data in a table is stored on every DN in the cluster. | Dimension tables and fact tables containing a small amount of data |
| Range | Table data is mapped to specified columns based on the range and distributed to the corresponding DNs. | Users need to customize distribution rules. |
| List | Table data is mapped to specified columns based on specific values and distributed to corresponding DNs. | Users need to customize distribution rules. |

NOTE

- When hash, range, or list distribution is specified, the primary key and unique index to be created must contain distribution columns.
- When hash, range, or list distribution is specified for a referenced table, the foreign key of the referencing table must contain distribution columns.

The example of defining a distribution table is as follows:

```
-- Define a table with each row stored in all DNs.
CREATE TABLE warehouse_d1
```

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```
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
)DISTRIBUTE BY REPLICATION;

-- Define a hash table.
CREATE TABLE warehouse_d2
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2),
    CONSTRAINT W_CONSTR_KEY3 UNIQUE(W_WAREHOUSE_SK)
)DISTRIBUTE BY HASH(W_WAREHOUSE_SK);

-- Define a table using RANGE distribution.
CREATE TABLE warehouse_d3
(
W_WAREHOUSE_SK            INTEGER               NOT NULL,
W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
W_WAREHOUSE_NAME          VARCHAR(20)                   ,
W_WAREHOUSE_SQ_FT         INTEGER                       ,
W_STREET_NUMBER           CHAR(10)                      ,
W_STREET_NAME             VARCHAR(60)                   ,
W_STREET_TYPE             CHAR(15)                      ,
W_SUITE_NUMBER            CHAR(10)                      ,
W_CITY                    VARCHAR(60)                   ,
W_COUNTY                  VARCHAR(30)                   ,
W_STATE                   CHAR(2)                       ,
W_ZIP                     CHAR(10)                      ,
W_COUNTRY                 VARCHAR(20)                   ,
W_GMT_OFFSET              DECIMAL(5,2)
)DISTRIBUTE BY RANGE(W_WAREHOUSE_ID)
(
  SLICE s1 VALUES LESS THAN (10) DATANODE dn1,
  SLICE s2 VALUES LESS THAN (20) DATANODE dn2,
  SLICE s3 VALUES LESS THAN (30) DATANODE dn3,
  SLICE s4 VALUES LESS THAN (MAXVALUE) DATANODE dn4
);

-- Define a table using LIST distribution.
CREATE TABLE warehouse_d4
(
W_WAREHOUSE_SK            INTEGER               NOT NULL,
W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
W_WAREHOUSE_NAME          VARCHAR(20)                   ,
W_WAREHOUSE_SQ_FT         INTEGER                       ,
```

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```
W_STREET_NUMBER          CHAR(10)                  ,
W_STREET_NAME            VARCHAR(60)               ,
W_STREET_TYPE            CHAR(15)                  ,
W_SUITE_NUMBER           CHAR(10)                  ,
W_CITY                   VARCHAR(60)               ,
W_COUNTY                 VARCHAR(30)               ,
W_STATE                  CHAR(2)                   ,
W_ZIP                    CHAR(10)                  ,
W_COUNTRY                VARCHAR(20)               ,
W_GMT_OFFSET             DECIMAL(5,2)
)DISTRIBUTE BY LIST(W_COUNTRY)
(
   SLICE s1 VALUES ('USA') DATANODE dn1,
   SLICE s2 VALUES ('CANADA') DATANODE dn2,
   SLICE s3 VALUES ('UK') DATANODE dn3,
   SLICE s4 VALUES (DEFAULT) DATANODE dn4
);
```

For details about the table distribution syntax, see **12.14.80 CREATE TABLE**.

## Selecting a Distribution Key

A distribution key is important for a distribution table. An improper distribution key may cause data skew. As a result, the I/O load is heavy on several DNs, affecting the overall query performance. Therefore, after determining the distribution policy of a distribution table, you need to check the table data skew to ensure that data is evenly distributed. Comply with the following rules to select a distribution key:

- [Proposal] Select a column containing discrete data as the distribution key, so that data can be evenly distributed on each DN. If the data in a single column is not discrete enough, consider using multiple columns as distribution keys. You can select the primary key of a table as the distribution key. For example, in an employee information table, select the certificate number column as the distribution key.
- [Proposal] If the first rule is met, do not select a column having constant filter conditions as the distribution key. For example, in a query on the **dwcjk** table, if the **zqdh** column contains the constant filter condition **zqdh='000001'**, avoid selecting the **zqdh** column as the distribution key.
- [Proposal] If the first and second rules are met, select the join conditions in a query as distribution keys. If a join condition is used as a distribution key, the data involved in a join task is locally distributed on DNs, which greatly reduces the data flow cost among DNs.

## Selecting a Partitioning Mode

Comply with the following rules to partition a table containing a large amount of data:

- [Proposal] Create partitions on columns that indicate certain ranges, such as dates and regions.
- [Proposal] A partition name should show the data characteristics of a partition. For example, its format can be *Keyword+Range* characteristics.
- [Proposal] Set the upper limit of a partition to **MAXVALUE** to prevent data overflow.

The example of a partitioned table definition is as follows:

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```
CREATE TABLE staffS_p1
(
  staff_ID       NUMBER(6) not null,
  FIRST_NAME     VARCHAR2(20),
  LAST_NAME      VARCHAR2(25),
  EMAIL          VARCHAR2(25),
  PHONE_NUMBER   VARCHAR2(20),
  HIRE_DATE      DATE,
  employment_ID  VARCHAR2(10),
  SALARY         NUMBER(8,2),
  COMMISSION_PCT NUMBER(4,2),
  MANAGER_ID     NUMBER(6),
  section_ID     NUMBER(4)
)
PARTITION BY RANGE (HIRE_DATE)
(
   PARTITION HIRE_19950501 VALUES LESS THAN ('1995-05-01 00:00:00'),
   PARTITION HIRE_19950502 VALUES LESS THAN ('1995-05-02 00:00:00'),
   PARTITION HIRE_maxvalue VALUES LESS THAN (MAXVALUE)
);
```

## 3.3.3 Column Design

### Selecting a Data Type

Comply with the following rules to improve query efficiency when you design columns:

- [Proposal] Use the most efficient data types allowed.

  If all of the following number types provide the required service precision, they are recommended in descending order of priority: integer, floating point, and numeric.
- [Proposal] In tables that are logically related, columns having the same meaning should use the same data type.
- [Proposal] For string data, you are advised to use variable-length strings and specify the maximum length. To avoid truncation, ensure that the specified maximum length is greater than the maximum number of characters to be stored. You are not advised to use CHAR(n), BPCHAR(n), NCHAR(n), or CHARACTER(n), unless you know that the string length is fixed.

  For details about string types, see **Common String Types**.

### Common String Types

Every column requires a data type suitable for its data characteristics. The following table lists common string types in GaussDB.

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**Table 3-3** Common string types

| String Type | Description | Max. Storage Capacity |
| --- | --- | --- |
| CHAR(n) | Fixed-length string, where *n* indicates the stored bytes. If the length of an input string is smaller than *n*, the string is automatically padded to *n* bytes using NULL characters. | 10 MB |
| CHARACTER(n) | Fixed-length string, where *n* indicates the stored bytes. If the length of an input string is smaller than *n*, the string is automatically padded to *n* bytes using NULL characters. | 10 MB |
| NCHAR(n) | Fixed-length string, where *n* indicates the stored bytes. If the length of an input string is smaller than *n*, the string is automatically padded to *n* bytes using NULL characters. | 10 MB |
| BPCHAR(n) | Fixed-length string, where *n* indicates the stored bytes. If the length of an input string is smaller than *n*, the string is automatically padded to *n* bytes using NULL characters. | 10 MB |
| VARCHAR(n) | Variable-length string, where *n* indicates the maximum number of bytes that can be stored. | 10 MB |
| CHARACTER VARYING(n) | Variable-length string, where *n* indicates the maximum number of bytes that can be stored. This data type and VARCHAR(n) are different representations of the same data type. | 10 MB |
| VARCHAR2(n) | Variable-length string, where *n* indicates the maximum number of bytes that can be stored. This data type is added to be compatible with the Oracle database, and its behavior is the same as that of VARCHAR(n). | 10 MB |
| NVARCHAR2(n) | Variable-length string, where *n* indicates the maximum number of bytes that can be stored. | 10 MB |

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| String Type | Description | Max. Storage Capacity |
| --- | --- | --- |
| TEXT | Variable-length string. Its maximum length is 1 GB minus 8203 bytes. | 1 GB minus 8203 bytes |

## 3.3.4 Constraint Design

### DEFAULT and NULL Constraints

- [Proposal] If all the column values can be obtained from services, you are not advised to use the **DEFAULT** constraint. Otherwise, unexpected results will be generated during data loading.
- [Proposal] Add **NOT NULL** constraints to columns that never have NULL values. The optimizer automatically optimizes the columns in certain scenarios.
- [Proposal] Explicitly name all constraints excluding **NOT NULL** and **DEFAULT**.

### Partial Cluster Keys

A partial cluster key (PCK) is a local clustering technology used for column-store tables. After creating a PCK, you can quickly filter and scan fact tables using min or max sparse indexes in GaussDB. Comply with the following rules to create a PCK:

- [Notice] Only one PCK can be created in a table. A PCK can contain multiple columns, preferably no more than two columns.
- [Proposal] Create a PCK on simple expression filter conditions in a query. Such filter conditions are usually in the form of *col op const*, where *col* specifies a column name, *op* specifies an operator (such as =, >, >=, <=, and <), and *const* specifies a constant.
- [Proposal] If the preceding conditions are met, create a PCK on the column having the most distinct values.

### Unique Constraints

- [Notice] Unique constraints can be used in row-store tables but not in column-store tables.
- [Proposal] The constraint name should indicate that it is a unique constraint, for example, **UNI***Included columns*.

### Primary Key Constraints

- [Notice] Primary key constraints can be used in row-store tables but not in column-store tables.
- [Proposal] The constraint name should indicate that it is a primary key constraint, for example, **PK***Included columns*.

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### Check Constraints

- [Notice] Check constraints can be used in row-store tables but not in column-store tables.
- [Proposal] The constraint name should indicate that it is a check constraint, for example, **CK***Included columns*.

## 3.3.5 View and Joined Table Design

### View Design

- [Proposal] Do not nest views unless they have strong dependency on each other.
- [Proposal] Try to avoid collation operations in a view definition.

### Joined Table Design

- [Proposal] Minimize joined columns across tables.
- [Proposal] Use the same data type for joined columns.
- [Proposal] The names of joined columns should indicate their relationship. For example, they can use the same name.

# 3.4 Tool Interconnection

## 3.4.1 JDBC Configuration

Currently, third-party tools are connected to GaussDB through JDBC. This section describes the precautions for configuring the tool.

### Connection Parameters

- [Notice] When a third-party tool connects to GaussDB through JDBC, JDBC sends a connection request to GaussDB. By default, the following parameters are added. For details, see the implementation of the ConnectionFactoryImpl JDBC code.

```
params = {
{ "user", user },
{ "database", database },
{ "client_encoding", "UTF8" },
{ "DateStyle", "ISO" },
{ "extra_float_digits", "3" },
{ "TimeZone",  createPostgresTimeZone() },
};
```

  These parameters may cause the JDBC and **gsql** clients to display inconsistent data, for example, date data display mode, floating point precision representation, and timezone.

  If the result is not as expected, you are advised to explicitly set these parameters in the Java connection setting.

  [Proposal] When the database is connected through JDBC, **extra_float_digits** is set to **3**. When the database is connected using gsql, **extra_float_digits** is set to **0**. As a result, the precision of the same data displayed in JDBC clients may be different from that displayed in gsql clients.

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[Proposal] In precision-sensitive scenarios, the numeric type is recommended.

- [Suggestion] When connecting to the database through JDBC, ensure that the following three time zones are the same:
  - Time zone of the host where the JDBC client is located
  - Time zone of the host where the GaussDB instance is located
  - Time zone during GaussDB instance configuration

    NOTE

    For details about how to set the time zone, contact the administrator.

## fetchsize

[Notice] To use **fetchsize** in applications, disable the **autocommit** switch. Enabling the **autocommit** switch makes the **fetchsize** configuration invalid.

## autocommit

[Suggestion] It is recommended that you enable the **autocommit** switch in the code for connecting to GaussDB by the JDBC. If **autocommit** needs to be disabled to improve performance or for other purposes, applications need to ensure their transactions are committed. For example, explicitly commit translations after specifying service SQL statements. Particularly, ensure that all transactions are committed before the client exits.

## Connection Releasing

[Suggestion] You are advised to use connection pools to limit the number of connections from applications. Do not connect to a database every time you run an SQL statement.

[Suggestion] After an application completes its jobs, disconnect it from GaussDB to release occupied resources. You are advised to set the session timeout interval in the jobs.

[Suggestion] Reset the session environment before releasing connections to the JDBC connection tool. Otherwise, historical session information may cause object conflicts.

- If GUC parameters are set in the connection, run **SET SESSION AUTHORIZATION DEFAULT;RESET ALL;** to clear the connection status before you return the connection to the connection pool.
- If a temporary table is used, delete the temporary table before you return the connection to the connection pool.

## CopyManager

[Suggestion] In the scenario where the ETL tool is not used and real-time data import is required, it is recommended that you use **CopyManager** driven by the GaussDB JDBC to import data in batches during application development.

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# 3.5 SQL Compilation

## DDL

- [Proposal] In GaussDB, you are advised to execute DDL operations, such as creating table or making comments, separately from batch processing jobs to avoid performance deterioration caused by many concurrent transactions.
- [Proposal] Execute data truncation after unlogged tables are used because GaussDB cannot ensure the security of unlogged tables in abnormal scenarios.
- [Proposal] Suggestions on the storage model of temporary and unlogged tables are the same as those on base tables. Create temporary tables in the same storage model as the base tables to avoid high computing costs caused by hybrid row and column correlation.
- [Proposal] The total length of an index column cannot exceed 50 bytes. Otherwise, the index size will increase greatly, resulting in large storage cost and low index performance.
- [Proposal] Do not delete objects using **DROP...CASCADE**, unless the dependency between objects is specified. Otherwise, the objects may be deleted by mistake.

## Data Loading and Uninstalling

- [Proposal] Provide the inserted column list in the insert statement. For example:
  ```
  INSERT INTO task(name,id,comment) VALUES ('task1','100','100th task');
  ```
- [Proposal] After data is imported to the database in batches or the data increment reaches the threshold, you are advised to analyze tables to prevent the execution plan from being degraded due to inaccurate statistics.
- [Proposal] To clear all data in a table, you are advised to use **TRUNCATE TABLE** instead of **DELETE TABLE**. **DELETE TABLE** is not efficient and cannot release disk space occupied by the deleted data.

## Type Conversion

- [Proposal] Convert data types explicitly. If you perform implicit conversion, the result may differ from expected.
- [Proposal] During data query, explicitly specify the data type for constants, and do not attempt to perform any implicit data type conversion.
- [Notice] If **sql_compatibility** is set to **ORA**, null strings will be automatically converted to NULL during data import. If null strings need to be reserved, set **sql_compatibility** to **TD**.

## Query Operation

- [Proposal] Do not return a large number of result sets to a client except the ETL program. If a large result set is returned, consider modifying your service design.
- [Proposal] Perform DDL and DML operations encapsulated in transactions. Operations like table truncation, update, deletion, and dropping, cannot be

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rolled back once committed. You are advised to encapsulate such operations in transactions so that you can roll back the operations if necessary.

- [Proposal] During query compilation, you are advised to list all columns to be queried and avoid using **SELECT ***. Doing so reduces output lines, improves query performance, and avoids the impact of adding or deleting columns on front-end service compatibility.
- [Proposal] During table object access, add the schema prefix to the table object to avoid accessing an unexpected table due to schema switchover.
- [Proposal] The cost of joining more than three tables or views, especially full joins, is difficult to be estimated. You are advised to use the **WITH TABLE AS** statement to create interim tables to improve the readability of SQL statements.
- [Proposal] Avoid using Cartesian products or full joins. Cartesian products and full joins will result in a sharp expansion of result sets and poor performance.
- [Notice] Only **IS NULL** and **IS NOT NULL** can be used to determine NULL value comparison results. If any other method is used, NULL is returned. For example, NULL instead of expected Boolean values is returned for **NULL<>NULL**, **NULL=NULL**, and **NULL<>1**.
- [Notice] Do not use **count(col)** instead of **count(*)** to count the total number of records in a table. **count(*)** counts the NULL value (actual rows) while **count(col)** does not.
- [Notice] While executing **count(col)**, the number of NULL record rows is counted as 0. While executing **sum(col)**, NULL is returned if all records are NULL. If not all the records are NULL, the number of NULL record rows is counted as 0.
- [Notice] To count multiple columns using **count()**, column names must be enclosed in parentheses. For example, count ((col1, col2, col3)). Note: When multiple columns are used to count the number of NULL record rows, a row is counted even if all the selected columns are NULL. The result is the same as that when **count(*)** is executed.
- [Notice] Null records are not counted when **count(distinct col)** is used to calculate the number of non-NULL columns that are not repeated.
- [Notice] If all statistical columns are NULL when **count(distinct (col1,col2,...))** is used to count the number of unique values in multiple columns, Null records are also counted, and the records are considered the same.
- [Proposal] Use the connection operator (||) to replace the **concat** function for string connection, because the output of the **concat** function depends on the data type of the strings to be connected. When the execution plan is generated, the value cannot be calculated in advance. As a result, the query performance deteriorates severely.
- [Proposal] Use the following time-related macros to replace the **now** function and obtain the current time, because the execution plan generated by the **now** function cannot be pushed down to disks. As a result, the query performance deteriorates severely.

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**Table 3-4** Time-related macros

| Macro Name | Description | Example |
| --- | --- | --- |
| CURRENT_DATE | Obtains the current date, excluding the hour, minute, and second details. | openGauss=# select CURRENT_DATE;<br>date<br>------------<br>2018-02-02<br>(1 row) |
| CURRENT_TIME | Obtains the current time, excluding the year, month, and day. | openGauss=# select CURRENT_TIME;<br>timetz<br>--------------------<br>00:39:34.633938+08<br>(1 row) |
| CURRENT_TIMESTAMP(n) | Obtains the current date and time, including year, month, day, hour, minute, and second.<br>**NOTE**<br>*n* indicates the number of digits after the decimal point in the time string. | openGauss=# select CURRENT_TIMESTAMP(6);<br>timestamptz<br>-------------------------------<br>2018-02-02 00:39:55.231689+08<br>(1 row) |

- [Proposal] Do not use scalar subquery statements. A scalar subquery appears in the output list of a **SELECT** statement. In the following example, the underlined part is a scalar subquery statement:

  ```
  SELECT id, (SELECT COUNT(*) FROM films f WHERE f.did = s.id) FROM staffs_p1 s;
  ```

  Scalar subqueries often result in query performance deterioration. During application development, scalar subqueries need to be converted into equivalent table associations based on the service logic.

- [Proposal] In **WHERE** clauses, the filtering conditions should be collated. The condition that few records are selected for reading (the number of filtered records is small) is listed at the beginning.

- [Proposal] Filtering conditions in **WHERE** clauses should comply with unilateral rules, that is, to place the column name on one side of a comparison operator. In this way, the optimizer automatically performs pruning optimization in some scenarios. Filtering conditions in a **WHERE** clause will be displayed in *col op expression* format, where *col* indicates a table column, *op* indicates a comparison operator, such as = and >, and *expression* indicates an expression that does not contain a column name. For example:

  ```
  SELECT id, from_image_id, from_person_id, from_video_id FROM face_data WHERE
  current_timestamp(6) - time < '1 days'::interval;
  ```

  The modification is as follows:

  ```
  SELECT id, from_image_id, from_person_id, from_video_id FROM face_data where time >
  current_timestamp(6) - '1 days'::interval;
  ```

- [Proposal] Do not perform unnecessary collation operations. Collation requires a large amount of memory and CPU. If service logic permits, **ORDER BY** and **LIMIT** can be combined to reduce resource overhead. By default, data in GaussDB is collated by ASC & NULL LAST.

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- [Proposal] When the **ORDER BY** clause is used for collation, specify collation modes (ASC or DESC), and use NULL FIRST or NULL LAST for NULL record sorting.
- [Proposal] Do not rely on only the **LIMIT** clause to return the result set displayed in a specific sequence. Combine **ORDER BY** and **LIMIT** clauses for some specific result sets and use **OFFSET** to skip specific results if necessary.
- [Proposal] If the service logic is accurate, you are advised to use **UNION ALL** instead of **UNION**.
- [Proposal] If a filtering condition contains only an **OR** expression, convert the **OR** expression to **UNION ALL** to improve performance. SQL statements that use **OR** expressions cannot be optimized, resulting in slow execution. For example:

  ```
  SELECT * FROM scdc.pub_menu
  WHERE (cdp= 300 AND inline=301) OR (cdp= 301 AND inline=302) OR (cdp= 302 ANDinline=301);
  ```

  Convert the statement to the following:

  ```
  SELECT * FROM scdc.pub_menu
  WHERE (cdp= 300 AND inline=301)
  union all
  SELECT * FROM scdc.pub_menu
  WHERE (cdp= 301 AND inline=302)
  union all
  SELECT * FROM tablename
  WHERE (cdp= 302 AND inline=301)
  ```

- [Proposal] If an **in(val1, val2, val3...)** expression contains a large number of columns, you are advised to replace it with the **in (values (va11), (val2), (val3)...)** statement. The optimizer will automatically convert the **IN** constraint into a non-correlated subquery to improve the query performance.
- [Proposal] Replace **(not) in** with **(not) exist** when associated columns do not contain null values. For example, in the following query statement, if the **T1.C1** column does not contain any NULL value, add the **NOT NULL** constraint to the **T1.C1** column, and then rewrite the statements.

  ```
  SELECT * FROM T1 WHERE T1.C1 NOT IN (SELECT T2.C2 FROM T2);
  ```

  Rewrite the statement as follows:

  ```
  SELECT * FROM T1 WHERE NOT EXISTS (SELECT  * FROM T2 WHERE T1.C1=T2.C2);
  ```

  **NOTE**

  - If the value of the **T1.C1** column will possibly be NULL, the preceding rewriting cannot be performed.
  - If the **T1.C1** column is the output of a subquery, check whether the output is NOT NULL based on the service logic.
- [Proposal] Use cursors instead of the **LIMIT OFFSET** syntax to perform pagination queries to avoid resource overheads caused by multiple executions. A cursor must be used in a transaction, and you must disable the cursor and commit the transaction once the query is finished.

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# 4 Best Practices

## 4.1 Best Practices of Table Design

### 4.1.1 Selecting a Storage Model

During database design, some key factors about table design will greatly affect the subsequent query performance of the database. Table design affects data storage as well. Scientific table design reduces I/O operations and minimizes memory usage, improving the query performance.

Selecting a model for table storage is the first step of table definition. Select a proper storage model for your service based on the following table.

| Storage Model | Application Scenario |
| --- | --- |
| Row storage | Point queries (simple index-based queries that only return a few records)<br>Scenarios requiring frequent addition, deletion, and modification operations |
| Column storage | Statistics analysis query, in which operations, such as group and join, are performed many times |

### 4.1.2 Selecting a Distribution Mode

In replication mode, full data in a table is copied to each DN in the cluster. This mode is used for tables containing a small volume of data. Full data in a table stored on each DN avoids data redistribution during the join operation. This reduces network costs and plan segment (each having a thread), but generates much redundant data. Generally, this mode is only used for small dimension tables.

In hash mode, hash values are generated for one or more columns. You can obtain the storage location of a tuple based on the mapping between DNs and the hash

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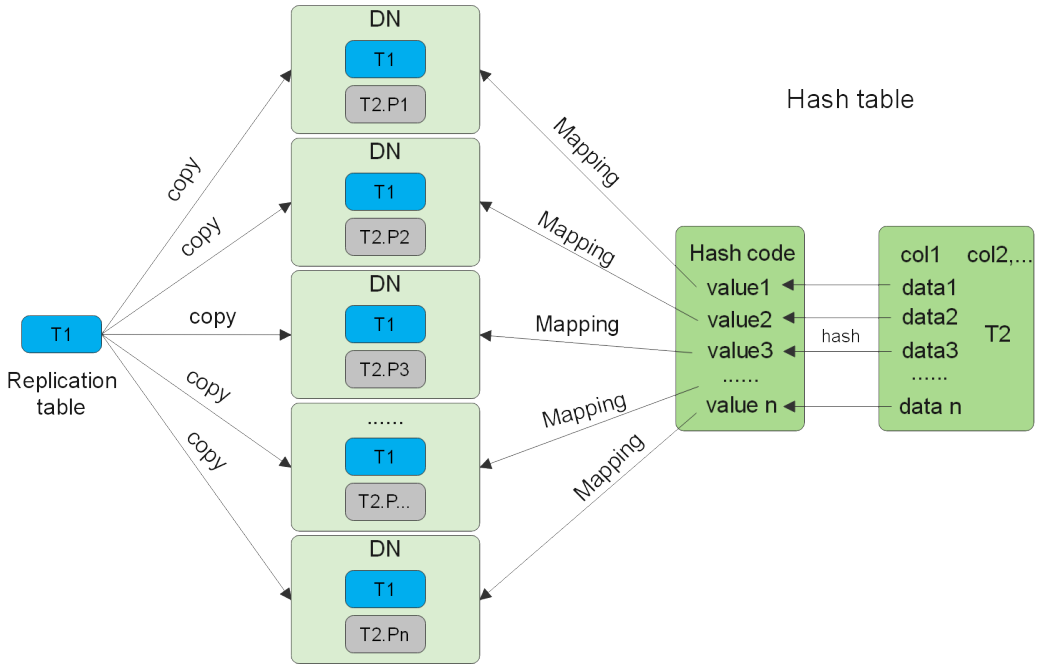
values. In a hash table, I/O resources on each node can be used during data read/write, which improves the read/write speed of a table. Generally, a table containing a large amount data is defined as a hash table.

Range distribution and list distribution are user-defined distribution policies. Values in a distribution column are within a certain range or fall into a specific value range of the corresponding target DN. The two distribution modes facilitate flexible data management, which, however, requires users equipped with certain data abstraction capability.

| Policy | Description | Application Scenario |
| --- | --- | --- |
| Hash | Table data is distributed on all DNs in the cluster. | Fact tables containing a large amount of data |
| Replication | Full data in a table is stored on every DN in the cluster. | Small tables and dimension tables |
| Range | Table data is mapped to specified columns based on the range and distributed to the corresponding DNs. | Users need to customize distribution rules. |
| List | Table data is mapped to specified columns based on specific values and distributed to corresponding DNs. | Users need to customize distribution rules. |

As shown in **Figure 4-1**, T1 is a replication table and T2 is a hash table.

**Figure 4-1** Replication tables and hash tables

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## 4.1.3 Selecting Distribution Keys

Selecting a distribution key for a hash table is essential. Details are as follows:

1. **Ensure that the column values are discrete so that data can be evenly distributed to each DN.** You can select the primary key of the table as the distribution key. For example, for a person information table, choose the ID card number column as the distribution key.
2. **With the above principles met, you can select join conditions as distribution keys** so that join tasks can be pushed down to DNs, reducing the amount of data transferred between the DNs.

For a hash table, an improper distribution key may cause data skew or poor I/O performance on certain DNs. Therefore, you need to check the table to ensure that data is evenly distributed on each DN. You can run the following SQL statement to check for data skew:

```
select
xc_node_id, count(1)
from tablename
group by xc_node_id
order by xc_node_id desc;
```

**xc_node_id** corresponds to a DN. Generally, **over 5% difference between the amount of data on different DNs is regarded as data skew. If the difference is over 10%, choose another distribution key.**

Multiple distribution keys can be selected in GaussDB to evenly distribute data.

You can select the distribution key of the range or list distribution table as required. In addition to selecting a proper distribution key, pay attention to the impact of distribution rules on data distribution.

## 4.1.4 Using PCKs

The PCK is the column-store-based technology. It can minimize or maximize sparse indexes to quickly filter base tables. You are advised to select a maximum of two columns as PCKs. Use the following principles to specify PCKs:

1. The selected PCKs must be restricted by simple expressions in base tables. Such constraints are usually represented by *col op const*, in which *col* indicates the column name, *op* indicates operators, (including =, >, >=, <=, and <), and *const* indicates constants.
2. Select columns that are frequently selected (to filter much more undesired data) in simple expressions.
3. List the most frequently selected columns at the top.
4. List the columns of the enumerated type at the top.

## 4.1.5 Using Partitioned Tables

Partitioning refers to splitting what is logically one large table into smaller physical pieces based on specific schemes. The table based on the logic is called a partitioned table, and a physical piece is called a partition. Data is stored on these physical partitions, instead of the logical partitioned table. A partitioned table has the following advantages over an ordinary table:

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1. High query performance: You can specify partitions when querying partitioned tables, improving query efficiency.
2. High availability: If a certain partition in a partitioned table is faulty, data in the other partitions is still available.
3. Easy maintenance: To fix a partitioned table having a faulty partition, you only need to fix the partition.

GaussDB supports range partitioned tables.

Range partitioned table: Data in different ranges is mapped to different partitions. The range is determined by the partition key specified during the partitioned table creation. The partition key is usually a date. For example, sales data is partitioned by month.

## 4.1.6 Selecting a Data Type

Use the following principles to select efficient data types:

1. **Select data types that facilitate data calculation.**

   Generally, the calculation of integers (including common comparison calculations, such as =, >, <, ≥, ≤, and ≠ and group by) is more efficient than that of strings and floating point numbers. For example, if you need to perform a point query on a column-store table whose numeric column is used as a filter condition, the query will take over 10s. If you change the data type from **NUMERIC** to **INT**, the query duration will be reduced to 1.8s.

2. **Select data types with a short length.**

   Data types with short length reduce both the data file size and the memory used for computing, improving the I/O and computing performance. For example, use **SMALLINT** instead of **INT**, and **INT** instead of **BIGINT**.

3. **Use the same data type for a join.**

   You are advised to use the same data type for a join. To join columns with different data types, the database needs to convert them to the same type, which leads to additional performance overheads.

## 4.1.7 Checking a Node Where a Table Resides

When creating a table, you can specify how the table is distributed or replicated among nodes. For details, see **•DISTRIBUTEBY**. For details about distribution modes, see **4.1.2 Selecting a Distribution Mode**.

When creating a table, you can also set **Node Group** to specify a group to which the table belongs. For details, see **•TO{GROUPgroupname|...**.

You can also run the following command to view the instance where the table is located.

1. Query the schema to which the table belongs.

   ```
   select t1.nspname,t2.relname from pg_namespace t1,pg_class t2 where t1.oid = t2.relnamespace and t2.relname = 'table1';
   ```

   In the preceding command, **nspname** indicates the name of a schema, **relname** indicates the name of a table, an index, or a view, **oid** indicates the row identifier, **relnamespace** is the OID of the namespace that contains the relationship, and **table1** indicates a table name.

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2. Check **relname** and **nodeoids** of the table.
   ```
   select t1.relname,t2.nodeoids from pg_class t1, pgxc_class t2, pg_namespace t3  where t1.relfilenode =  t2.pcrelid and t1.relnamespace=t3.oid and t1.relname = 'table1' and t3.nspname ='schema1';
   ```
   In the preceding command, **nodeoids** indicates the OID list of the nodes where the table is distributed, **relfilenode** indicates the name of the file related to the table on the disk, **pcrelid** indicates the OID of the table, and **schema1** indicates the schema of the table queried in step 1.
3. Query the instance where the table is located based on the queried node where the table is distributed.
   ```
   select * from pgxc_node where oid in (nodeoids1, nodeoids2, nodeoids3);
   ```
   In the preceding command, **nodeoids1, nodeoids2, nodeoids3** indicates the three nodeoids queried in step 2. Use the actual nodeoids and separate them with commas (,).

# 4.2 Best Practices of Data Import

## Using GDS to Import Data

- Data skew deteriorates the query performance. Before importing all the data from a table containing over 10 million records, you are advised to import some of the data and check whether there is data skew and whether the distribution keys need to be changed. Troubleshoot the data skew if any. It is costly to address data skew and change the distribution keys after a large amount of data has been imported. For details, see **8.7 Checking for Data Skew**.
- To speed up the import, you are advised to split files and use multiple Gauss Data Services (GDSs) to import data in parallel. An import task can be split into multiple concurrent import tasks. If multiple import tasks use the same GDS, you can specify the **-t** parameter to enable GDS multi-thread concurrent import. To prevent physical I/O and network bottleneck, you are advised to mount GDSs to different physical disks and NICs.
- To ensure normal job execution, configure robust system resources in the physical environment where GDSs are located based on the load and concurrency of GDSs. The system resources include but are not limited to the memory size, number of handles, and available space of the disk corresponding to the GDS data directory. If GDSs are deployed outside the GaussDB cluster, ensure that their physical environment configuration is consistent with that in the cluster.
- If the GDS I/O and NICs do not reach their physical bottleneck, you can enable SMP on GaussDB for acceleration. SMP will multiply pressure on GDSs. Note that SMP adaptation is implemented based on the GaussDB CPU pressure rather than the GDS pressure.
- The communication between GDS and GaussDB must be smooth. 10GE network is recommended. Gigabit networks cannot bear the high-speed data transmission. That is, Gigabit networks cannot guarantee the network communications of GaussDB. To maximize the import speed of a single file, ensure that a 10GE network is used, and the data disk group I/O rate is greater than the upper limit of the GDS single-core processing capability (about 400 Mbit/s).
- Similar to the single-table import, ensure that the I/O rate is greater than the maximum network throughput in the concurrent import.

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- You are advised to deploy one or two GDSs on a RAID of a data server.
- It is recommended that the ratio of GDS quantity to DN quantity be in the range of 1:3 to 1:6.
- To improve the efficiency of importing data in batches to column-store partitioned tables, the data is buffered before being written into a disk. You can specify the number of buffers and the buffer size by setting **partition_mem_batch** and **partition_max_cache_size**, respectively. The smaller the values, the slower the batch import to column-store partitioned tables. The larger the values, the higher the memory consumption.

## Using INSERT to Insert Multiple Rows

If the **COPY** statement cannot be used and you require SQL insert, use multi-row insert whenever possible. If you use a column-store table and insert one or more rows at a time, the data compression efficiency is low.

Multi-row insert improves performance by batching up a series of inserts. The following example inserts three rows into a three-column table using a single **INSERT** statement. This is still a small insert, shown simply to illustrate the syntax of a multi-row insert. For details about how to create a table, see **2.6 Creating and Managing Tables**.

To insert multiple rows of data to the table **customer_t1**, run the following command:

```
openGauss=# INSERT INTO customer_t1 VALUES
(68, 'a1', 'zhou','wang'),
(43, 'b1', 'wu', 'zhao'),
(95, 'c1', 'zheng', 'qian');
```

For more details and examples, see **12.14.141 INSERT**.

## Using COPY to Import Data

The **COPY** statement imports data from local and remote databases in parallel. It imports large amounts of data more efficiently than using **INSERT** statements.

For details about how to use the **COPY** statement, see **8.3 Running the COPY FROM STDIN Statement to Import Data**.

## Using a gsql Meta-Command to Import Data

The **\copy** command can be used to import data after you log in to a database through any **psql** client. Unlike the **COPY** statement, the **\copy** command reads from or writes to a file.

Data read or written using the **\copy** command is transferred through the connection between the server and the client and may not be efficient. The **COPY** statement is recommended when the amount of data is large.

For details about how to use the **\copy** command, see **8.4 Using a gsql Meta-Command to Import Data**.

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NOTE

**\copy** applies only to small-scale data import in good format. It does not preprocess invalid characters nor provide error tolerance. Therefore, **\copy** cannot be used in scenarios where abnormal data exists. GDS or **COPY** is preferred for data import.

### Using INSERT for Bulk Insert

Use a bulk insert operation with a **SELECT** clause for high-performance data insertion.

Use the **12.14.141 INSERT** and **12.14.82 CREATE TABLE AS** statements when you need to move data or a subset of data from one table into another.

Assume that you have created a backup table **customer_t2** for table **customer_t1**. To insert data from **customer_t1** to **customer_t2**, run the following statements:

```
openGauss=# CREATE TABLE customer_t2
(
    c_customer_sk             integer,
    c_customer_id             char(5),
    c_first_name              char(6),
    c_last_name               char(8)
);
openGauss=# INSERT INTO customer_t2 SELECT * FROM customer_t1;
```

The preceding example is equivalent to:

```
openGauss=# CREATE TABLE customer_t2 AS SELECT * FROM customer_t1;
```

## 4.3 Best Practices of SQL Queries

Based on the SQL execution mechanism and a large number of practices, SQL statements can be optimized by following certain rules to enable the database to execute SQL statements more quickly and obtain correct results.

- Replace **UNION** with **UNION ALL**.

  **UNION** eliminates duplicate rows while merging two result sets but **UNION ALL** merges the two result sets without deduplication. Therefore, replace **UNION** with **UNION ALL** if you are sure that the two result sets do not contain duplicate rows based on the service logic.

- Add **NOT NULL** to the join columns.

  If there are many NULL values in the **JOIN** columns, you can add the filter criterion **IS NOT NULL** to filter data in advance to improve the **JOIN** efficiency.

- Convert **NOT IN** to **NOT EXISTS**.

  **nestloop anti join** must be used to implement **NOT IN**, and **hash anti join** is required for **NOT EXISTS**. If no NULL value exists in the **JOIN** columns, **NOT IN** is equivalent to **NOT EXISTS**. Therefore, if you are sure that no NULL value exists, you can convert **NOT IN** to **NOT EXISTS** to generate **hash join** and to improve the query performance.

  As shown in the following figure, the **t2.d2** column does not contain null values (it is set to **NOT NULL**) and **NOT EXISTS** is used for the query.

  ```
  SELECT * FROM t1 WHERE  NOT EXISTS (SELECT * FROM t2 WHERE t1.c1=t2.d2);
  ```

  The generated execution plan is as follows:

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**Figure 4-2** NOT EXISTS execution plan

```
 id |                 operation
----+-------------------------------------------
  1 | -> Streaming (type: GATHER)
  2 |    ->  Hash Anti Join (3, 4)
  3 |       ->  Seq Scan on t1
  4 |       ->  Hash
  5 |          ->  Streaming (type: REDISTRIBUTE)
  6 |             ->  Seq Scan on t2
(6 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
  2 --Hash Anti Join (3, 4)
        Hasn Cond: (t1.c1 = t2.d2)
(2 rows)
```

- Use **hashagg**.

  If a plan involving groupAgg and SORT operations generated by the **GROUP BY** statement is poor in performance, you can set **work_mem** to a larger value to generate a **hashagg** plan, which does not require sorting and improves the performance.

- Replace functions with **CASE** statements.

  The GaussDB performance greatly deteriorates if a large number of functions are called. In this case, you can modify the pushdown functions to **CASE** statements.

- Do not use functions or expressions for indexes.

  Using functions or expressions for indexes stops indexing. Instead, it enables scanning on the full table.

- Do not use **!=** or **<>** operators, **NULL**, **OR**, or implicit parameter conversion in **WHERE** clauses.

- Split complex SQL statements.

  You can split an SQL statement into several ones and save the execution result to a temporary table if the SQL statement is too complex to be tuned using the solutions above, including but not limited to the following scenarios:

  - The same subquery is involved in multiple SQL statements of a job and the subquery contains large amounts of data.
  - Incorrect plan cost causes a small hash bucket of subquery. For example, the actual number of rows is 10 million, but only 1000 rows are in hash bucket.
  - Functions such as **substr** and **to_number** cause incorrect measures for subqueries containing large amounts of data.
  - **BROADCAST** subqueries are performed on large tables in multi-DN environment.

For details about optimization, see **10.3.6 Typical SQL Optimization Methods**.

# 4.4 Best Practices for Data Skew Query

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## 4.4.1 Detecting Storage Skew in Real Time During Data Import

During the import, the system collects statistics on the number of rows imported on each DN. After the import is complete, the system calculates the skew ratio. If the skew ratio exceeds the specified threshold, an alarm is generated immediately. The skew ratio is calculated as follows: Skew ratio = (Maximum number of rows imported on a DN – Minimum number of rows imported on a DN)/Number of imported rows. Currently, data can be imported only by running **INSERT** or **COPY**.

NOTE

**enable_stream_operator** must be set to **on** so that DNs can return the number of imported rows at a time when a plan is delivered to them. Then, the skew ratio is calculated on CNs based on the returned values.

### Procedure

1. Set parameters **table_skewness_warning_threshold** (threshold for triggering a table skew alarm) and **table_skewness_warning_rows** (minimum number of rows for triggering a table skew alarm).
   - The value of **table_skewness_warning_threshold** ranges from 0 to 1. The default value is **1**, indicating that the alarm is disabled. Other values indicate that the alarm is enabled.
   - The value of **table_skewness_warning_rows** ranges from 0 to 2147483647. The default value is **100,000**. The alarm is triggered only when the following condition is met: Total number of imported rows > Value of **table_skewness_warning_rows** x Number of DNs involving in the import.

   ```
   show table_skewness_warning_threshold;
   set table_skewness_warning_threshold = xxx;
   show table_skewness_warning_rows;
   set table_skewness_warning_rows = xxx;
   ```

2. Import data by running the **INSERT** or **COPY** statement.
3. Detect and handle alarms. The alarm information includes the table name, minimum number of rows, maximum number of rows, total number of rows, average number of rows, skew rate, and prompt information about data distribution or parameter modification.

   ```
   WARNING: Skewness occurs, table name: xxx, min value: xxx, max value: xxx, sum value: xxx, avg value: xxx, skew ratio: xxx
   HINT: Please check data distribution or modify warning threshold
   ```

## 4.4.2 Quickly Locating Tables That Cause Data Skew

Currently, the **table_distribution(schemaname text, tablename text)** and **table_distribution()** functions as well as the **15.3.192 PGXC_GET_TABLE_SKEWNESS** view are provided to query for data skew. You can choose any of them as needed.

### Scenario 1: Data Skew Caused by a Full Disk

First, use the **pg_stat_get_last_data_changed_time(oid)** function to query for the tables whose data is changed recently. The last change time of a table is recorded only on the CN where **INSERT**, **UPDATE**, and **DELETE** operations are performed.

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Therefore, you need to query for tables that are changed within the last day (the period can be changed in the function).

```
CREATE OR REPLACE FUNCTION get_last_changed_table(OUT schemaname text, OUT relname text)
RETURNS setof record
AS $$
DECLARE
   row_data record;
   row_name record;
   query_str text;
   query_str_nodes text;
   BEGIN
      query_str_nodes := 'SELECT node_name FROM pgxc_node where node_type = ''C''';
      FOR row_name IN EXECUTE(query_str_nodes) LOOP
         query_str := 'EXECUTE DIRECT ON (' || row_name.node_name || ') ''SELECT b.nspname,a.relname
FROM pg_class a INNER JOIN pg_namespace b on a.relnamespace = b.oid where
pg_stat_get_last_data_changed_time(a.oid) BETWEEN current_timestamp - 1 AND current_timestamp;''';
         FOR row_data IN EXECUTE(query_str) LOOP
            schemaname = row_data.nspname;
            relname = row_data.relname;
            return next;
         END LOOP;
      END LOOP;
      return;
   END; $$
LANGUAGE 'plpgsql';
```

Then, execute the **table_distribution(schemaname text, tablename text)** function to query for the storage space occupied the tables on each DN.

```
SELECT table_distribution(schemaname,relname) FROM get_last_changed_table();
```

## Scenario 2: Routine Data Skew Inspection

- If the number of tables in the database is less than 10,000, use the skew view to query data skew of all tables in the database.
  ```
  SELECT * FROM pgxc_get_table_skewness ORDER BY totalsize DESC;
  ```
- If the number of tables in the database is no less than 10,000, you are advised to use the **table_distribution()** function instead of the **15.3.192 PGXC_GET_TABLE_SKEWNESS** view because the view takes a longer time (hours) due to the query of the entire database for skew columns. When you use the **table_distribution()** function, you can define the output based on **15.3.192 PGXC_GET_TABLE_SKEWNESS**, optimizing the calculation and reducing the output columns. For example:
  ```
  SELECT schemaname,tablename,max(dnsize) AS maxsize, min(dnsize) AS minsize
  FROM pg_catalog.pg_class c
  INNER JOIN pg_catalog.pg_namespace n ON n.oid = c.relnamespace
  INNER JOIN pg_catalog.table_distribution() s ON s.schemaname = n.nspname AND s.tablename =
  c.relname
  INNER JOIN pg_catalog.pgxc_class x ON c.oid = x.pcrelid AND x.pclocatortype = 'H'
  GROUP BY schemaname,tablename;
  ```

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# 5 Tutorial: Using GDS to Import Data from a Remote Server

## 5.1 Overview

This tutorial demonstrates how to use GDS to import data from remote servers to GaussDB.

In this tutorial, you will:

- Generate the source data files in CSV format to be used in this tutorial.
- Upload the source data files to a data server.
- Create foreign tables used for importing data from a data server to GaussDB through GDS.
- Start GaussDB, create a table, and import data to the table.
- Analyze import errors based on the information in the error table and correct the faults.

## 5.2 Prerequisites

A server for storing source data has been prepared, and it can communicate with GaussDB. The server has robust system resources such as memory, disk spaces, and file handles.

### Obtaining the Driver Package

Download particular packages listed in **Table 5-1** based on the version of your instance.

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**Table 5-1** Driver package download list

| Version | Download Address |
| --- | --- |
| 3.*x* | **Driver package**<br>**Verification package for the driver package** |
| 2.*x* | **Driver package**<br>**Verification package for the driver package** |

To prevent a software package from being tampered with during transmission or storage, download the corresponding verification package and perform the following steps to verify the software package:

1. Upload the software package and verification package to the same directory on a Linux VM.
2. Run the following command to verify the integrity of the software package:

   **cat** *GaussDB_driver.zip.sha256* **| sha256sum --check**

   If **OK** is displayed in the command output, the verification is successful.

   ```
   GaussDB_driver.zip: OK
   ```

# 5.3 Step 1: Preparing Source Data

You can import data in TEXT, CSV, or FIXED format from a remote server to GaussDB. This tutorial uses data in CSV format as an example. The method is the same for data in TEXT and FIXED format except that the parameter settings of foreign tables are different. For details, see **8.1 Importing Data in Parallel Using Foreign Tables**.

## Preparing Source Data Files

To demonstrate how to import multiple files, this tutorial uses the following three CSV data files as an example. Generally, source data files are exported from a database. In this tutorial, the CSV source data files are manually created.

- Data file **product_info0.csv**

  The file contains the following data:

  ```
  100,XHDK-A,2017-09-01,A,2017 Shirt Women,red,M,328,2017-09-04,715,good!
  205,KDKE-B,2017-09-01,A,2017 T-shirt Women,pink,L,584,2017-09-05,40,very good!
  300,JODL-X,2017-09-01,A,2017 T-shirt men,red,XL,15,2017-09-03,502,Bad.
  310,QQPX-R,2017-09-02,B,2017 jacket women,red,L,411,2017-09-05,436,It's nice.
  150,ABEF-C,2017-09-03,B,2017 Jeans Women,blue,M,123,2017-09-06,120,good.
  ```

- Data file **product_info1.csv**

  The file contains the following data:

  ```
  200,BCQP-E,2017-09-04,B,2017 casual pants men,black,L,997,2017-09-10,301,good quality.
  250,EABE-D,2017-09-10,A,2017 dress women,black,S,841,2017-09-15,299,This dress fits well.
  108,CDXK-F,2017-09-11,A,2017 dress women,red,M,85,2017-09-14,22,It's really amazing to buy.
  450,MMCE-H,2017-09-11,A,2017 jacket women,white,M,114,2017-09-14,22,very good.
  260,OCDA-G,2017-09-12,B,2017 woolen coat women,red,L,2004,2017-09-15,826,Very comfortable.
  ```

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- Data file **product_info2.csv**

  The file contains the following data:

```
980,"ZKDS-J",2017-09-13,"B","2017 Women's Cotton Clothing","red","M",112,,,
98,"FKQB-I",2017-09-15,"B","2017 new shoes men","red","M",4345,2017-09-18,5473
50,"DMQY-K",2017-09-21,"A","2017 pants men","red","37",28,2017-09-25,58,"good","good","good"
80,"GKLW-l",2017-09-22,"A","2017 Jeans Men","red","39",58,2017-09-25,72,"Very comfortable."
30,"HWEC-L",2017-09-23,"A","2017 shoes women","red","M",403,2017-09-26,607,"good!"
40,"IQPD-M",2017-09-24,"B","2017 new pants Women","red","M",35,2017-09-27,52,"very good."
50,"LPEC-N",2017-09-25,"B","2017 dress Women","red","M",29,2017-09-28,47,"not good at all."
60,"NQAB-O",2017-09-26,"B","2017 jacket women","red","S",69,2017-09-29,70,"It's beautiful."
70,"HWNB-P",2017-09-27,"B","2017 jacket women","red","L",30,2017-09-30,55,"I like it so much"
80,"JKHU-Q",2017-09-29,"C","2017 T-shirt","red","M",90,2017-10-02,82,"very good."
```

  CSV is short for Comma Separated Values. A CSV file is similar to a TXT or DOC file, which is a type of text files. A CSV file is composed of records that are separated as columns by tabs. Each record shares the same column sequence. In Windows, CSV files can be opened in different applications, such as Notepad and Notepad++.

  The following describes how to generate a CSV file in Windows:

**Step 1** Create a text file and open it in Notepad++. Copy the sample data into it. Then, check the total number of rows and check whether the data of rows is correctly separated.

**Step 2** Choose **Encoding** > **Encode in UTF-8 without BOM**.

**Step 3** Choose **File** > **Save as**.

**Step 4** In the displayed dialog box, enter the file name and click **Save**.

To identify the file type, use the file name extension .csv when entering the file name.

**----End**

## Uploading Source Data Files to a Data Server

**Step 1** Log in to the server 192.168.0.90 storing source data files (also known as the data server or GDS server).

**Step 2** Run the following command to create a directory named **/input_data**:

```
mkdir -p /input_data
```

**Step 3** Use MobaXterm to upload source data files to the created directory.

**----End**

# 5.4 Step 2: Installing, Configuring, and Starting GDS on a Data Server

## Obtaining the Driver Package

Download particular packages listed in **Table 5-2** based on the version of your instance.

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**Table 5-2** Driver package download list

| Version | Download Address |
| --- | --- |
| 3.*x* | **Driver package**<br>**Verification package for the driver package** |
| 2.*x* | **Driver package**<br>**Verification package for the driver package** |

To prevent a software package from being tampered with during transmission or storage, download the corresponding verification package and perform the following steps to verify the software package:

1. Upload the software package and verification package to the same directory on a Linux VM.
2. Run the following command to verify the integrity of the software package:

   **cat** *GaussDB_driver.zip.sha256* **| sha256sum --check**

   If **OK** is displayed in the command output, the verification is successful.

   ```
   GaussDB_driver.zip: OK
   ```

Before data import, install, configure, and start GDS on the servers where source data files are stored. Then you can connect GDS to GaussDB to import data.

**Step 1** Log in to the data server 192.168.0.90 where GDS is to be installed, and create user **gds_user** and its user group **gdsgrp**. This user is used to start GDS and must have the permission to read the source data file directory.

```
groupadd gdsgrp
useradd -g gdsgrp gds_user
```

**Step 2** Switch to user **gds_user**.

```
su - gds_user
```

**Step 3** Create the **/opt/bin** directory for storing the GDS package.

```
mkdir -p /opt/bin
```

**Step 4** Change the owner of the GDS package and source data file directory to **gds_user** and the user group to **gdsgrp**.

```
chown -R gds_user:gdsgrp /opt/bin
chown -R gds_user:gdsgrp /input_data
```

**Step 5** Upload the GDS package to the created directory.

Use the Euler Linux tool package as an example. Upload the GDS tool package **GaussDB-Kernel-VxxxRxxxCxx-xxxxx-64bit-Gds.tar.gz** in the software installation package to the created directory.

Download link of **GaussDB-Kernel-VxxxRxxxCxx-xxxxx-64bit-Gds.tar.gz**: **Driver package**

**Step 6** Run the following commands to go to the directory and decompress the package:

```
cd /opt/bin
tar -zxvf GaussDB-Kernel-VxxxRxxxCxx-xxxxx-64bit-Gds.tar.gz
export LD_LIBRARY_PATH="/opt/bin/lib:$LD_LIBRARY_PATH"  // GDS depends on the Cjson dynamic library. Therefore, you need to configure the path of the dynamic library.
```

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**Step 7** (Optional) If SSL is used, upload the SSL certificate to the directory created in **Step 1**.

The SSL certificate is stored in the ***$GAUSSHOME*/share/sslcert/gds** directory of GaussDB.

In this example, *$GAUSSHOME* of the GaussDB server (192.168.10.60) is **/opt/huawei/Bigdata/gaussdb/core**. You can download the SSL certificate to the **/opt/bin** directory for GDS by using the following command:

```
scp -r root@192.168.10.60:/opt/huawei/Bigdata/gaussdb/core/share/sslcert/gds ./
```

**Step 8** Start the GDS.

- If SSL is not enabled, run the following command to start GDS:
  ```
  /opt/bin/gds/gds -d /input_data/ -p 192.168.0.90:5000 -H 10.10.0.1/24 -l /opt/bin/gds/gds_log.txt -D
  --enable-ssl off
  ```
- If SSL encryption is used, run the following command to start GDS after performing **Step 7**:
  ```
  /opt/bin/gds/gds -d /input_data/ -p 192.168.0.90:5000 -H 10.10.0.1/24 -l /opt/bin/gds/gds_log.txt -D
  --enable-ssl on --ssl-dir /opt/bin/gds
  ```

Replace the italic parts as required.

- **-d** *dir*: directory storing data files that contain data to be imported. It is **/input_data/** in this tutorial.
- **-p** *ip:port*: listening IP address and port for GDS. The default value is **127.0.0.1**. Replace it with the IP address of a 10GE network that can communicate with GaussDB. The listening port can be any one ranging from 1024 to 65535. The default port is **8098**. This parameter is set to **192.168.0.90:5000** in this tutorial.
- **-H** *address_string*: network segment for hosts that can connect to and use GDS. The value must be in CIDR format. Set this parameter to enable the GaussDB instance to access GDS for data import. Ensure that the network segment covers all hosts in the GaussDB instance.
- **-l** *log_file*: GDS log directory and log file name. This parameter is set to **/opt/bin/gds/gds_log.txt** in this tutorial.
- **-D**: GDS in daemon mode. This parameter is used only in Linux.
- **--enable-ssl**: Data transmission in SSL encryption mode. By default, the SSL encryption mode is enabled. If this parameter is not used, you need to add **--ssl-dir** to specify the SSL certificate directory.
- **--ssl-dir**: SSL certificate directory. Set it to the certificate directory mentioned in **Step 7**.

**----End**

# 5.5 Step 3: Creating a Foreign Table in GaussDB

**Step 1** Use the SQL client tool to connect to the GaussDB database.

**Step 2** Create a foreign table based on **Table 5-3**.

```
openGauss=# DROP FOREIGN TABLE IF EXISTS product_info_ext;
openGauss=# CREATE FOREIGN TABLE product_info_ext
(
    product_price               integer       not null,
    product_id                  char(30)      not null,
```

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```
    product_time                date          ,
    product_level               char(10)      ,
    product_name                varchar(200)  ,
    product_type1               varchar(20)   ,
    product_type2               char(10)      ,
    product_monthly_sales_cnt   integer       ,
    product_comment_time        date          ,
    product_comment_num         integer       ,
    product_comment_content     varchar(200)
)
SERVER gsmpp_server
OPTIONS(
LOCATION 'gsfs://192.168.0.90:5000/*',
FORMAT 'CSV' ,
DELIMITER ',',
ENCODING 'utf8',
HEADER 'false',
FILL_MISSING_FIELDS 'true',
IGNORE_EXTRA_DATA 'true'
)
READ ONLY
LOG INTO product_info_err
PER NODE REJECT LIMIT 'unlimited';
```

If the following information is displayed, the foreign table has been created:

```
CREATE FOREIGN TABLE
```

**Table 5-3** Configurations in the foreign table

| Configuration Item | Value | Description |
| --- | --- | --- |
| SERVER | gsmpp_server | Use the default value **gsmpp_server**. |
| LOCATION | gsfs://192.168.0.90:5000/* | Location of source data files.<br>If SSL is used for encrypted transmission, use the gsfss protocol. In this case, the location is **gsfss://192.168.0.90:5000/***. |
| FORMAT | CSV | Format of source data files. |
| ENCODING | UTF-8 | Data encoding format. |
| DELIMITER | It is set to a comma (,). | Field separator. |
| HEADER | **false** (default value) | Specifies whether a data file contains a header. This parameter is valid only for data files in CSV or FIXED format. The first line of data files in **Preparing Source Data Files** is not a header. Therefore, it is set to **false**. |

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| Configuration Item | Value | Description |
| --- | --- | --- |
| FILL_MISSING_FIELDS | true | Specifies how to handle the problem that the last column of a row in a source data file is lost during data import. The default value is **false/off**. **true** is used in this tutorial.<br>• **true/on**: The last column is set to **NULL**. No error is reported.<br>• **false/off**: Error "missing data for column "tt"" is reported.<br>For example, the last column **product_comment_content** of the second row in the **product_info2.csv** source data file is lost. If **FILL_MISSING_FIELDS** is set to **false/off**, information similar to the following will be displayed in the error table during data import:<br>**missing data for column** "product_comment_content" |
| IGNORE_EXTRA_DATA | true | Specifies whether to ignore excessive columns when the number of columns in a source data file exceeds that defined in the foreign table. The default value is **false/off**. **true** is used in this tutorial.<br>• **true/on**: The excessive columns of a row are ignored. No error is reported.<br>• **false/off**: Error "extra data after last expected column" is reported.<br>For example, the number of columns in the third record in the **product_info2.csv** source data file is greater than that defined in the foreign table. If **IGNORE_EXTRA_DATA** is set to **false/off**, information similar to the following will be displayed in the error table during data import:<br>**extra data after last expected column** |

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| Configuration Item | Value | Description |
| --- | --- | --- |
| PER NODE REJECT LIMIT 'value' | unlimited | Maximum number of data format errors allowed on each DN during data import. If the number of errors exceeds the specified value on any DN, data import fails, an error is reported, and the system exits data import.<br>It is set to **unlimited** in this tutorial, indicating that all data format errors during import are allowed. |
| READ ONLY | - | Syntax defined in a foreign table can be used for both importing data to and exporting data from GaussDB. To import data to the cluster, use **READ ONLY** in the foreign table. To export data, use **WRITE ONLY**. |
| WITH error_table_name | Error table name: **product_info_err** | Data format errors during import are recorded in the table specified by **product_info_err**. You can query this table after the import to obtain error details. |

For more configuration items, see **12.14.60 CREATE FOREIGN TABLE (for Import and Export)**.

**----End**

# 5.6 Step 4: Importing Data to GaussDB

**Step 1** Run the following statements to create the target table **product_info** in GaussDB to store imported data:

```
openGauss=# DROP TABLE IF EXISTS product_info;
openGauss=# CREATE TABLE product_info
(
    product_price               integer        not null,
    product_id                  char(30)       not null,
    product_time                date           ,
    product_level               char(10)       ,
    product_name                varchar(200)   ,
    product_type1               varchar(20)    ,
    product_type2               char(10)       ,
    product_monthly_sales_cnt   integer        ,
    product_comment_time        date           ,
    product_comment_num         integer        ,
    product_comment_content     varchar(200)
)
WITH (
orientation = column,
compression=middle
```

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```
)
DISTRIBUTE BY hash (product_id);
```

**Step 2** (Optional) This step is not required in this example because no index is created in **Step 1**. If the target table has indexes, the index information will be incrementally updated during import, affecting data import performance. You are advised to delete the indexes from the target table before the import. You can create the indexes again after the import is complete.

1. Assume that there is an ordinary index **product_idx** in the **product_id** column of the target table **product_info**. Delete the index in the table.
   ```
   openGauss=# DROP INDEX product_idx;
   ```
2. After importing the data, create the index again.
   ```
   openGauss=# CREATE INDEX product_idx ON product_info(product_id);
   ```
3. Set **enable_stream_operator** to **on**.
   ```
   openGauss=# set enable_stream_operator=on;;
   ```

NOTE

- You can temporarily add the GUC parameter **maintenance_work_mem** or **psort_work_mem** to accelerate index recreation.
- To import foreign tables in parallel, you must enable the stream operator.
- If **enable_stream_operator** is set to **on**, the performance is affected. If there are other SQL statements to be executed in the session, you are advised to set **enable_stream_operator** to **off**. If there is no SQL statement to be executed in the session, disconnect the session.

**Step 3** Import data from source data files to the **product_info** table through the foreign table **product_info_ext**.

```
openGauss=# INSERT INTO product_info SELECT * FROM product_info_ext ;
```

If information similar to the following is displayed, the data has been imported:

```
INSERT 0 20
```

**Step 4** Run **SELECT** to view the data imported to the target table **product_info** in GaussDB.

```
openGauss=# SELECT count(*) FROM product_info;
```

If the following information is displayed, the import is successful:

```
count
-------
    20
(1 row)
```

**----End**

# 5.7 Step 5: Analyzing and Handling Import Errors

This section describes how to handle data format errors that occurred during import. If no error information is reported, skip this section.

**Step 1** Query error information in the error table.

```
openGauss=# SELECT * FROM product_info_err ;
```

**Step 2** Handle errors if any.

In this tutorial, there should be no error information in the error table.

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Alternatively, you can change **FILL_MISSING_FIELDS** and **IGNORE_EXTRA_DATA** in the foreign table created in **5.4 Step 2: Installing, Configuring, and Starting GDS on a Data Server** to **false**, and import the data again. Then, query the error table. In this case, you will find the following data format error information:

- The last column **product_comment_content** of the second row in the **product_info2.csv** source data file is lost.
- The number of columns in the third row in the **product_info2.csv** source data file is greater than that defined in the foreign table.

```
openGauss=# select * from product_info_err;
 nodeid |          begintime          |          filename          | rownum |                                    rawrecord                                    |                    detail
--------+-----------------------------+----------------------------+--------+-------------------------------------------------------------------------------+-----------------------------------------------------
--------------------
      0 | 2018-08-31 15:57:32.221265+08 | /input_data/product_info2.csv |      2 | 98,"FKQB-I",2017-09-15,"B","2017 new shoes men","red","M",4345,2017-09-18,5473                | missing data for column "prod
uct_comment_content"
      0 | 2018-08-31 15:57:32.221265+08 | /input_data/product_info2.csv |      3 | 50,"DMQY-K",2017-09-21,"A","2017 pants men","red","37",28,2017-09-25,58,"good","good","good" | extra data after last expecte
d column
(2 rows)
```

For details about error tables and troubleshooting, see **8.1.7 Handling Import Errors**.

**----End**

# 5.8 Step 6: Improving Query Efficiency After Data Import

After data is imported, run the **ANALYZE** statement to generate table statistics. The statistics data is useful when you run the planner, which provides you with an efficient query execution plan.

If a large number of rows were updated or deleted during import, run **VACUUM FULL** before **ANALYZE**. A large number of updates and delete operations generate huge disk page fragments, which reduces the query efficiency. **VACUUM FULL** can restore disk page fragments and return them to the OS.

**Step 1** Run **VACUUM FULL** on the **product_info** table.

```
openGauss=# VACUUM FULL product_info;
VACUUM
```

**Step 2** Update statistics in the **product_info** table.

```
openGauss=# ANALYZE product_info;
ANALYZE
```

**----End**

# 5.9 Step 7: Stopping GDS

Stop GDS after data is imported successfully.

## Procedure

**Step 1** Log in as user **gds_user** to the data server where GDS is installed.

**Step 2** Perform the following operations to stop GDS:

1. Query the GDS process ID. The GDS process ID is 128954.

```
ps -ef|grep gds
gds_user 128954     1  0 15:03 ?        00:00:00 gds -d /input_data/ -p 192.168.0.90:5000 -
```

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```
l /opt/bin/gds/gds_log.txt  -D
gds_user 129003 118723  0 15:04 pts/0    00:00:00 grep gds
```

2. Run the **kill** command to stop GDS. **128954** in the command is the GDS process ID.

```
kill -9 128954
```

**----End**

# 5.10 Step 8: Cleaning Up Resources

After completing operations in this tutorial, if you no longer need to use the resources created during the operations, you can delete them to avoid resource waste or quota occupation.

## Deleting the Foreign Table and Target Table

**Step 1** Run the following command to delete the target table **product_info**:

```
openGauss=# DROP TABLE product_info;
```

If the following information is displayed, the target table has been deleted:

```
DROP TABLE
```

**Step 2** Run the following command to delete the foreign table **product_info_ext**:

```
openGauss=# DROP FOREIGN TABLE product_info_ext;
```

If the following information is displayed, the foreign table has been deleted:

```
DROP FOREIGN TABLE
```

**----End**

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# 6 Application Development Guide

## 6.1 Development Specifications

If the connection pool mechanism is used during application development, comply with the following specifications:

- If GUC parameters are set in the connection, run **SET SESSION AUTHORIZATION DEFAULT;RESET ALL;** to clear the connection status before you return the connection to the connection pool.
- If a temporary table is used, delete the temporary table before you return the connection to the connection pool.

If you do not do so, the connection state in the connection pool will remain, which affects subsequent operations using the connection pool.

Compatibility:

The new driver is forward compatible with the database. However, to use the new features added to the driver and database, you must upgrade the database.

If the driver is used in a multi-thread environment:

The JDBC driver is not thread-safe and does not guarantee that the connection methods are synchronized. The caller synchronizes the calls to the driver.

Table 6-1 describes the compatibility of application development drivers.

**Table 6-1** Description of compatibility

| Driver | Compatibility |
| --- | --- |
| JDBC | The driver is forward compatible with earlier database versions. However, to use the new features added to the driver and database, you must upgrade the database. |
| ODBC, libpq, and Psycopg | The driver version must match the database version. |

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# 6.2 Obtaining the Driver Package

## Obtaining the Driver Package

Download the required packages listed in **Table 6-2**.

**Table 6-2** Driver package download list

| Version | Download Address |
| --- | --- |
| 2.*x* | **Driver package**<br>**Verification package for the driver package** |

To prevent a software package from being tampered with during transmission or storage, download the corresponding verification package and perform the following steps to verify the software package:

1. Upload the software package and verification package to the same directory on a Linux VM.
2. Run the following command to verify the integrity of the software package:

   **cat** *GaussDB_driver.zip.sha256* **| sha256sum --check**

   If **OK** is displayed in the command output, the verification is successful.

   ```
   GaussDB_driver.zip: OK
   ```

# 6.3 Development Based on JDBC

Java Database Connectivity (JDBC) is a Java API for running SQL statements. It provides unified access interfaces for different relational databases, based on which applications process data. The GaussDB library supports JDBC 4.0 and requires JDK 1.8 for code compiling. It does not support JDBC-ODBC bridge.

## 6.3.1 JDBC Package, Driver Class, and Environment Class

### JDBC Package

Obtain the driver package named **GaussDB-Kernel-*VxxxRxxxCxx-OS version number*-64bit-Jdbc.tar.gz**.

After the decompression, you will obtain the following JDBC packages in .jar format:

- **gsjdbc4.jar**: The driver class name and loading path are the same as those of PostgreSQL driver, which facilitates the migration of services running on PostgreSQL. However, some interfaces supported by **gsjdbc4.jar** are different from those supported by PostgreSQL and need to be adjusted on the service side.

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- **gsjdbc200.jar**: The driver class name and loading path are the same as those of GaussDB 200, which facilitates the migration of services running on GaussDB 200. However, some interfaces supported by **gsjdbc200.jar** are different from those supported by GaussDB 200 and need to be adjusted on the service side.
- **opengaussjdbc.jar**: The main class name is **com.huawei.opengauss.jdbc.Driver**. The URL prefix of the database connection is **jdbc:opengauss**. This driver package is recommended. This driver package is used when both PostgreSQL and GaussDB are accessed in a JVM process.

**NOTICE**

- The loading paths of driver classes in different driver packages are different, but the interface functions are the same.
- The **gsjdbc4** driver package cannot be used to operate the PostgreSQL database. Although the connection can be successfully established in some versions, some interface behaviors are different from those of PostgreSQL JDBC, which may cause unknown errors.
- The PostgreSQL driver package cannot be used to operate the GaussDB database. Although the connection can be successfully established in some versions, some interface behaviors are different from those of GaussDB JDBC, which may cause unknown errors.

## Driver Class

Before creating a database connection, load the database driver class **org.postgresql.Driver** (decompressed from **gsjdbc4.jar**).

**NOTE**

1. GaussDB is compatible with PostgreSQL in the use of JDBC. Therefore, when two JDBC drivers are used in the same process, class names may conflict.
2. JDBC of this version does not support identity & access management suite (IAM) for authentication.
3. Compared with the PostgreSQL driver, the GaussDB JDBC driver has the following enhanced features:
    1. The SHA256 encryption mode is supported for login.
    2. The third-party log framework that implements the sf4j API can be connected.
    3. Distributed load balancing at the connection level is supported.
    4. DR failover is supported.

## Environment Class

The JDK1.8 must be configured on the client. JDK supports multiple platforms such as Windows and Linux. The following uses Windows as an example to describe how to configure JDK.

**Step 1** In the MS-DOS window, run **java -version** to check the JDK version. Ensure that the version is JDK 1.8. If the JDK is not installed, download the installation package and install it.

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**Step 2** On the Windows desktop, right-click **This PC** and choose **Properties** from the shortcut menu.

**Step 3** In the displayed **System** window, click **Advanced system settings** in the navigation tree on the left.

**Step 4** In the **System Properties** dialog box, click **Environment Variables** in the lower right corner.

**Step 5** In the **System variables** area of the **Environment Variables** dialog box that is displayed, set the following variables.

| Variable | Operation | Variable Value |
| --- | --- | --- |
| JAVA_HOME | • If the variable exists, click **Edit**.<br>• If the variable does not exist, click **New**. | Specifies the Java installation directory.<br>Example: C:\Program Files\Java\jdk1.8.0_131 |
| Path | Edit | • If JAVA_HOME is configured, add **%JAVA_HOME%\bin** before the variable value.<br>• If JAVA_HOME is not configured, add the full Java installation path before the variable value:<br>C:\Program Files\Java\jdk1.8.0_131\bin; |
| CLASSPATH | New | .;%JAVA_HOME%\lib;%JAVA_HOME%\lib\tools.jar; |

**Step 6** Click **OK** and close the windows one by one.

**----End**

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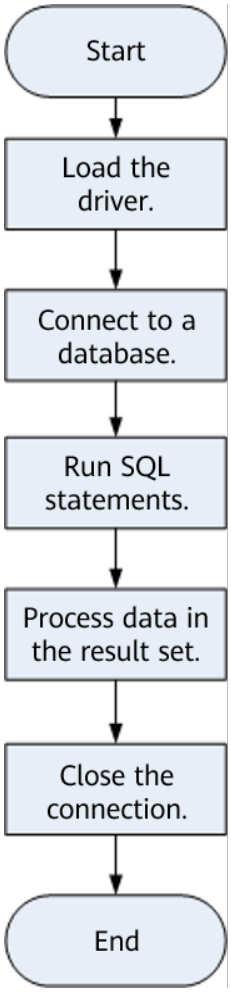
## 6.3.2 Development Process

**Figure 6-1** Application development process based on JDBC




## 6.3.3 Loading a Driver

Load the database driver before creating a database connection.

You can load the driver in the following ways:

- Before creating a connection, implicitly load the driver in the code using the Class.forName("org.postgresql.Driver") method.
- During the JVM startup, transfer the driver as a parameter to JVM using the **java -Djdbc.drivers=org.postgresql.Driver jdbctest** argument.

  NOTE

  - **jdbctest** is the name of a test application.
  - If **opengaussjdbc.jar** is used, change the driver class name to **com.huawei.opengauss.jdbc.Driver**.

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# 6.3.4 Connecting to a Database

After a database is connected, you can use JDBC to run SQL statements to operate data.

## Function Prototype

JDBC provides the following three database connection methods:

- DriverManager.getConnection(String url);
- DriverManager.getConnection(String url, Properties info);
- DriverManager.getConnection(String url, String user, String password);

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## Parameters

**Table 6-3** Database connection parameters

| Parameter | Description |
| --- | --- |
| url | **gsjdbc4.jar** database connection descriptor. The format is as follows:<br>• jdbc:postgresql: (The default database name is the same as the username.)<br>• jdbc:postgresql:database<br>• jdbc:postgresql://host/database (If the port number is not specified, the default port number is used.)<br>• jdbc:postgresql://*host*:*port*/*database*<br>• jdbc:postgresql://*host*:*port*/*database*?*param1*=*value1*&*param2*=*value2*<br>• jdbc:postgresql://*host1*:*port1*,*host2*:*port2*/*database*?*param1*=*value1*&*param2*=*value2*<br>**NOTE**<br>If **gsjdbc200.jar** is used, replace **jdbc:postgresql** with **jdbc:gaussdb**.<br>• **database** indicates the name of the database to connect.<br>• **host** indicates the name or IP address of the database server.<br>For security purposes, the database CN forbids access from other nodes in the cluster without authentication. To access the CN from inside the cluster, deploy the JDBC program on the host where the CN is located and set **host** to **127.0.0.1**. Otherwise, the error message "FATAL: Forbid remote connection with trust method!" may be displayed.<br>It is recommended that the service system be deployed outside the cluster. If it is deployed inside, database performance may be affected.<br>By default, the local host is used to connect to the server.<br>• **port** indicates the port number of the database server.<br>By default, the database on port 5431 of the local host is connected.<br>• **param** indicates a database connection attribute.<br>The parameter can be configured in the URL. The URL starts with a question mark (?), uses an equal sign (=) to assign a value to the parameter, and uses an ampersand (&) to separate parameters. You can also use the attributes of the **info** object for configuration. For details, see the example below.<br>• **value** indicates the database connection attribute values.<br>• In a distributed environment, you are advised to configure the **autoBalance** parameter for the connection strings for load balancing and configure at least two CNs to prevent connection setup failures due to node faults. |

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| Parameter | Description |
| --- | --- |
| info | Database connection attributes (all attributes are case sensitive). Common attributes are described as follows:<br>• **PGDBNAME**: string type. This parameter specifies the database name. You do not need to set this parameter in the URL because the database name is automatically parsed from the URL.<br>• **PGHOST**: string type. This parameter specifies the host IP address. Use colons (:) to separate IP addresses and port numbers, and use commas (,) to separate multiple CNs. (This parameter does not need to be set in the URL. The system automatically parses the URL to obtain its value.) For details, see the example below.<br>• **PGPORT**: integer type. This parameter specifies the host port number. Use colons (:) to separate IP addresses and port numbers, and use commas (,) to separate multiple CNs. (This parameter does not need to be set in the URL. The system automatically parses the URL to obtain its value.) For details, see the example below.<br>• **user**: string type. This parameter specifies the database user who creates the connection.<br>• **password**: string type. This parameter specifies the password of the database user.<br>• **enable_ce**: string type. If **enable_ce** is set to **1**, JDBC supports encrypted equality queries.<br>• **refreshClientEncryption**: string type. If **refreshClientEncryption** is set to **1** (default value), the encrypted database supports cache update on the client.<br>• **loggerLevel**: string type. The following log levels are supported: **OFF**, **INFO**, **DEBUG**, and **TRACE**. Set this parameter to **OFF** to disable the log function. **INFO**, **DEBUG** and **TRACE** logs record information of different levels.<br>• **loggerFile**: string type. This parameter specifies the log output path (directory and file name). If only the file name is specified and the directory is not specified, logs are generated in the client running program directory. If no path is configured or the configured path does not exist, logs are output through flows by default. This parameter has been discarded and does not take effect. To use this parameter, you can configure it in the **java.util.logging** attribute file or system attributes.<br>• **logger**: string type. It indicates the log output framework used by the JDBC driver. The JDBC driver supports the log output framework used for interconnecting with applications. Currently, only the third-party Slf4j-API-based log framework is supported. For details, see **6.2.9 Log Management**.<br>1. If this parameter is not set or is set to **JDK LOGGER**, JDK LOGGER is used.<br>2. Otherwise, the slf4j-API-based third-party log framework must be used. |

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| Parameter | Description |
| --- | --- |
| | • **allowEncodingChanges**: Boolean type. If this parameter is set to **true**, the character set type can be changed. This parameter is used together with **characterEncoding=CHARSET** to set the character set. The two parameters are separated by ampersands (&). The value of **characterEncoding** can be **UTF8**, **GBK**, or **LATIN1**.<br>• **currentSchema**: string type. This parameter specifies the schema to be set in **search-path**.<br>• **loadBalanceHosts**: Boolean type. In the default mode (disabled), multiple hosts specified in the URL are connected in sequence. If load balancing is enabled, the shuffle algorithm is used to randomly select a host from the candidate hosts to establish a connection.<br>• **autoBalance**: string type.<br>1. If this parameter is set to **true**, **balance**, or **roundrobin**, the JDBC load balancing function is enabled to balance multiple connections of an application to each CN available in the database cluster. Example: jdbc:postgresql://host1:port1,host2:port2/database?autoBalance=true<br>JDBC periodically obtains the list of available CNs in the entire cluster. For example, the obtained list is **host1:port1,host2:port2,host3:port3,host4:port4**. The **refreshCNIpListTime** parameter specifies the interval for obtaining the list, and the default value is **10s**. Hosts obtained from the CN list are data IP addresses. Generally, floating IP addresses are used in the cloud environment. Before using the load balancing capability, ensure that the access permissions of the data IP addresses have been added.<br>When **autoBalance** is enabled on **host1** and **host2**, HA is implemented only for the first connection. The JDBC driver will select available CNs from **host1**, **host2**, **host3**, and **host4** in sequence to update the available CN listm and new connections will be established on **host1**, **host2**, **host3**, and **host4** using the RoundRobin algorithm.<br>2. **priority***n* indicates that the JDBC-based load balancing function is enabled. Multiple connections of an application are balanced to the first *n* available CNs configured in the URL. When the first *n* CNs are unavailable, connections are randomly allocated to other available CNs in the database cluster. *n* is a number not less than 0 and less than the number of CNs configured in the URL. Example: jdbc:postgresql://host1:port1,host2:port2,host3:port3,host4:port4/database?autoBalance=priority2<br>JDBC periodically obtains the list of available CNs in the entire cluster (defined by **refreshCNIpListTime**). For example, the obtained list is |

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| Parameter | Description |
| --- | --- |
| | **host1:port1,host2:port2,host3:port3,host4:port4,host5:port5,host6:port6**, where **host1** and **host2** are in **AZ1**, and **host3** and **host4** are in **AZ2**.<br>The JDBC driver preferentially selects **host1** and **host2** for load balancing. If both **host1** and **host2** are unavailable, the JDBC driver randomly selects a CN from **host3**, **host4**, **host5**, and **host6** for connection.<br>3. If this parameter is set to **shuffle**, JDBC random load balancing is enabled to randomly and evenly distribute multiple connections of the application to available CNs in the database cluster. Example: jdbc:postgresql://host1:port1,host2:port2,host3:port3/database?autoBalance=shuffle<br>JDBC periodically obtains the list of available CNs in the entire cluster. For example, the obtained list is **host1:port1,host2:port2,host3:port3,host4:port4**. The **refreshCNIpListTime** parameter specifies the interval for obtaining the list, and the default value is **10s**.<br>For the first connection, **host1:port1,host2:port2,host3:port3** is used for HA. For subsequent connections, the shuffle algorithm is used to randomly select a CN from the refreshed CN list.<br>4. If this parameter is set to **false**, the JDBC load balancing and priority-based load balancing functions are disabled. The default value is **false**.<br>**CAUTION**<br>1. Load balancing is based on the connection level rather than the transaction level. If the connection is persistent and the load on the connection is unbalanced, the load on the CN may be unbalanced.<br>2. Load balancing can be used only in distributed scenarios and cannot be used in centralized scenarios.<br>• **refreshCNIpListTime**: integer type. This parameter specifies the interval at which JDBC periodically checks the status of CNs in the database cluster and obtains the IP address list of available CNs. The default value is 10 seconds.<br>• **hostRecheckSeconds**: integer type. After JDBC attempts to connect to a host, the host status is saved: connection success or connection failure. This status is trusted within the duration specified by **hostRecheckSeconds**. After the duration expires, the status becomes invalid. The default value is 10 seconds.<br>• **ssl**: Boolean type. This parameter specifies a connection in SSL mode. When **ssl** is set to **true**, the NonValidatingFactory channel and certificate mode are supported.<br>1. For the NonValidatingFactory channel, configure the username and password and set **SSL** to **true**.<br>2. In certification mode, configure the client certificate, key, and root certificate, and set **SSL** to **true**. |

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| Parameter | Description |
| --- | --- |
| | • **sslmode**: string type. This parameter specifies the SSL authentication mode. The value can be **require**, **verify-ca**, or **verify-full**.<br>– **require**: The system only attempts to set up an SSL connection. It neither checks whether the server certificate is issued by a trusted CA, nor checks whether the host name of the server is the same as that in the certificate.<br>– **verify-ca**: attempts to set up an SSL connection and checks whether the server certificate is issued by a trusted CA.<br>– **verify-full**: The system attempts to set up an SSL connection, checks whether the server certificate is issued by a trusted CA, and checks whether the host name of the server is the same as that in the certificate.<br>• **sslcert**: string type. This parameter specifies the complete path of the certificate file. The type of the client and server certificates is **End Entity**.<br>• **sslkey**: string type. This parameter specifies the complete path of the key file. You need to convert the client certificate to the DER format. For details, see **6.3.5 Connecting to the Database (Using SSL)**.<br>• **sslrootcert**: string type. This parameter specifies the name of the SSL root certificate. The root certificate type is CA.<br>• **sslpassword**: string type. This parameter is provided for ConsoleCallbackHandler.<br>• **sslpasswordcallback**: string type. This parameter specifies the class name of the SSL password provider. The default value is **org.postgresql.ssl.jdbc4.LibPQFactory.ConsoleCallbackHandler**.<br>• **sslfactory**: string type. This parameter specifies the class name used by SSLSocketFactory to establish an SSL connection.<br>• **sslprivatekeyfactory**: string type. This parameter specifies the fully qualified name of the implementation class of the **org.postgresql.ssl.PrivateKeyFactory** interface that implements the private key decryption method. If this parameter is not specified, try the default JDK private key decryption algorithm. If the decryption fails, use **org.postgresql.ssl.BouncyCastlePrivateKeyFactory**. You need to provide the **bcpkix-jdk15on.jar** package. The recommended version is 1.65 or later.<br>• **sslfactoryarg**: string type. The value is an optional parameter of the constructor function of the **sslfactory** (This parameter is not recommended).<br>• **sslhostnameverifier**: string type. This parameter specifies the class name of the host name verifier. The interface must implement javax.net.ssl.HostnameVerifier. The default value is **org.postgresql.ssl.PGjdbcHostnameVerifier**.<br>• **loginTimeout**: integer type. This parameter specifies the waiting time for establishing the database connection, in seconds. When multiple IP |

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| Parameter | Description |
| --- | --- |
| | addresses are configured in the URL, if the time for obtaining the connection exceeds the value of this parameter, the connection fails and the subsequent IP addresses are not tried.<br>• **connectTimeout**: integer type. This parameter specifies the timeout duration for connecting to a server, in seconds. If the time taken to connect to a server exceeds the value specified, the connection is interrupted. If the value is **0**, the timeout mechanism is disabled. When multiple IP addresses are configured in the URL, this parameter indicates the timeout interval for connecting to a single IP address.<br>• **socketTimeout**: integer type. This parameter specifies the timeout duration for a socket read operation, in seconds. If the time taken to read data from a server exceeds the value specified, the connection is closed. If the value is **0**, the timeout mechanism is disabled.<br>• **cancelSignalTimeout**: integer type. Cancel messages may cause a block. This parameter controls **connectTimeout** and **socketTimeout** in a cancel message, in seconds. The default value is 10 seconds.<br>• **tcpKeepAlive**: Boolean type. This parameter is used to enable or disable TCP keepalive detection. The default value is **false**.<br>• **logUnclosedConnections**: Boolean type. The client may leak a connection object because it does not call the connection object's close() method. These objects will be collected as garbage and finalized using the finalize() method. If the caller ignores this operation, this method closes the connection.<br>• **assumeMinServerVersion** (discarded): string type. This parameter indicates the version of the server to connect.<br>• **ApplicationName**: string type. This parameter specifies the name of the application that is being connected. You can query the **pgxc_stat_activity** table on the CN to view information about the client that is being connected. The name is displayed in the **application_name** column. The default value is **PostgreSQL JDBC Driver**.<br>• **connectionExtraInfo**: Boolean type. This parameter specifies whether the JDBC driver reports the driver deployment path and process owner to the database.<br>The value can be **true** or **false**. The default value is **false**. If **connectionExtraInfo** is set to **true**, the JDBC driver reports the driver deployment path, process owner, and URL connection configuration information to the database and displays the information in the **connection_info** parameter. In this case, you can query the information from **PG_STAT_ACTIVITY** or **PGXC_STAT_ACTIVITY**.<br>• **autosave**: string type. The value can be **always**, **never**, or **conservative**. The default value is **never**. This parameter specifies the action that the driver should perform upon a query failure. If **autosave** is set to **always**, the JDBC driver sets a savepoint before each query and |

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| Parameter | Description |
| --- | --- |
| | rolls back to the savepoint if the query fails. If **autosave** is set to **never**, there is no savepoint. If **autosave** is set to **conservative**, a savepoint is set for each query. However, the system rolls back and retries only when there is an invalid statement.<br>• **protocolVersion**: integer type. This parameter specifies the connection protocol version. Only versions 1 and 3 are supported. Note: If this parameter is set to **1**, only the V1 server is connected. MD5 encryption is used when this parameter is set to **3**. You need to set **password_encryption_type** to **1** to change the database encryption mode. After the cluster is restarted, create a user that uses MD5 encryption to encrypt passwords. You must also change the client connection mode to **md5** in the **pg_hba.conf** file. Log in to the system as the new user. (You are not advised to set this parameter because the MD5 encryption algorithm has lower security and poses security risks.)<br>**NOTE**<br>The MD5 encryption algorithm has lower security and poses security risks. Therefore, you are advised to use a more secure encryption algorithm.<br>• **prepareThreshold**: integer type. This parameter specifies the number of times that the PreparedStatement object is executed before the prepared statement on the server is used. The default value is **5**, indicating that when the same PreparedStatement object is executed for five or more times, the parse message is not sent to the server to parse the statement. Instead, the statement that has been parsed on the server is used.<br>• **preparedStatementCacheQueries**: integer type. This parameter specifies the maximum number of queries generated by the cache statement object of each connection. The default value is **256**. If the number of queries generated by the statement object is greater than 256, the least recently used queries will be discarded from the cache. The value **0** indicates that the cache function is disabled.<br>• **preparedStatementCacheSizeMiB**: integer type. This parameter specifies the maximum number of queries generated by the cache statement object of each connection. The unit is MB. The default value is **5**. If the size of the cached queries exceeds 5 MB, the least recently used query cache will be discarded. The value **0** indicates that the cache function is disabled.<br>• **databaseMetadataCacheFields**: integer type. The default value is **65536**. This parameter specifies the maximum number of columns that can be cached in each connection. The value **0** indicates that the cache function is disabled.<br>• **databaseMetadataCacheFieldsMiB**: integer type. The default value is **5**. This parameter indicates the maximum size of columns that can be cached in each connection, in MB. The value **0** indicates that the cache function is disabled. |

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| Parameter | Description |
| --- | --- |
| | • **stringtype**: string type. The value can be **unspecified** or **varchar**. This parameter specifies the type of the **PreparedStatement** parameter used by the setString() method. If **stringtype** is set to **varchar**, these parameters are sent to the server as varchar parameters. If **stringtype** is set to **unspecified**, these parameters are sent to the server as an untyped value, and the server attempts to infer their appropriate type.<br>• **batchMode**: string type. This parameter specifies whether to connect the database in batch mode. The default value is **on**, indicating that the batch mode is enabled.<br>• **fetchsize**: integer type. This parameter specifies the default fetchsize for statements in the created connection. The default value is **0**, indicating that all results are obtained at a time. It is equivalent to **defaultRowFetchSize**.<br>• **reWriteBatchedInserts**: Boolean type. During batch import, set this parameter to **true** to combine *N* insertion statements into one: **insert into TABLE_NAME values(values1, ..., valuesN), ..., (values1, ..., valuesN)**. To use this parameter, set **batchMode** to **off**.<br>• **unknownLength**: integer type. The default value is **Integer.MAX_VALUE**. This parameter specifies the length of the unknown length type when the data of some postgresql types (such as TEXT) is returned by functions such as ResultSetMetaData.getColumnDisplaySize and ResultSetMetaData.getPrecision.<br>• **defaultRowFetchSize**: integer type. This parameter specifies the number of rows read by fetch in ResultSet at a time. Limiting the number of rows read each time in a database access request can avoid unnecessary memory consumption, thereby avoiding out of memory exception. The default value is **0**, indicating that all rows are obtained at a time in ResultSet. This parameter cannot be set to a negative value.<br>• **binaryTransfer**: Boolean type. This parameter specifies whether data is sent and received in binary format. The default value is **false**.<br>• **binaryTransferEnable**: string type. This parameter specifies the type for which binary transmission is enabled. Every two types are separated by commas (,). You can select either the OID or name, for example, **binaryTransferEnable=INT4_ARRAY,INT8_ARRAY**.<br>For example, if the OID name is **BLOB** and the OID number is **88**, you can configure the OID as follows:<br>**binaryTransferEnable=BLOB** or **binaryTransferEnable=88**<br>• **binaryTransferDisEnable**: string type. This parameter specifies the type for which binary transmission is disabled. Every two types are separated by commas (,). You can select either the OID or name. The value of this parameter overwrites the value of **binaryTransferEnable**.<br>• **blobMode**: string type. This parameter is used to set the data type of parameters bound to the setBinaryStream method. If the value is **on**, |

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| Parameter | Description |
| --- | --- |
| | the data type is blob. If the value is **off**, the data type is bytea. The default value is **on**. You are advised to set this parameter to **on** for systems migrated from Oracle and MySQL and to **off** for systems migrated from PostgreSQL.<br>• **socketFactory**: string type. This parameter specifies the name of the class used to create a socket connection with the server. This class must implement the **javax.net.SocketFactory** interface and define a constructor with no parameter or a single string parameter.<br>• **socketFactoryArg**: string type. The value is an optional parameter of the constructor function of the socketFactory class and is not recommended.<br>• **receiveBufferSize**: integer type. This parameter is used to set **SO_RCVBUF** on the connection stream.<br>• **sendBufferSize**: integer type. This parameter is used to set **SO_SNDBUF** on the connection stream.<br>• **preferQueryMode**: string type. The value can be **extended**, **extendedForPrepared**, **extendedCacheEverything**, or **simple**. This parameter specifies the query mode. The default value is **extended**. In **simple** mode, only the Q message in text mode can be sent. The parse and bind messages are not supported. In **extended** mode, parse, bind, and execute messages are used. In **extendedForPrepared** mode, only the prepared statement object uses extended query, and the statement object uses only simple query. The **extendedCacheEverything** mode caches the query generated by each statement object.<br>• **ApplicationType**: string type. The value can be **not_perfect_sharding_type** or **perfect_sharding_type**. It indicates whether to enable distributed write and query. The default value is **not_perfect_sharding_type**. Distributed write and query are enabled if this parameter is set to **not_perfect_sharding_type**. If it is set to **perfect_sharding_type**, distributed write and query are disabled by default. Distributed write and query can be performed only when **/* multinode */** is added to the SQL statement. This parameter is valid only when the database is in the GTM-free scenario.<br>• **priorityServers**: integer type. This value is used to specify the first *n* nodes configured in the URL as the primary cluster to be connected preferentially. The default value is **null**. The value is a number greater than 0 and less than the number of CNs configured in the URL. It is used in streaming DR scenarios.<br>Example: jdbc:postgresql://host1:port1,host2:port2,host3:port3,host4:port4,/database?priorityServers=2. That is, **host1** and **host2** are primary cluster nodes, and **host3** and **host4** are DR cluster nodes.<br>• **usingEip**: Boolean type. The value specifies whether to use the elastic IP address for load balancing. The default value is **true**, indicating that |

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| Parameter | Description |
| --- | --- |
| | an elastic IP address is used for load balancing. The value **false** indicates that a data IP address is used for load balancing.<br>• **iamUser**: string type. The fully-encrypted database encrypts data on the client. During encryption, you can access the Key Management Service (KMS) provided by Huawei Cloud to obtain keys. When accessing the KMS, you need to provide the IAM identity authentication information and KMS project information. **iamUser** and **iamPassword** are used to set identity authentication information. **kmsDomain**, **kmsProjectId**, and **kmsProjectName** are used to set KMS project information. To obtain the preceding five parameters, log in to the Huawei Cloud official website and choose **Console** > **My Credential**.<br>• **iamPassword**: string type, used to set the password of the IAM user.<br>• **kmsDoamin**: string type, used to set the Huawei Cloud account to which the KMS belongs.<br>• **kmsProjectName**: string type, used to set the deployment zone of a KMS project. KMS projects deployed in different zones are isolated from each other.<br>• **kmsProjectId**: string type, used to set the ID of a KMS project.<br>• **traceInterfaceClass**: string type. The default value is **null**, which is used to obtain the implementation class of **traceId**. The value is the fully qualified name of the implementation class of the **org.postgresql.log.Tracer** API that implements the method for obtaining **traceId**.<br>• **use_boolean**: Boolean type. This parameter is used to set the OID type bound to the setBoolean method in extended mode. The default value is **false**, indicating that the int2 type is bound. The value **true** indicates that the Boolean type is bound.<br>• **allowReadOnly**: Boolean type. This parameter specifies whether the read-only mode is allowed. The default value is **true**, indicating that the read-only mode is allowed. If this parameter is set to **false**, the read-only mode is disabled.<br>• **TLSCiphersSupperted**: string type. This parameter is used to set the supported TLS encryption suite. The default value is **TLS_DHE_RSA_WITH_AES_128_GCM_SHA256,TLS_DHE_RSA_WITH_AES_256_GCM_SHA384,TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256,TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384,TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256,TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384**.<br>• **stripTrailingZeros**: Boolean type. The default value is **false**. If this parameter is set to **true**, trailing 0s of the numeric type are removed. This parameter is valid only for **ResultSet.getObject(int columnIndex)**.<br>• **enableTimeZone**: Boolean type. The default value is **true**. This parameter specifies whether to enable the time zone setting on the |

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| Parameter | Description |
| --- | --- |
| | server. The value **true** indicates that the JVM time zone is obtained to specify the database time zone. The value **false** indicates that the database time zone is used.<br>• **socketTimeoutInConnecting**: integer type. The default value is **5s**. It specifies the timeout value for a socket read operation during connection establishment. If the time taken to read data from a server exceeds the value specified during connection establishment, the connection is closed. If the value is **0**, the timeout mechanism is disabled. |
| user | Database user. |
| password | Password of the database user. |

NOTE

After the **uppercaseAttributeName** parameter is enabled, if the database contains metadata with a mixture of uppercase and lowercase letters, only the metadata in lowercase letters can be queried and output in uppercase letters. Before using the metadata, ensure that the metadata is stored in lowercase letters to prevent data errors.

## Examples

```
// The following uses gsjdbc4.jar as an example.
// The following code encapsulates database connection operations into an interface. The database can then be connected using an authorized username and a password.
public static Connection getConnect(String username, String passwd)
   {
      // Driver class.
      String driver = "org.postgresql.Driver";
      // Database connection descriptor.
      String sourceURL = "jdbc:postgresql://10.10.0.13:8000/postgres";
      Connection conn = null;

      try
      {
         // Load the driver.
         Class.forName(driver);
      }
      catch( Exception e )
      {
         e.printStackTrace();
         return null;
      }

      try
      {
          // Create a connection.
         conn = DriverManager.getConnection(sourceURL, username, passwd);
         System.out.println("Connection succeed!");
```

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```
        }
        catch(Exception e)
        {
            e.printStackTrace();
            return null;
        }

        return conn;
    }
// The following code uses the Properties object as a parameter to establish a connection.
public static Connection getConnectUseProp(String username, String passwd)
    {
        // Driver class.
        String driver = "org.postgresql.Driver";
        // Database connection descriptor.
        String sourceURL = "jdbc:postgresql://10.10.0.13:8000/postgres?autoBalance=true";
        Connection conn = null;
        Properties info = new Properties();

        try
        {
            // Load the driver.
            Class.forName(driver);
        }
        catch( Exception e )
        {
            e.printStackTrace();
            return null;
        }

        try
        {
             info.setProperty("user", username);
             info.setProperty("password", passwd);
             // Create a connection.
             conn = DriverManager.getConnection(sourceURL, info);
             System.out.println("Connection succeed!");
        }
        catch(Exception e)
        {
            e.printStackTrace();
            return null;
        }

        return conn;
    }
```

# 6.3.5 Connecting to the Database (Using SSL)

When establishing connections to the GaussDB server using JDBC, you can enable SSL connections to encrypt client and server communications for security of sensitive data transmission on the Internet. This section describes how applications establish an SSL connection to GaussDB using JDBC. To start the SSL mode, you must have the server certificate, client certificate, and private key files. For details on how to obtain these files, see related documents and commands of OpenSSL.

## Configuring the Client

Unlike GSQL program, the JDBC driver supports server certificate validation by default. If a CA certificate is in use, no configuration is required because Java has copies of the most common CAs' certificates. If a self-signed license is in use, a client program must be configured based on the openssl or Java keytool for license authentication. The procedure is as follows:

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> **NOTE**
>
> If the built-in certificate is used, the following steps are valid.

**Step 1** Upload the certificate file on the client.

1. Log in to the host where the client resides as a common user.
2. Create the **/tmp/cacert** directory.
   ```
   mkdir /tmp/cacert
   ```
3. Save the root certificate file, client certificate file, and private key file to the created directory.

**Step 2** Import the root certificate to TrustStore.

```
openssl x509 -in cacert.pem -out cacert.crt.der -outform der
```

Generate the intermediate file **cacert.crt.der**.

```
keytool -keystore mytruststore -alias cacert -import -file cacert.crt.der
```

Enter the trustStorePassword (for example, **xxxxxxxxx**) as prompted to generate **mytruststore**.

- **cacert.pem** indicates the root certificate.
- **cacert.crt.der** indicates the intermediate file.
- **mytruststore** indicates the generated KeyStore name. You can change the name and its alias as needed.

**Step 3** Import the client certificate and key to KeyStore.

```
openssl pkcs12 -export -out client.pkcs12 -in client.crt -inkey client.key
```

Enter the clientkey (for example, **xxxxxxxxx**) as prompted to generate **client.pkcs12**.

```
keytool -importkeystore -deststorepass xxxxxxxxxx -destkeystore client.jks -srckeystore client.pkcs12 -srcstorepass xxxxxxxxx -srcstoretype PKCS12 -alias 1 -destkeypass xxxxxxxxx
```

**deststorepass** must be consistent with **destkeypass**, and **srcstorepass** must be the same as the export password in the preceding command. Generate **client.jks**.

**----End**

## Examples

Note: Select either example 1 or example 2.

```
public class SSL{
    public static void main(String[] args) {
        Properties urlProps = new Properties();
        String urls = "jdbc:postgresql://10.29.37.136:8000/postgres";

        /**
         * ================== Example 1: Use the NonValidatingFactory channel.
         */
        urlProps.setProperty("sslfactory","org.postgresql.ssl.NonValidatingFactory");
        urlProps.setProperty("user", "world");
        urlProps.setProperty("password", "test@123");
        urlProps.setProperty("ssl", "true");
        /**
         * ==================  Examples 2: Use a certificate.
         */
        urlProps.setProperty("sslcert", "client.crt");
        urlProps.setProperty("sslkey", "client.key.pk8");
```

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```
        urlProps.setProperty("sslrootcert", "cacert.pem");
        urlProps.setProperty("user", "world");
        urlProps.setProperty("ssl", "true");
        /* sslmode can be set to require, verify-ca, or verify-full. Select one from the following three
examples.*/
       /* ================== Example 2.1: Set sslmode to require to use the certificate for authentication.
*/
        urlProps.setProperty("sslmode", "require");
       /* ================== Example 2.2: Set sslmode to verify-ca to use the certificate for
authentication. */
        urlProps.setProperty("sslmode", "verify-ca");
       /* ================== Example 2.3: Set sslmode to verify-full to use the certificate (in the Linux
OS) for authentication. */
        urls = "jdbc:postgresql://world:8000/postgres";
        urlProps.setProperty("sslmode", "verify-full");

        try {
            Class.forName("org.postgresql.Driver").newInstance();
        } catch (Exception e) {
            e.printStackTrace();
        }
        try {
            Connection conn;
            conn = DriverManager.getConnection(urls,urlProps);
            conn.close();
        } catch (Exception e) {
            e.printStackTrace();
        }
    }
}
/**
 * Note: Convert the client key to the DER format.
 * openssl pkcs8 -topk8 -outform DER -in client.key -out client.key.pk8 -nocrypt
 * openssl pkcs8 -topk8 -inform PEM -in client.key -outform DER -out client.key.der -v1 PBE-MD5-DES
 * openssl pkcs8 -topk8 -inform PEM -in client.key -outform DER -out client.key.der -v1 PBE-SHA1-3DES
 * The preceding algorithms are not recommended due to their low security.
 * If the customer needs to use a higher-level private key encryption algorithm, the following private key
encryption algorithms can be used after the BouncyCastle or a third-party private key is used to decrypt the
password package:
 * openssl pkcs8 -in client.key -topk8  -outform DER -out client.key.der -v2 AES128
 * openssl pkcs8 -in client.key -topk8  -outform DER -out client.key.der -v2 aes-256-cbc -iter 1000000
 * openssl pkcs8 -in client.key -topk8 -out client.key.der  -outform Der -v2 aes-256-cbc -v2prf
hmacWithSHA512
 * Enable BouncyCastle: Introduce the bcpkix-jdk15on.jar package for projects that use JDBC. The
recommended version is 1.65 or later.
 */
```

## 6.3.6 Connecting to a Database (Using UDS)

The Unix domain socket is used for data exchange between different processes on the same host. You can add **junixsocket** to obtain the socket factory.

The **junixsocket-core-*XXX*.jar**, **junixsocket-common-*XXX*.jar**, and **junixsocket-native-common-*XXX*.jar** JAR packages need to be referenced. In addition, you need to add **socketFactory=org.newsclub.net.unix.AFUNIXSocketFactory$FactoryArg&socketFactoryArg=** *[path-to-the-unix-socket]* to the URL connection string.

Example:

```
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.Statement;
import java.util.Properties;

public class Test {
    public static void main(String[] args) {
```

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```
        String driver = "org.postgresql.Driver";
        Connection conn;
        try {
            Class.forName(driver).newInstance();
            Properties properties = new Properties();
            properties.setProperty("user", "username");
            properties.setProperty("password", "password");
            conn = DriverManager.getConnection("jdbc:postgresql://localhost:8000/postgres?
socketFactory=org.newsclub" +
                            ".net.unix" +
                            ".AFUNIXSocketFactory$FactoryArg&socketFactoryArg=/data/tmp/.s.PGSQL.8000",
                    properties);
            System.out.println("Connection Successful!");
            Statement statement = conn.createStatement();
            statement.executeQuery("select 1");
        } catch (Exception e) {
            e.printStackTrace();
        }
    }
}
```

**NOTICE**

- Set the **socketFactoryArg** parameter based on the actual path. The value must be the same as that of the GUC parameter **unix_socket_directory**.
- The connection host name must be set to **localhost**.

# 6.3.7 Running SQL Statements

## Running a Common SQL Statement

To enable an application to operate data in the database by running SQL statements (statements that do not need to transfer parameters), perform the following operations:

**Step 1** Create a statement object by calling the **createStatement** method in **Connection**.

```
Connection conn = DriverManager.getConnection("url","user","password");
Statement stmt = conn.createStatement();
```

**Step 2** Run the SQL statement by calling the **executeUpdate** method in **Statement**.

```
int rc = stmt.executeUpdate("CREATE TABLE customer_t1(c_customer_sk INTEGER, c_customer_name
VARCHAR(32));");
```

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NOTE

- If an execution request (not in a transaction block) received in the database contains multiple statements, the request is packed into a transaction. The VACUUM operation is not supported in a transaction block. If one of the statements fails, the entire request will be rolled back.
- Use semicolons (;) to separate statements. Stored procedures, functions, and anonymous blocks do not support multi-statement execution. When **preferQueryMode** is set to **simple**, the statement does not execute the parsing logic, and the semicolons (;) cannot be used to separate statements in this scenario.
- The slash (/) can be used as the terminator for creating a single stored procedure, function, anonymous block, or package body. When **preferQueryMode** is set to **simple**, the statement does not execute the parsing logic, and the slash (/) cannot be used as the terminator in this scenario.
- When **prepareThreshold** is set to **1**, each SQL statement executed by the statement is cached because cached statements are not evicted by default (default value of **preferQueryMode**). As a result, memory bloat may occur. In this case, set **preferQueryMode** to **extendedCacheEverything** to evict cached statements.

**Step 3** Close the statement object.

```
stmt.close();
```

**----End**

## Running a Prepared SQL Statement

Prepared statements are complied and optimized once but can be used in different scenarios by assigning multiple values. Using prepared statements improves execution efficiency. If you want to run a statement for several times, use a precompiled statement. Perform the following operations:

**Step 1** Create a prepared statement object by calling the **prepareStatement** method in **Connection.**

```
PreparedStatement pstmt = con.prepareStatement("UPDATE customer_t1 SET c_customer_name = ? WHERE c_customer_sk = 1");
```

**Step 2** Set parameters by calling the **setShort** method in **PreparedStatement**.

```
pstmt.setShort(1, (short)2);
```

**Step 3** Run the prepared statement by calling the **executeUpdate** method in **PreparedStatement**.

```
int rowcount = pstmt.executeUpdate();
```

**Step 4** Close the prepared statement object by calling the **close** method in **PreparedStatement**.

```
pstmt.close();
```

**----End**

## Calling a Stored Procedure

To call an existing stored procedure by using JDBC in GaussDB, perform the following operations:

**Step 1** Create a call statement object by calling the **prepareCall** method in **Connection**.

```
Connection myConn = DriverManager.getConnection("url","user","password");
CallableStatement cstmt = myConn.prepareCall("{? = CALL TESTPROC(?,?,?)}");
```

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**Step 2** Set parameters by calling the **setInt** method in **CallableStatement**.

```
cstmt.setInt(2, 50);
cstmt.setInt(1, 20);
cstmt.setInt(3, 90);
```

**Step 3** Register an output parameter by calling the **registerOutParameter** method in **CallableStatement**.

```
cstmt.registerOutParameter(4, Types.INTEGER);  // Register an OUT parameter of the integer type.
```

**Step 4** Call the stored procedure by calling the **execute** method in **CallableStatement**.

```
cstmt.execute();
```

**Step 5** Obtain the output parameter by calling the **getInt** method in **CallableStatement**.

```
int out = cstmt.getInt(4);  // Obtain the OUT parameter.
```

Example:

```
// The following stored procedure (containing the OUT parameter) has been created:
create or replace procedure testproc
(
    psv_in1 in integer,
    psv_in2 in integer,
    psv_inout in out integer
)
as
begin
    psv_inout := psv_in1 + psv_in2 + psv_inout;
end;
/
```

**Step 6** Close the call statement by calling the **close** method in **CallableStatement**.

```
cstmt.close();
```

NOTE

- Many database classes such as Connection, Statement, and ResultSet have a close() method. Close these classes after using their objects. Closing Connection will close all the related Statements, and closing a Statement will close its ResultSet.
- Some JDBC drivers support named parameters, which can be used to set parameters by name rather than sequence. If a parameter has the default value, you do not need to specify any parameter value but can use the default value directly. Even though the parameter sequence changes during a stored procedure, the application does not need to be modified. Currently, the GaussDB JDBC driver does not support this method.
- GaussDB does not support functions containing OUT parameters, or stored procedures and function parameters containing default values.
- When you bind parameters in **myConn.prepareCall("{? = CALL TESTPROC(?,?,?)}")** during a stored procedure calling, you can bind parameters according to the placeholders sequence and register the first or the fourth parameter as the output parameter. The preceding example registers the fourth parameter.

NOTICE

- If JDBC is used to call a stored procedure whose returned value is a cursor, the returned cursor cannot be used.
- A stored procedure and an SQL statement must be run separately.
- Output parameters must be registered for parameters of the inout type in the stored procedure.

**----End**

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## Batch Processing

When a prepared statement processes multiple pieces of similar data, the database creates only one execution plan. This improves compilation and optimization efficiency. Perform the following operations:

**Step 1** Create a prepared statement object by calling the **prepareStatement** method in **Connection.**

```
Connection conn = DriverManager.getConnection("url","user","password");
PreparedStatement pstmt = conn.prepareStatement("INSERT INTO customer_t1 VALUES (?)");
```

**Step 2** Call the setShort parameter for each piece of data, and call addBatch to confirm that the setting is complete.

```
pstmt.setShort(1, (short)2);
pstmt.addBatch();
```

**Step 3** Perform batch processing by calling the **executeBatch** method in **PreparedStatement**.

```
int[] rowcount = pstmt.executeBatch();
```

**Step 4** Close the prepared statement object by calling the **close** method in **PreparedStatement**.

```
pstmt.close();
```

NOTE

Do not terminate a batch processing action when it is ongoing; otherwise, database performance will deteriorate. Therefore, disable automatic commit during batch processing. Manually commit several rows at a time. The statement for disabling automatic commit is **conn.setAutoCommit(false);**.

**----End**

## Adding Single-Shard Execution Syntaxes to Statements

**Step 1** Set the **nodeName** parameter by calling **setClientInfo("nodeName","dnx")** in **Connection**.

```
Connection conn = getConnection();
conn.setClientInfo("nodeName","datanode1");
```

**Step 2** Execute the SQL statements by using the **executeQuery(String sql)** and **execute(String sql)** methods in **Statement** and the **executeQuery()** and **execute()** methods in **PreparedStatement**.

```
PreparedStatement pstm = conn.prepareStatement("select * from test");
pstm.execute();
pstm.executeQuery();
Statement stmt=conn.createStatement();
stmt.execute("select * from test");
stmt.executeQuery("select * from test");
```

**Step 3** Set the parameter to an empty string to disable it.

```
conn.setClientInfo("nodeName","");
```

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**NOTICE**

1. This function is adapted based on the single-shard execution function of the kernel. Therefore, before using this function, check whether the database kernel supports single-shard execution.
2. After the parameter is enabled, you must manually disable it. Otherwise, the execution of other query statements will be affected.
3. Once this parameter is enabled, all statements of the current connection will be executed on a specified DN.
4. After the parameter is enabled, the cache mechanism of **PreparedStatement** will be affected, cached statements will be cleared, and subsequent statements executed for single-shard queries will not be cached until the parameter is disabled.
5. The parameter is a connection parameter. Therefore, the parameter value takes effect once. The API cannot be used to execute the statements on different shards at the same time.

**----End**

# 6.3.8 Processing Data in a Result Set

## Setting a Result Set Type

Different types of result sets apply to different application scenarios. Applications select proper types of result sets based on requirements. Before running an SQL statement, you must create a statement object. Some methods of creating statement objects can set the type of a result set. **Table 6-4** lists result set parameters. The related Connection methods are as follows:

```
// Create a Statement object. This object will generate a ResultSet object with a specified type and concurrency.
createStatement(int resultSetType, int resultSetConcurrency);

// Create a PreparedStatement object. This object will generate a ResultSet object with a specified type and concurrency.
prepareStatement(String sql, int resultSetType, int resultSetConcurrency);

// Create a CallableStatement object. This object will generate a ResultSet object with a specified type and concurrency.
prepareCall(String sql, int resultSetType, int resultSetConcurrency);
```

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**Table 6-4** Result set types

| Parameter | Description |
| --- | --- |
| resultSetType | Type of a result set. There are three types of result sets:<br>• **ResultSet.TYPE_FORWARD_ONLY**: The ResultSet object can only be navigated forward. It is the default value.<br>• **ResultSet.TYPE_SCROLL_SENSITIVE**: You can view the modified result by scrolling to the modified row.<br>• **ResultSet.TYPE_SCROLL_INSENSITIVE**: The ResultSet object is insensitive to changes in the underlying data source.<br>**NOTE**<br>After a result set has obtained data from the database, the result set is insensitive to data changes made by other transactions, even if the result set type is **ResultSet.TYPE_SCROLL_SENSITIVE**. To obtain up-to-date data of the record pointed by the cursor from the database, call the refreshRow() method in a ResultSet object. |
| resultSetConcurrency | Concurrency type of a result set. There are two types of concurrency.<br>• **ResultSet.CONCUR_READ_ONLY**: Data in a result set cannot be updated except that an updated statement has been created in the result set data.<br>• **ResultSet.CONCUR_UPDATEABLE**: changeable result set. The concurrency type for a result set object can be updated if the result set is scrollable. |

## Positioning a Cursor in a Result Set

ResultSet objects include a cursor pointing to the current data row. The cursor is initially positioned before the first row. The next method moves the cursor to the next row from its current position. When a ResultSet object does not have a next row, a call to the next method returns **false**. Therefore, this method is used in the while loop for result set iteration. However, the JDBC driver provides more cursor positioning methods for scrollable result sets, which allows positioning cursor in the specified row. **Table 6-5** describes these methods.

**Table 6-5** Methods for positioning a cursor in a result set

| Method | Description |
| --- | --- |
| next() | Moves cursor to the next row from its current position. |
| previous() | Moves cursor to the previous row from its current position. |
| beforeFirst() | Places cursor before the first row. |

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| Method | Description |
| --- | --- |
| afterLast() | Places cursor after the last row. |
| first() | Places cursor to the first row. |
| last() | Places cursor to the last row. |
| absolute(int) | Places cursor to a specified row. |
| relative(int) | Moves the row specified by the parameter forward (that is, the value is 1, which is equivalent to next()) or backward (that is, the value is -1, which is equivalent to previous()). |

## Obtaining the Cursor Position from a Result Set

This cursor positioning method will be used to change the cursor position for a scrollable result set. The JDBC driver provides a method to obtain the cursor position in a result set. **Table 6-6** describes these methods.

**Table 6-6** Methods for obtaining a cursor position in a result set

| Method | Description |
| --- | --- |
| isFirst() | Checks whether the cursor is in the first row. |
| isLast() | Checks whether the cursor is in the last row. |
| isBeforeFirst() | Checks whether the cursor is before the first row. |
| isAfterLast() | Checks whether the cursor is after the last row. |
| getRow() | Gets the current row number of the cursor. |

## Obtaining Data from a Result Set

ResultSet objects provide a variety of methods to obtain data from a result set. **Table 6-7** describes the common methods for obtaining data. If you want to know more about other methods, see JDK official documents.

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**Table 6-7** Common methods for obtaining data from a result set

| Method | Description |
| --- | --- |
| int getInt(int columnIndex) | Retrieves the value of the column designated by a column index in the current row as an integer. |
| int getInt(String columnLabel) | Retrieves the value of the column designated by a column label in the current row as an integer. |
| String getString(int columnIndex) | Retrieves the value of the column designated by a column index in the current row as a string. |
| String getString(String columnLabel) | Retrieves the value of the column designated by a column label in the current row as a string. |
| Date getDate(int columnIndex) | Retrieves the value of the column designated by a column index in the current row as a date. |
| Date getDate(String columnLabel) | Retrieves the value of the column designated by a column name in the current row as a date. |

## 6.3.9 Closing a Connection

After you complete required data operations in the database, close the database connection.

Call the close method to close the connection, for example, **Connection conn = DriverManager.getConnection("url","user","password"); conn.close();**

## 6.3.10 Log Management

The GaussDB JDBC driver uses log records to help solve problems when the GaussDB JDBC driver is used in applications. GaussDB JDBC supports the following log management methods:

1. Use the SLF4J log framework for interconnecting with applications.
2. Use the JdkLogger log framework for interconnecting with applications.

SLF4J and JdkLogger are mainstream frameworks for Java application log management in the industry. For details about how to use these frameworks, see the official documents (SLF4J: **http://www.slf4j.org/manual.html**; JdkLogger: **https://docs.oracle.com/javase/8/docs/technotes/guides/logging/overview.html**).

Method 1: Use the SLF4J log framework for interconnecting with applications.

When a connection is set up, **logger=Slf4JLogger** is configured in the URL.

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The SLF4J may be implemented by using Log4j or Log4j2. When the Log4j is used to implement the SLF4J, the following JAR packages need to be added: **log4j-*.jar**, **slf4j-api-*.jar**, and **slf4j-log4*-*.jar** (* varies according to versions), and configuration file **log4j.properties**. If the Log4j2 is used to implement the SLF4J, you need to add the following JAR packages: **log4j-api-*.jar**, **log4j-core-*.jar**, **log4j-slf4j18-impl-*.jar**, and **slf4j-api-*-alpha1.jar** (* varies according to versions), and configuration file **log4j2.xml**.

This method supports log management and control. The SLF4J can implement powerful log management and control functions through related configurations in files. This method is recommended.

Example:

```
public static Connection GetConnection(String username, String passwd){

    String sourceURL = "jdbc:postgresql://10.10.0.13:8000/postgres?logger=Slf4JLogger";
    Connection conn = null;

    try{
// Create a connection.
        conn = DriverManager.getConnection(sourceURL,username,passwd);
        System.out.println("Connection succeed!");
    }catch (Exception e){
        e.printStackTrace();
        return null;
    }
    return conn;
}
```

The following is an example of the **log4j.properties** file:

```
log4j.logger.org.postgresql=ALL, log_gsjdbc

# Default file output configuration
log4j.appender.log_gsjdbc=org.apache.log4j.RollingFileAppender
log4j.appender.log_gsjdbc.Append=true
log4j.appender.log_gsjdbc.File=gsjdbc.log
log4j.appender.log_gsjdbc.Threshold=TRACE
log4j.appender.log_gsjdbc.MaxFileSize=10MB
log4j.appender.log_gsjdbc.MaxBackupIndex=5
log4j.appender.log_gsjdbc.layout=org.apache.log4j.PatternLayout
log4j.appender.log_gsjdbc.layout.ConversionPattern=%d %p %t %c - %m%n
log4j.appender.log_gsjdbc.File.Encoding = UTF-8
```

The following is an example of the **log4j2.xml** file:

```
<?xml version="1.0" encoding="UTF-8"?>
<configuration status="OFF">
    <appenders>
        <Console name="Console" target="SYSTEM_OUT">
            <PatternLayout pattern="%d %p %t %c - %m%n"/>
        </Console>
        <File name="FileTest" fileName="test.log">
            <PatternLayout pattern="%d %p %t %c - %m%n"/>
        </File>
        <!-- JDBC driver log file output configuration. Log rewinding is supported. When the log size exceeds
10 MB, a new file is created. The new file is named in the format of yyyy-mm-dd-file ID. -->
        <RollingFile name="RollingFileJdbc" fileName="gsjdbc.log" filePattern="%d{yyyy-MM-dd}-%i.log">
            <PatternLayout pattern="%d %p %t %c - %m%n"/>
            <Policies>
                <SizeBasedTriggeringPolicy size="10 MB"/>
            </Policies>
        </RollingFile>
    </appenders>
    <loggers>
        <root level="all">
```

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```
        <appender-ref ref="Console"/>
        <appender-ref ref="FileTest"/>
    </root>
    <!-- JDBC driver logs. The log level is all. All logs can be viewed and exported to the gsjdbc.log file. -->
    <!-- If opengaussjdbc.jar is used, replace org.postgresql with com.huawei.opengauss.jdbc.Driver.-->
    <logger name="org.postgresql" level="all" additivity="false">
        <appender-ref ref="RollingFileJdbc"/>
    </logger>
  </loggers>
</configuration>
```

Method 2: Use the JdkLogger log framework for interconnecting with applications.

The default Java logging framework stores its configurations in a file named **logging.properties**. Java installs the global configuration file in the folder in the Java installation directory. The **logging.properties** file can also be created and stored with a single project.

Configuration example of **logging.properties**:

```
# Specify the processing program as a file.
handlers= java.util.logging.FileHandler

# Specify the default global log level.
.level= ALL

# Specify the log output control standard.
java.util.logging.FileHandler.level=ALL
java.util.logging.FileHandler.pattern = gsjdbc.log
java.util.logging.FileHandler.limit = 500000
java.util.logging.FileHandler.count = 30
java.util.logging.FileHandler.formatter = java.util.logging.SimpleFormatter
java.util.logging.FileHandler.append=false
```

The following is a code example:

```
System.setProperty("java.util.logging.FileHandler.pattern","jdbc.log");
FileHandler fileHandler = new FileHandler(System.getProperty("java.util.logging.FileHandler.pattern"));
Formatter formatter = new SimpleFormatter();
fileHandler.setFormatter(formatter);
Logger logger = Logger.getLogger("org.postgresql");
logger.addHandler(fileHandler);
logger.setLevel(Level.ALL);
logger.setUseParentHandlers(false);
```

**Link trace function**

The GaussDB JDBC driver provides the application-to-database link trace function to associate discrete SQL statements on the database side with application requests. This function requires application developers to implement the **org.postgresql.log.Tracer** API class and specify the full name of the API implementation class in the URL.

URL example:

```
String URL = "jdbc:postgresql://127.0.0.1:8000/postgres?
traceInterfaceClass=xxx.xxx.xxx.OpenGaussTraceImpl";
```

The **org.postgresql.log.Tracer** API class is defined as follows:

```
public interface Tracer {
// Retrieves the value of traceId.
String getTraceId();
}
```

The following is an example of the **org.postgresql.log.Tracer** API implementation class:

```
import org.postgresql.log.Tracer;
```

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```
public class OpenGaussTraceImpl implements Tracer {
    private static MDC mdc = new MDC();

    private final String TRACE_ID_KEY = "traceId";

    public void set(String traceId) {
        mdc.put(TRACE_ID_KEY, traceId);
    }

    public void reset() {
        mdc.clear();
    }

    @Override
    public String getTraceId() {
        return mdc.get(TRACE_ID_KEY);
    }
}
```

The following is an example of context mapping which is used to store **traceId** generated for different requests.

```
import java.util.HashMap;

public class MDC {
    static final private ThreadLocal<HashMap<String, String>> threadLocal = new ThreadLocal<>();

    public void put(String key, String val) {
        if (key == null || val == null) {
            throw new IllegalArgumentException("key or val cannot be null");
        } else {
            if (threadLocal.get() == null) {
                threadLocal.set(new HashMap<>());
            }
            threadLocal.get().put(key, val);
        }
    }

    public String get(String key) {
        if (key == null) {
            throw new IllegalArgumentException("key cannot be null");
        } else if (threadLocal.get() == null) {
            return null;
        } else {
            return threadLocal.get().get(key);
        }
    }

    public void clear() {
        if (threadLocal.get() == null) {
            return;
        } else {
            threadLocal.get().clear();
        }
    }
}
```

The following is an example of using **traceId**:

```
String traceId = UUID.randomUUID().toString().replaceAll("-", "");
openGaussTrace.set(traceId);
pstm = con.prepareStatement("select * from test_trace_id where id = ?");
pstm.setInt(1, 1);
pstm.execute();
pstm = con.prepareStatement("insert into test_trace_id values(?,?)");
pstm.setInt(1, 2);
pstm.setString(2, "test");
pstm.execute();
openGaussTrace.reset();
```

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NOTE

- When the link trace function is used, the link function at the application layer is guaranteed by services.
- The application must expose the API for obtaining **traceId** to the JDBC and configure the API implementation class to the JDBC connection string.
- SQL statements of the same request must use the same **traceId**.
- The value of **traceId** transferred by the application cannot exceed 32 bytes. Otherwise, the extra bytes will be truncated.

# 6.3.11 Example: Common Operations

## Example 1:

This example illustrates how to develop applications based on the JDBC API provided by GaussDB. Before executing the code in this example, load the driver first. For details about how to obtain and load the driver, see **6.3.1 JDBC Package, Driver Class, and Environment Class**.

```
//DBtest.java
/*The following uses gsjdbc4.jar as an example.*/
// This example illustrates the main processes of JDBC-based development, covering database connection creation, table creation, and data insertion.

import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.PreparedStatement;
import java.sql.SQLException;
import java.sql.Statement;
import java.sql.CallableStatement;
import java.sql.Types;

public class DBTest {

 // Create a database connection.
 public static Connection GetConnection(String username, String passwd) {
   String driver = "org.postgresql.Driver";
   String sourceURL = "jdbc:postgresql://localhost:8000/postgres";
   Connection conn = null;
   try {
     // Load the database driver.
     Class.forName(driver).newInstance();
   } catch (Exception e) {
     e.printStackTrace();
     return null;
   }

   try {
     // Create a database connection.
     conn = DriverManager.getConnection(sourceURL, username, passwd);
     System.out.println("Connection succeed!");
   } catch (Exception e) {
     e.printStackTrace();
     return null;
   }

   return conn;
 };

 // Run a common SQL statement to create table customer_t1.
 public static void CreateTable(Connection conn) {
   Statement stmt = null;
   try {
     stmt = conn.createStatement();
```

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```
    // Run a common SQL statement.
    int rc = stmt
        .executeUpdate("CREATE TABLE customer_t1(c_customer_sk INTEGER, c_customer_name
VARCHAR(32));");

    stmt.close();
  } catch (SQLException e) {
    if (stmt != null) {
      try {
        stmt.close();
      } catch (SQLException e1) {
        e1.printStackTrace();
      }
    }
    e.printStackTrace();
  }
}

// Run a prepared statement to insert data in batches.
public static void BatchInsertData(Connection conn) {
  PreparedStatement pst = null;

  try {
    // Generate a prepared statement.
    pst = conn.prepareStatement("INSERT INTO customer_t1 VALUES (?,?)");
    for (int i = 0; i < 3; i++) {
      // Add parameters.
      pst.setInt(1, i);
      pst.setString(2, "data " + i);
      pst.addBatch();
    }
    // Perform batch processing.
    pst.executeBatch();
    pst.close();
  } catch (SQLException e) {
    if (pst != null) {
      try {
        pst.close();
      } catch (SQLException e1) {
      e1.printStackTrace();
      }
    }
    e.printStackTrace();
  }
}

// Run a prepared statement to update data.
public static void ExecPreparedSQL(Connection conn) {
  PreparedStatement pstmt = null;
  try {
    pstmt = conn
        .prepareStatement("UPDATE customer_t1 SET c_customer_name = ? WHERE c_customer_sk = 1");
    pstmt.setString(1, "new Data");
    int rowcount = pstmt.executeUpdate();
    pstmt.close();
  } catch (SQLException e) {
    if (pstmt != null) {
      try {
        pstmt.close();
      } catch (SQLException e1) {
        e1.printStackTrace();
      }
    }
    e.printStackTrace();
  }
}
```

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```
// Run a stored procedure.
 public static void ExecCallableSQL(Connection conn) {
   CallableStatement cstmt = null;
   try {
     // The stored procedure TESTPROC must be created in advance.
     cstmt=conn.prepareCall("{? = CALL TESTPROC(?,?,?)}");
     cstmt.setInt(2, 50);
     cstmt.setInt(1, 20);
     cstmt.setInt(3, 90);
     cstmt.registerOutParameter(4, Types.INTEGER);  // Register an OUT parameter of the integer type.
     cstmt.execute();
     int out = cstmt.getInt(4);  // Obtain the OUT parameter.
     System.out.println("The CallableStatment TESTPROC returns:"+out);
     cstmt.close();
   } catch (SQLException e) {
     if (cstmt != null) {
       try {
         cstmt.close();
       } catch (SQLException e1) {
         e1.printStackTrace();
       }
     }
     e.printStackTrace();
   }
 }


 /**
  *Main process. Call static methods one by one.
  * @param args
 */
 public static void main(String[] args) {
   // Create a database connection.
   Connection conn = GetConnection("tester", "Password1234");

   // Create a table.
   CreateTable(conn);

   // Insert data in batches.
   BatchInsertData(conn);

 // Run a prepared statement to update data.
   ExecPreparedSQL(conn);

   // Run a stored procedure.
   ExecCallableSQL(conn);

   // Close the connection to the database.
   try {
     conn.close();
   } catch (SQLException e) {
     e.printStackTrace();
   }

 }

}
```

## Example 2: High Client Memory Usage

In this example, **setFetchSize** adjusts the memory usage of the client by using the database cursor to obtain server data in batches. It may increase network interaction and damage some performance.

The cursor is valid within a transaction. Therefore, disable automatic commit and then manually commit the code.

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```
// Disable automatic commit.
conn.setAutoCommit(false);
Statement st = conn.createStatement();

// Open the cursor and obtain 50 lines of data each time.
st.setFetchSize(50);
ResultSet rs = st.executeQuery("SELECT * FROM mytable");
while (rs.next())
{
    System.out.print("a row was returned.");
}
conn.commit();
rs.close();

// Disable the server cursor.
st.setFetchSize(0);
rs = st.executeQuery("SELECT * FROM mytable");
while (rs.next())
{
    System.out.print("many rows were returned.");
}
conn.commit();
rs.close();

// Close the statement.
st.close();
conn.close();
```

Run the following command to enable automatic commit:

```
conn.setAutoCommit(true);
```

## Example 3: Example of Common Data Types

```
// Example of the bit type. Note that the value range of the bit type is [0,1].
Statement st = conn.createStatement();
String sqlstr = "create or replace function fun_1()\n" +
        "returns bit AS $$\n" +
        "select col_bit from t_bit limit 1;\n" +
        "$$\n" +
        "LANGUAGE SQL;";
st.execute(sqlstr);
CallableStatement c = conn.prepareCall("{ ? = call fun_1() }");
// Register the output type, which is a bit string.
c.registerOutParameter(1, Types.BIT);
c.execute();
// Use the Boolean type to obtain the result.
System.out.println(c.getBoolean(1));

// Example of using the money type
// Example of using a column of the money type in the table structure.
st.execute("create table t_money(id int,col1 money)");
PreparedStatement pstm = conn.prepareStatement("insert into t_money values(1,?)");
// Use PGobject to assign a value. The value range is [–92233720368547758.08,92233720368547758.07].
PGobject minMoney = new PGobject();
minMoney.setType("money");
minMoney.setValue("-92233720368547758.08");
pstm.setObject(1, minMoney);
pstm.execute();
// Use PGMoney to assign a value. The value range is [–9999999.99,9999999.99].
pstm.setObject(1,new PGmoney(9999999.99));
pstm.execute();

// Example of using the function whose return value is of the money type.
st.execute("create or replace function func_money() " +
            "return money " +
            "as declare " +
            "var1 money; " +
            "begin " +
```

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```
            " select col1 into var1 from t_money limit 1; " +
            " return var1; " +
            "end;");
CallableStatement cs = conn.prepareCall("{? = call func_money()}");
cs.registerOutParameter(1,Types.DOUBLE);
cs.execute();
cs.getObject(1);
```

### Example 4: Obtaining the Driver Version

```
Driver.getGSVersion();
```

## 6.3.12 Example: Retrying SQL Queries for Applications

If the primary DN is faulty and cannot be restored within 10s, GaussDB automatically promotes the standby DN to primary to ensure that the cluster runs properly. Jobs running during the failover will fail and those started after the failover will not be affected. To prevent upper-layer services from being affected by the DN failover, refer to the following example to construct an SQL retry mechanism at the service layer. Before executing the code in this example, load the driver first. For details about how to obtain and load the driver, see **6.3.1 JDBC Package, Driver Class, and Environment Class**.

```
// The following uses gsjdbc4.jar as an example.
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.PreparedStatement;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;

class ExitHandler extends Thread {
    private Statement cancel_stmt = null;

    public ExitHandler(Statement stmt) {
        super("Exit Handler");
        this.cancel_stmt = stmt;
    }
    public void run() {
        System.out.println("exit handle");
        try {
            this.cancel_stmt.cancel();
        } catch (SQLException e) {
            System.out.println("cancel query failed.");
            e.printStackTrace();
        }
    }
}

public class SQLRetry {
  // Create a database connection.
  public static Connection GetConnection(String username, String passwd) {
    String driver = "org.postgresql.Driver";
    String sourceURL = "jdbc:postgresql://10.131.72.136:8000/postgres";
    Connection conn = null;
    try {
     // Load the database driver.
      Class.forName(driver).newInstance();
    } catch (Exception e) {
      e.printStackTrace();
      return null;
    }

    try {
     // Create a database connection.
      conn = DriverManager.getConnection(sourceURL, username, passwd);
```

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```
      System.out.println("Connection succeed!");
    } catch (Exception e) {
      e.printStackTrace();
      return null;
    }

    return conn;
}

  // Execute an ordinary SQL statement. Create a jdbc_test1 table.
  public static void CreateTable(Connection conn) {
    Statement stmt = null;
    try {
      stmt = conn.createStatement();


      Runtime.getRuntime().addShutdownHook(new ExitHandler(stmt));

     // Run a common SQL statement.
      int rc2 = stmt
         .executeUpdate("DROP TABLE if exists jdbc_test1;");

      int rc1 = stmt
         .executeUpdate("CREATE TABLE jdbc_test1(col1 INTEGER, col2 VARCHAR(10));");

      stmt.close();
    } catch (SQLException e) {
      if (stmt != null) {
        try {
          stmt.close();
        } catch (SQLException e1) {
          e1.printStackTrace();
        }
      }
      e.printStackTrace();
    }
  }

 // Run a prepared statement to insert data in batches.
  public static void BatchInsertData(Connection conn) {
    PreparedStatement pst = null;

    try {
     // Generate a prepared statement.
      pst = conn.prepareStatement("INSERT INTO jdbc_test1 VALUES (?,?)");
      for (int i = 0; i < 100; i++) {
       // Add parameters.
        pst.setInt(1, i);
        pst.setString(2, "data " + i);
        pst.addBatch();
      }
     // Perform batch processing.
      pst.executeBatch();
      pst.close();
    } catch (SQLException e) {
      if (pst != null) {
        try {
          pst.close();
        } catch (SQLException e1) {
        e1.printStackTrace();
        }
      }
      e.printStackTrace();
    }
  }

  // Run a prepared statement to update data.
  private static boolean QueryRedo(Connection conn){
    PreparedStatement pstmt = null;
```

```
  boolean retValue = false;
  try {
    pstmt = conn
        .prepareStatement("SELECT col1 FROM jdbc_test1 WHERE col2 = ?");

        pstmt.setString(1, "data 10");
        ResultSet rs = pstmt.executeQuery();

        while (rs.next()) {
            System.out.println("col1 = " + rs.getString("col1"));
        }
        rs.close();

    pstmt.close();
     retValue = true;
   } catch (SQLException e) {
    System.out.println("catch..... retValue " + retValue);
    if (pstmt != null) {
      try {
       pstmt.close();
     } catch (SQLException e1) {
       e1.printStackTrace();
      }
    }
    e.printStackTrace();
  }

   System.out.println("finesh.....");
  return retValue;
 }

// Configure the number of retry attempts for the retry of a query statement upon a failure.
 public static void ExecPreparedSQL(Connection conn) throws InterruptedException {
       int maxRetryTime = 50;
       int time = 0;
       String result = null;
       do {
           time++;
           try {
System.out.println("time:" + time);
boolean ret = QueryRedo(conn);
if(ret == false){
 System.out.println("retry, time:" + time);
 Thread.sleep(10000);
 QueryRedo(conn);
}
           } catch (Exception e) {
               e.printStackTrace();
           }
       } while (null == result && time < maxRetryTime);

 }

 /**
 * Main process. Call static methods one by one.
  * @param args
  * @throws InterruptedException
  */
 public static void main(String[] args) throws InterruptedException {
// Create a database connection.
   Connection conn = GetConnection("testuser", "test@123");

  // Create a table.
   CreateTable(conn);

  // Insert data in batches.
   BatchInsertData(conn);

// Run a prepared statement to update data.
```

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```
    ExecPreparedSQL(conn);

   // Close the connection to the database.
    try {
      conn.close();
    } catch (SQLException e) {
      e.printStackTrace();
    }

  }

}
```

## 6.3.13 Example: Importing and Exporting Data Through Local Files

When Java is used for secondary development based on GaussDB, you can use the CopyManager interface to export data from the database to a local file or import a local file to the database by streaming. The file can be in CSV or TEXT format.

The sample program is as follows. Load the driver before executing the sample code. For details about how to obtain and load the driver, see **6.3.1 JDBC Package, Driver Class, and Environment Class**.

```
// The following uses gsjdbc4.jar as an example.
import java.sql.Connection;
import java.sql.DriverManager;
import java.io.IOException;
import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.sql.SQLException;
import org.postgresql.copy.CopyManager;
import org.postgresql.core.BaseConnection;

public class Copy{

    public static void main(String[] args)
    {
     String urls = new String("jdbc:postgresql://10.180.155.74:8000/postgres"); // Database URL
     String username = new String("jack");            // Username
     String password = new String("xxxxxxxxx");             // Password
     String tablename = new String("migration_table"); // Table information
     String tablename1 = new String("migration_table_1"); // Table information
     String driver = "org.postgresql.Driver";
     Connection conn = null;

     try {
           Class.forName(driver);
           conn = DriverManager.getConnection(urls, username, password);
         } catch (ClassNotFoundException e) {
             e.printStackTrace(System.out);
         } catch (SQLException e) {
             e.printStackTrace(System.out);
         }

     // Export the query result of SELECT * FROM migration_table to the local file d:/data.txt.
     try {
    copyToFile(conn, "d:/data.txt", "(SELECT * FROM migration_table)");
  } catch (SQLException e) {

 e.printStackTrace();
  } catch (IOException e) {

 e.printStackTrace();
  }
     // Import data from the d:/data.txt file to the migration_table_1 table.
     try {
```

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```
    copyFromFile(conn, "d:/data.txt", tablename1);
  } catch (SQLException e) {
       e.printStackTrace();
} catch (IOException e) {

 e.printStackTrace();
}

    // Export the data from the migration_table_1 table to the d:/data1.txt file.
    try {
    copyToFile(conn, "d:/data1.txt", tablename1);
  } catch (SQLException e) {

 e.printStackTrace();
  } catch (IOException e) {


 e.printStackTrace();
}
   }
 // Use copyIn to import data from a file to the database.
 public static void copyFromFile(Connection connection, String filePath, String tableName)
       throws SQLException, IOException {

   FileInputStream fileInputStream = null;

   try {
      CopyManager copyManager = new CopyManager((BaseConnection)connection);
      fileInputStream = new FileInputStream(filePath);
      copyManager.copyIn("COPY " + tableName + " FROM STDIN", fileInputStream);
   } finally {
      if (fileInputStream != null) {
         try {
            fileInputStream.close();
         } catch (IOException e) {
            e.printStackTrace();
         }
      }
   }
}

 // Use copyOut to export data from the database to a file.
 public static void copyToFile(Connection connection, String filePath, String tableOrQuery)
       throws SQLException, IOException {

    FileOutputStream fileOutputStream = null;

    try {
       CopyManager copyManager = new CopyManager((BaseConnection)connection);
       fileOutputStream = new FileOutputStream(filePath);
       copyManager.copyOut("COPY " + tableOrQuery + " TO STDOUT", fileOutputStream);
    } finally {
       if (fileOutputStream != null) {
          try {
             fileOutputStream.close();
          } catch (IOException e) {
             e.printStackTrace();
          }
       }
    }
 }
}
```

## 6.3.14 Example: Migrating Data from MySQL

The following example shows how to use CopyManager to migrate data from MySQL. Before executing the code in this example, load the driver first. For details

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about how to obtain and load the driver, see **6.3.1 JDBC Package, Driver Class, and Environment Class**.

```
// The following uses gsjdbc4.jar as an example.
import java.io.StringReader;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;

import org.postgresql.copy.CopyManager;
import org.postgresql.core.BaseConnection;

public class Migration{

    public static void main(String[] args) {
        String url = new String("jdbc:postgresql://10.180.155.74:8000/postgres"); // Database URL
        String user = new String("jack");            // database username
String pass = new String(" xxxxxxxxx "); //database password
        String tablename = new String("migration_table"); // Table information
        String delimiter = new String("|");              // Delimiter
        String encoding = new String("UTF8");           // Character set
        String driver = "org.postgresql.Driver";
        StringBuffer buffer = new StringBuffer();       // Buffer to store formatted data

        try {
            // Obtain the query result set of the source database.
            ResultSet rs = getDataSet();

            // Traverse the result set and obtain records row by row.
            // The values of columns in each record are separated by the specified delimiter and end with a
linefeed, forming strings.
            // Add the strings to the buffer.
            while (rs.next()) {
                buffer.append(rs.getString(1) + delimiter
                        + rs.getString(2) + delimiter
                        + rs.getString(3) + delimiter
                        + rs.getString(4)
                        + "\n");
            }
            rs.close();

            try {
                // Connect to the target database.
                Class.forName(driver);
                Connection conn = DriverManager.getConnection(url, user, pass);
                BaseConnection baseConn = (BaseConnection) conn;
                baseConn.setAutoCommit(false);

                // Initialize the table.
                String sql = "Copy " + tablename + " from STDIN DELIMITER " + "'" + delimiter + "'" + "
ENCODING " + "'" + encoding + "'";

                // Commit data in the buffer.
                CopyManager cp = new CopyManager(baseConn);
                StringReader reader = new StringReader(buffer.toString());
                cp.copyIn(sql, reader);
                baseConn.commit();
                reader.close();
                baseConn.close();
            } catch (ClassNotFoundException e) {
                e.printStackTrace(System.out);
            } catch (SQLException e) {
                e.printStackTrace(System.out);
            }

        } catch (Exception e) {
            e.printStackTrace();
```

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```
        }
    }

    //**********************************
    // Return the query result set from the source database.
    //**********************************
    private static ResultSet getDataSet() {
        ResultSet rs = null;
        try {
            Class.forName("com.mysql.jdbc.Driver").newInstance();
            Connection conn = DriverManager.getConnection("jdbc:mysql://10.119.179.227:3306/jack?
useSSL=false&allowPublicKeyRetrieval=true", "jack", "xxxxxxxxx");
            Statement stmt = conn.createStatement();
            rs = stmt.executeQuery("select * from migration_table");
        } catch (SQLException e) {
            e.printStackTrace();
        } catch (Exception e) {
            e.printStackTrace();
        }
        return rs;
    }
}
```

## 6.3.15 Example: Logic Replication Code

The following example demonstrates how to use the logical replication function through the JDBC API.

For logical replication, in addition to the configuration items described in section "Logical Decoding", the following configuration items are added for streaming decoders such as JDBC:

1. Decoding thread concurrency

   Set **parallel-decode-num** to specify the number of decoder threads for parallel decoding. The value is an integer ranging from 1 to 20. The value **1** indicates that decoding is performed based on the original serial logic. Other values indicate that parallel decoding is enabled. The default value is **1**. When this parameter is set to **1**, do not configure the following options: **decode-style**, **sending-batch**, and **parallel-queue-size**.

2. Decoding format

   Configure **decode-style** to specify the decoding format. The value can be **'j'**, **'t'**, or **'b'** of the char type, indicating the JSON, text, or binary format, respectively. The default value is **'b'**, indicating binary decoding. This item is set only when parallel decoding is allowed and the binary decoding is supported only in the parallel decoding scenario. For the JSON and text formats corresponding to the binary format, in the decoding result sent in batches, the uint32 consisting of the first four bytes of each decoding statement indicates the total number of bytes of the statement (the four bytes occupied by the uint32 are excluded, and **0** indicates that the decoding of this batch ends). The 8-byte uint64 indicates the corresponding LSN (**begin** corresponds to **first_lsn**, **commit** corresponds to **end_lsn**, and other values correspond to the LSN of the statement).

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**NOTE**

The binary encoding rules are as follows:

1. The first four bytes represent the total number of bytes of the decoding result of statements following the statement-level delimiter letter P (excluded) or the batch end character F (excluded). If the value is **0**, the decoding of this batch ends.
2. The next eight bytes (uint64) indicate the corresponding LSN (**begin** corresponds to **first_lsn**, **commit** corresponds to **end_lsn**, and other values correspond to the LSN of the statement).
3. The next one-byte letter can be **B**, **C**, **I**, **U**, or **D**, representing BEGIN, COMMIT, INSERT, UPDATE, or DELETE.
4. If **B** is used in the step 3:
    1. The next eight bytes (uint64) indicate the CSN.
    2. The next eight bytes (uint64) indicate **first_lsn**.
    3. (Optional) If the next one-byte letter is **T**, the following four bytes (uint32) indicate the timestamp length for committing the transaction. The following characters with the same length are the timestamp character string.
    4. (Optional) If the next one-byte letter is **N**, the following four bytes (uint32) indicate the length of the transaction user name. The following characters with the same length are the transaction user name.
    5. Because there may still be a decoding statement subsequently, a 1-byte letter **P** or **F** is used as a separator between statements. **P** indicates that there are still decoded statements in this batch, and **F** indicates that this batch is completed.
5. If **C** is used in the step 3:
    1. (Optional) If the next one-byte letter is **X**, the following eight bytes (uint64) indicate the XID.
    2. (Optional) If the next one-byte letter is **T**, the following four bytes (uint32) indicate the timestamp length. The following characters with the same length are the timestamp character string.
    3. When logs are sent in batches, decoding results of other transactions may still exist after a COMMIT log is decoded. If the next one-byte letter is **P**, the batch still needs to be decoded. If the letter is **F**, the decoding of the batch ends.
6. If **I**, **U**, or **D** is used in the step 3:
    1. The next two bytes (uint16) indicate the length of the schema name.
    2. The schema name is read based on the preceding length.
    3. The next two bytes (uint16) indicate the length of the table name.
    4. The table name is read based on the preceding length.
    5. (Optional) If the next one-byte letter is **N**, it indicates a new tuple. If the letter is **O**, it indicates an old tuple. In this case, the new tuple is sent first.
        1. The next two bytes (uint16) indicate the number of columns to be decoded for the tuple, which is recorded as **attrnum**.
        2. The following procedure is repeated for *attrnum* times.
            1. The next two bytes (uint16) indicate the length of the column name.
            2. The column name is read based on the preceding length.
            3. The next four bytes (uint32) indicate the OID of the current column type.
            4. The next four bytes (uint32) indicate the length of the value (stored in the character string format) in the current column. If the value is **0xFFFFFFFF**, it indicates a null value. If the value is **0**, it indicates a character string whose length is 0.
            5. The column value is read based on the preceding length.

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6. Because there may still be a decoding statement subsequently, if the next one-byte letter is **P**, it indicates that the batch still needs to be decoded, and if the next one-byte letter is **F**, it indicates that decoding of the batch ends.

3. Decoding only on the standby node

   Configure **standby-connection** to specify whether to perform decoding only on the standby node. The value is of the Boolean type (**0** or **1**). The value **true** (or **1**) indicates that only the standby node can be connected for decoding. When the primary node is connected for decoding, an error is reported and the system exits. The value **false** (or **0**) indicates that there is no restriction. The default value is **false** (**0**).

4. Batch sending

   Configure **sending-batch** to specify whether to send results in batches. The value is an integer ranging from 0 to 1. The value **0** indicates that decoding results are sent one by one. The value **1** indicates that decoding results are sent in batches when the accumulated size of decoding results reaches 1 MB. The default value is **0**. This parameter can be set only during parallel decoding. In the scenario where batch sending is enabled, if the decoding format is 'j' or 't', before each original decoding statement, a uint32 number is added indicating the length of the decoding result (excluding the current uint32 number), and a uint64 number is added indicating the LSN corresponding to the current decoding result.

5. Length of the parallel decoding queue

   Configure **parallel-queue-size** to specify the length of the queue for interaction among parallel logical decoding threads. The value ranges from 2 to 1024 and must be a power of 2. The default value is **128**. The queue length is positively correlated with the memory usage during decoding.

6. Memory threshold for logical decoding

   Configure **max-txn-in-memory** to specify the memory threshold for caching the intermediate decoding result of a single transaction. The value ranges from 0 to 100, in MB. The default value is **0**, indicating that the memory usage is not controlled. Configure **max-reorderbuffer-in-memory** to specify the memory threshold for caching the intermediate decoding result of all transactions. The value ranges from 0 to 100, in GB. The default value is **0**, indicating that the memory usage is not controlled. When the memory usage exceeds the threshold, the intermediate decoding result is written into a temporary file during decoding, which affects the logical decoding performance.

7. Logical decoding sending timeout threshold

   The **sender-timeout** configuration item specifies the heartbeat timeout threshold between the kernel and client. If no message is received from the client within the period, the logic decoding stops and disconnects from the client. The unit is ms, and the value range is [0,2147483647]. The default value depends on the value of **logical_sender_timeout**.

8. User blacklist options for logical decoding

   Use the user blacklist for logical decoding. The transaction operations of blacklisted users are filtered from the logic decoding result. The options are as follows:

   a. **exclude-userids**: specifies the OIDs of blacklisted users. Multiple OIDs are separated by commas (,). The system does not check whether the user

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OIDs exist. Note: The OIDs of the same service user on different DNs may be different. Therefore, the OID of the service user on each DN needs to be transferred for logic decoding of directly connected DNs in distributed mode. Otherwise, the logic decoding results of some DNs may be filtered while those of some DNs are not filtered.

b. **exclude-users**: specifies blacklisted user names. Multiple user names are separated by commas (,). **dynamic-resolution** specifies whether to dynamically parse and identify user names. If the decoding is interrupted because the user does not exist and the corresponding blacklisted user does not exist at the time when logs are generated, you can set **dynamic-resolution** to **true** or delete the user name from the blacklist to start decoding and continue to obtain logical logs.

c. **dynamic-resolution**: indicates whether to dynamically parse blacklisted user names. The default value is **true**. If the parameter is set to **false**, an error is reported and the logic decoding exits when the decoding detects that the user does not exist in blacklist **exclude-users**. If the parameter is set to **true**, decoding continues when it detects that the user does not exist in blacklist **exclude-users**.

9. Output options for transaction logic logs

   a. **include-xids**: indicates whether the BEGIN logical log of a transaction outputs the transaction ID. The default value is **true**.

   b. **include-timestamp**: indicates whether the BEGIN logical log of a transaction outputs the time when the transaction is committed. The default value is **false**.

   c. **include-user**: indicates whether the BEGIN logical log of a transaction outputs the user name of the transaction. The default value is **false**. The user name of a transaction refers to the authorized user, that is, the login user who executes the session corresponding to the transaction. The user name does not change during the execution of the transaction.

10. By default, **socketTimeout** of the logical decoding connection is set to **10s**. When the primary node is overloaded during decoding on the standby node, the connection may be closed due to timeout. You can set **withStatusInterval(10000,TimeUnit.MILLISECONDS)** to adjust the timeout interval.

The decoding performance (Xlog consumption) is greater than or equal to 100 MBps in the following standard parallel decoding scenario: 16-core CPU, 128 GB memory, network bandwidth > 200 MBps, 10 to 100 columns in a table, 0.1 KB to 1 KB data volume in a single row, DML operations are mainly INSERT operations, the number of statements in a single transaction is less than 4096, **parallel-decode-num** is set to **8**, the decoding format is **'b'**, and the batch sending function is enabled. To ensure that the decoding performance meets the requirements and minimize the impact on services, you are advised to set up only one parallel decoding connection on a standby node to ensure that the CPU, memory, and bandwidth resources are sufficient.

Note: The logical replication class PGReplicationStream is a non-thread-safe class. Concurrent calls may cause data exceptions. Before executing the code in this example, load the driver first. For details about how to obtain and load the driver, see **6.3.1 JDBC Package, Driver Class, and Environment Class**.

```
// The following uses gsjdbc4.jar as an example.
// Logical replication function example: file name, LogicalReplicationDemo.java
```

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```
// Prerequisite: Add the IP address of the JDBC user machine to the database whitelist. Add the following content to pg_hba.conf:
// Assume that the IP address of the JDBC user is 10.10.10.10.
//host    all             all             10.10.10.10/32        sha256
//host    replication     all             10.10.10.10/32        sha256

import org.postgresql.PGProperty;
import org.postgresql.jdbc.PgConnection;
import org.postgresql.replication.LogSequenceNumber;
import org.postgresql.replication.PGReplicationStream;

import java.nio.ByteBuffer;
import java.sql.DriverManager;
import java.util.Properties;
import java.util.concurrent.TimeUnit;

public class LogicalReplicationDemo {
    private static PgConnection conn = null;
    public static void main(String[] args) {
        String driver = "org.postgresql.Driver";
        // Configure the IP address and haPort of the database. By default, the value of haPort is the port number of the connected DN plus 1.
        String sourceURL = "jdbc:postgresql://$ip:$port/postgres";

        // The default name of the logical replication slot is replication_slot.
        // Test mode: Create a logical replication slot.
        int TEST_MODE_CREATE_SLOT = 1;
        // Test mode: Enable logical replication (the prerequisite is that the logical replication slot already exists).
        int TEST_MODE_START_REPL = 2;
        // Test mode: Delete a logical replication slot.
        int TEST_MODE_DROP_SLOT = 3;
        // Enable different test modes.
        int testMode = TEST_MODE_START_REPL;

        try {
            Class.forName(driver);
        } catch (Exception e) {
            e.printStackTrace();
            return;
        }

        try {
            Properties properties = new Properties();
            PGProperty.USER.set(properties, "user");
            PGProperty.PASSWORD.set(properties, "passwd");
     // For logical replication, the following three attributes are mandatory.
            PGProperty.ASSUME_MIN_SERVER_VERSION.set(properties, "9.4");
            PGProperty.REPLICATION.set(properties, "database");
            PGProperty.PREFER_QUERY_MODE.set(properties, "simple");
            conn = (PgConnection) DriverManager.getConnection(sourceURL, properties);
            System.out.println("connection success!");

            if(testMode == TEST_MODE_CREATE_SLOT){
                conn.getReplicationAPI()
                        .createReplicationSlot()
                        .logical()
                        .withSlotName("replication_slot") // If the character string contains uppercase letters, the uppercase letters are automatically converted to lowercase letters.
                        .withOutputPlugin("test_decoding")
                        .make();
            }else if(testMode == TEST_MODE_START_REPL) {
                // Create a replication slot before enabling this mode.
                LogSequenceNumber waitLSN = LogSequenceNumber.valueOf("6F/E3C53568");
                PGReplicationStream stream = conn
                        .getReplicationAPI()
                        .replicationStream()
                        .logical()
                        .withSlotName("replication_slot")
```

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```
                    .withSlotOption("include-xids", false)
                    .withSlotOption("skip-empty-xacts", true)
                    .withStartPosition(waitLSN)
                    .withSlotOption("parallel-decode-num", 10) // Decoding thread concurrency
                    .withSlotOption("white-table-list", "public.t1,public.t2") // Whitelist
                    .withSlotOption("standby-connection", true) // Forcible standby decoding
                    .withSlotOption("decode-style", "t") // Decoding format
                    .withSlotOption("sending-batch", 1) // Decoding results are sent in batches.
                    .withSlotOption("max-txn-in-memory", 100) // The memory threshold for flushing a single
decoding transaction to disks is 100 MB.
                    .withSlotOption("max-reorderbuffer-in-memory", 50) // The total memory threshold for
flushing decoding transactions that are being handled to disks is 50 GB.
                    .withSlotOption("exclude-users", 'userA') // The logical log of the transaction executed by
user A is not returned.
                    .withSlotOption("include-user", true) // The BEGIN logical log of the transaction contains
the user name.
                    .start();
            while (true) {
                ByteBuffer byteBuffer = stream.readPending();

                if (byteBuffer == null) {
                    TimeUnit.MILLISECONDS.sleep(10L);
                    continue;
                }

                int offset = byteBuffer.arrayOffset();
                byte[] source = byteBuffer.array();
                int length = source.length - offset;
                System.out.println(new String(source, offset, length));

                // If the LSN needs to be flushed, call the following APIs based on the service requirements:
//                LogSequenceNumber lastRecv = stream.getLastReceiveLSN();
//                stream.setFlushedLSN(lastRecv);
//                stream.forceUpdateStatus();

            }
        }else if(testMode == TEST_MODE_DROP_SLOT){
            conn.getReplicationAPI()
                    .dropReplicationSlot("replication_slot");
        }
    } catch (Exception e) {
        e.printStackTrace();
        return;
    }
  }
}
```

# 6.3.16 Example: Parameters for Connecting to the Database in Different Scenarios

NOTE

In the following example, **host:port** represents a node, where **host** indicates the name or IP address of the server where the database resides, and **port** indicates the port number of the server where the database resides.

## Load Balancing

A customer has a database cluster that contains the following nodes: {node1,node2,node3,node4,node5,node6,node7,node8,node9,node10,node11,node12}.

1. The customer establishes 120 persistent connections in application A and expects that the connections on application A can be evenly distributed on each node in the current cluster. The URL can be configured as follows.

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```
jdbc:postgresql://node1,node2,node3/database?autoBalance=true
```

2. The customer develops two applications B and C and wants the three applications to be evenly distributed on specified nodes. For example, the connections of application A are distributed on {node1,node2,node3,node4}. The connections of application B are distributed on {node5,node6,node7,node8}. The connections of application C are distributed on {node9,node10,node11,node12}. The URLs can be configured as follows.

   Application A: **jdbc:postgresql://node1,node2,node3,node4,node5/database?autoBalance=priority4**

   Application B: **jdbc:postgresql://node5,node6,node7,node8,node9/database?autoBalance=priority4**

   Application C: **jdbc:postgresql://node9,node10,node11,node12,node1/database?autoBalance=priority4**

3. The customer develops more applications, uses the same connection configuration string, and expects that the application connections can be evenly distributed on each node in the cluster. The URL can be configured as follows.

   ```
   jdbc:postgresql://node1,node2,node3,node4/database?autoBalance=shuffle
   ```

4. If the customer does not want to use the load balancing function, configure the URL as follows.

   ```
   jdbc:postgresql://node1/database
   ```

   Or

   ```
   jdbc:postgresql://node1/database?autoBalance=false
   ```

   **NOTE**

   When the **autoBalance** parameter is enabled, the interval for the JDBC to refresh the available CN list is 10s by default. You can use **refreshCNIpListTime** to set the interval:

   ```
   jdbc:postgresql://node1,node2,node3,node4/database?autoBalance=true&refreshCNIpListTime=3
   ```

## Log Diagnosis

To locate faults, a customer can enable the trace log function for diagnosis. The URL can be configured as follows.

```
jdbc:postgresql://node1/database?loggerLevel=trace&loggerFile=jdbc.log
```

## High Performance

A customer may execute the same SQL statement for multiple times with different input parameters. To improve the execution efficiency, the **prepareThreshold** parameter can be enabled to avoid repeatedly generating execution plans. The URL can be configured as follows.

```
jdbc:postgresql://node1/database?prepareThreshold=5
```

A customer queries 10 million data records at a time. To prevent memory overflow caused by simultaneous return of the data records, the **defaultRowFetchSize** parameter can be used. The URL can be configured as follows.

```
jdbc:postgresql://node1/database?defaultRowFetchSize=50000
```

A customer needs to insert 10 million data records in batches. To improve efficiency, the **batchMode** parameter can be used. The URL can be configured as follows.

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```
jdbc:postgresql://node1/database?batchMode=true
```

## 6.3.17 JDBC Interface Reference

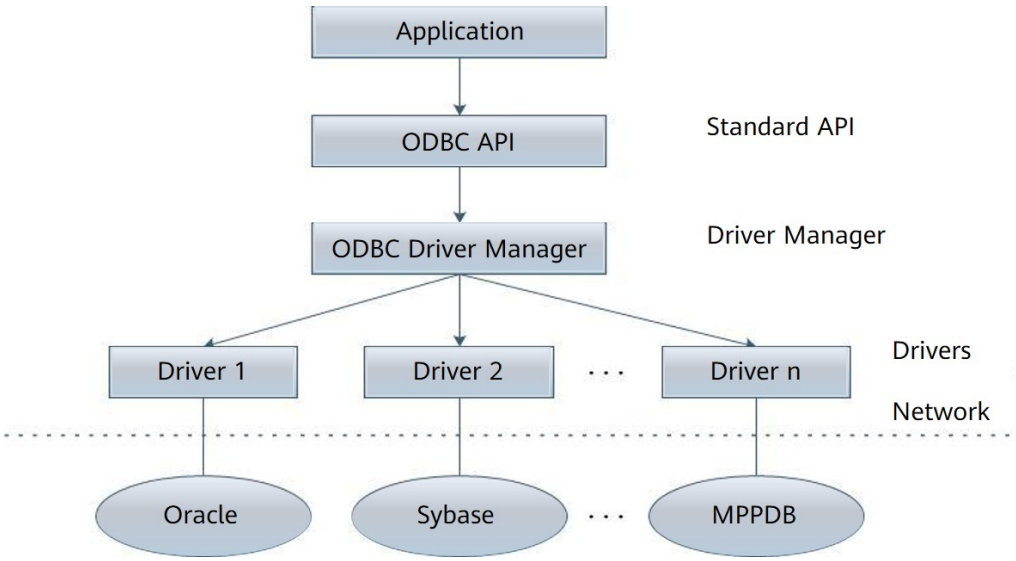
For details, see **21.1 JDBC Interface Reference**.

# 6.4 Development Based on ODBC

ODBC is a Microsoft API for accessing databases based on the X/OPEN CLI. ODBC APIs alleviate applications from directly operating in databases, and enhance the database portability, extensibility, and maintainability.

**Figure 6-2** shows the system structure of ODBC.

**Figure 6-2** ODBC system structure




GaussDB supports ODBC 3.5 in the following environments.

**Table 6-8** OSs Supported by ODBC

| OS | Platform |
| --- | --- |
| EulerOS 2.5 | x86_64 |
| EulerOS 2.8 | ARM64 |
| Windows 7 | x86_32 |
| Windows 7 | x86_64 |
| Windows Server 2008 | x86_32 |
| Windows Server 2008 | x86_64 |
| Kylin V10 | x86_64 |
| Kylin V10 | ARM64 |

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The ODBC Driver Manager running on UNIX or Linux can be unixODBC or iODBC. unixODBC-2.3.0 is used as the component for connecting to the database.

Windows has a native ODBC Driver Manager. You can locate **Data Sources (ODBC)** by choosing **Control Panel > Administrative Tools**.

NOTE

The current database ODBC driver is based on an open-source version and may be incompatible with Huawei-developed data types such as tinyint, smalldatetime, and nvarchar2.

## 6.4.1 ODBC Packages, Dependent Libraries, and Header Files

### ODBC Packages for the Linux OS

Obtain the ODBC package **GaussDB-Kernel-*VxxxRxxxCxx*-xxxxx-64bit-Odbc.tar.gz** from the release package. In the Linux OS, header files (including **sql.h** and **sqlext.h**) and the library (**libodbc.so**) are required in application development. These header files and library can be obtained from the unixODBC-2.3.0 installation package.

### ODBC Packages for the Windows OS

Obtain the ODBC package **GaussDB-Kernel-*VxxxRxxxCxx*-Windows-Odbc-X86.tar.gz** from the release package. In the Windows OS, the required header files and library files are system-resident.

## 6.4.2 Configuring a Data Source in the Linux OS

The ODBC DRIVER (**psqlodbcw.so**) provided by GaussDB can be used after it has been configured in a data source. To configure a data source, you must configure the **odbc.ini** and **odbcinst.ini** files on the server. The two files are generated during the unixODBC compilation and installation, and are saved in the **/usr/local/etc** directory by default.

### Procedure

**Step 1** Obtain the source code package of unixODBC by the following link:

**https://sourceforge.net/projects/unixodbc/files/unixODBC**

After the download, verify the integrity based on the integrity verification algorithm provided by the community.

**Step 2** Install unixODBC. It does not matter if unixODBC of another version has been installed.

Currently, unixODBC-2.2.1 is not supported. For example, to install unixODBC-2.3.0, run the commands below. It is installed in the **/usr/local** directory by default. The data source file is generated in the **/usr/local/etc** directory, and the library file is generated in the **/usr/local/lib** directory.

```
tar zxvf unixODBC-2.3.0.tar.gz
cd unixODBC-2.3.0
# Modify the configure file and find LIB_VERSION.
# Change the value of LIB_VERSION to 1:0:0 to compile a *.so.1 dynamic library with the same dependency
```

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```
on psqlodbcw.so.
vim configure

./configure --enable-gui=no # To perform compilation on an Arm server, add the configure parameter: --build=aarch64-unknown-linux-gnu.
make
# The installation may require root permissions.
make install
```

**Step 3** Replace the GaussDB client driver.

Decompress the **GaussDB-Kernel-*VxxxRxxxCxx*-xxxxx-64bit-Odbc.tar.gz** package. After the decompression, the **lib** and **odbc** folders are generated. The **odbc** folder contains another **lib** folder. Copy all dynamic libraries in the **/lib** and **/odbc/lib** folders to the **/usr/local/lib** directory.

**Step 4** Configure a data source.

1. Configure the ODBC driver file.

   Add the following content to the **/usr/local/etc/odbcinst.ini** file:

   ```
   [GaussMPP]
   Driver64=/usr/local/lib/psqlodbcw.so
   setup=/usr/local/lib/psqlodbcw.so
   ```

   For descriptions of the parameters in the **odbcinst.ini** file, see **Table 6-9**.

   **Table 6-9** odbcinst.ini configuration parameters

   | Parameter | Description | Example Value |
   | --- | --- | --- |
   | [DriverName] | Driver name, corresponding to Driver in DSN. | [DRIVER_N] |
   | Driver64 | Path of the dynamic driver library. | Driver64=/usr/local/lib/psqlodbcw.so |
   | setup | Driver installation path, which is the same as the dynamic library path in Driver64. | setup=/usr/local/lib/psqlodbcw.so |

2. Configure the data source file.

   Add the following content to the end of the **/usr/local/etc/odbc.ini** file:

   ```
   [gaussdb]
   Driver=GaussMPP
   Servername=10.145.130.26 (IP address of the server where the database resides)
   Database=postgres  (database name)
   Username=omm  (database username)
   Password=    (database user password)
   Port=8000 (database listening port)
   Sslmode=allow
   ```

   For descriptions of the parameters in the **odbc.ini** file, see **Table 6-10**.

   **Table 6-10** odbc.ini configuration parameters

   | Parameter | Description | Example Value |
   | --- | --- | --- |
   | [DSN] | Data source name. | [gaussdb] |

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| Parameter | Description | Example Value |
| --- | --- | --- |
| Driver | Driver name, corresponding to DriverName in **odbcinst.ini**. | Driver=DRIVER_N |
| Servername | Server IP address. Multiple IP addresses can be configured. | Servername=10.145.130.26 |
| Database | Name of the database to connect. | Database=postgres |
| Username | Database username. | Username=omm |
| Password | Database user password. | Password=<br>**NOTE**<br>After a user established a connection, the ODBC driver automatically clears their password stored in memory.<br>However, if this parameter is configured, UnixODBC will cache data source files, which may cause the password to be stored in the memory for a long time.<br>When you connect to an application, you are advised to send your password through an API instead of writing it in a data source configuration file. After the connection has been established, immediately clear the memory segment where your password is stored.<br>**CAUTION**<br>The password in the configuration file must comply with the following HTTP rules:<br>1. Characters must comply with the URL encoding specifications. For example, the exclamation mark (!) must be written as %21, and the percent sign (%) must be written as %25. Therefore, pay attention to the handling of the percent sign (%).<br>2. A plus sign (+) will be replaced with a space. |

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| Parameter | Description | Example Value |
| --- | --- | --- |
| Port | Port number of the server. When load balancing is enabled, multiple port numbers can be configured and must correspond to multiple IP addresses. If multiple IP addresses are configured and only one port number is configured when load balancing is enabled, all IP addresses share the same port number by default, that is, the configured port number. | Port=8000 |
| Sslmode | Whether to enable SSL. | Sslmode=allow |
| Debug | If this parameter is set to **1**, the **mylog** file of the PostgreSQL ODBC driver will be printed. The directory generated for storing logs is **/tmp/**. If this parameter is set to **0**, no directory is generated. | Debug=1 |
| UseServerSidePrepare | Whether to enable the extended query protocol for the database.<br>The value can be **0** or **1**. The default value is **1**, indicating that the extended query protocol is enabled. | UseServerSidePrepare=1 |

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| Parameter | Description | Example Value |
| --- | --- | --- |
| UseBatchProtocol | Whether to enable the batch query protocol. If it is enabled, DML performance can be improved. The value can be **0** or **1**. The default value is **1**.<br>If this parameter is set to **0**, the batch query protocol is disabled (mainly for communication with earlier database versions).<br>If this parameter is set to **1** and **support_batch_bind** is set to **on**, the batch query protocol is enabled. | UseBatchProtocol=1 |
| ForExtensionConnec-tor | This parameter specifies whether the savepoint is sent. | ForExtensionConnector=1 |
| ConnectionExtraInfo | Whether to display the driver deployment path and process owner in the **connection_info** parameter mentioned in **connection_info**. | ConnectionExtraInfo=1<br>**NOTE**<br>The default value is **0**. If this parameter is set to **1**, the ODBC driver reports the driver deployment path and process owner to the database and displays the information in the **connection_info** parameter (see **connection_info**). In this case, you can query the information from **15.3.146 PG_STAT_ACTIVITY** or **15.3.197 PGXC_STAT_ACTIVITY**. |
| BoolAsChar | If this parameter is set to **Yes**, the Boolean value is mapped to the SQL_CHAR type. If this parameter is not set, the value is mapped to the SQL_BIT type. | BoolsAsChar = Yes |

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| Parameter | Description | Example Value |
| --- | --- | --- |
| RowVersioning | When an attempt is made to update a row of data, setting this parameter to **Yes** allows the application to detect whether the data has been modified by other users. | RowVersioning=Yes |
| ShowSystemTables | By default, the driver regards the system table as a common SQL table. | ShowSystemTables=Yes |
| AutoBalance | Specifies whether ODBC enables load balancing. The default value is **0**, indicating that load balancing is disabled. The value **1** indicates that load balancing is enabled. All values except **1** indicate that load balancing is disabled. | AutoBalance=1 |
| RefreshCNListTime | Specifies the interval for refreshing the CN list. The value is an integer and the default value is **10**. This parameter can be configured when load balancing is enabled. | RefreshCNListTime=5 |

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| Parameter | Description | Example Value |
| --- | --- | --- |
| Priority | This parameter can be configured for load balancing. The default value is **0**, indicating that load balancing is disabled. The value **1** indicates that load balancing is enabled. All values except **1** indicate that load balancing is disabled. When **Priority** is enabled, all connections initiated by applications are preferentially sent to the CNs configured in the configuration file. If all the configured CNs are unavailable, the connections are sent to the remaining CNs. | Priority=1 |
| UsingEip | This parameter can be configured for load balancing. The default value is **0**, indicating that load balancing is disabled. The value **1** indicates that load balancing is enabled. All values except **1** indicate that load balancing is disabled. The value specifies whether to use the elastic IP address for load balancing. If **UsingEip** is enabled, the elastic IP address is used for load balancing. If **UsingEip** is disabled, the data IP address is used for load balancing. | UsingEip=1 |

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| Parameter | Description | Example Value |
| --- | --- | --- |
| TcpUserTimeout | Specifies the maximum duration for which transmitted data can remain unacknowledged before the TCP connection is forcibly closed on an operating system that supports the **TCP_USER_TIMEOUT** socket option. The unit is millisecond. The value **0** indicates that the default value is used. Ignore this parameter for Unix-domain connections. | TcpUserTimeout=5000 |

The valid values of **Sslmode** are as follows:

**Table 6-11** sslmode options and description

| sslmode | Whether SSL Encryption Is Enabled | Description |
| --- | --- | --- |
| disable | No | SSL connection is not enabled. |
| allow | Possible | If the database server requires SSL connection, SSL connection can be enabled. However, authenticity of the database server will not be verified. |
| prefer | Possible | If the database supports SSL connection, SSL connection is preferred. However, authenticity of the database server will not be verified. |
| require | Yes | SSL connection is required and data is encrypted. However, authenticity of the database server will not be verified. |
| verify-ca | Yes | SSL connection is required and whether the database has a trusted certificate will be verified. |

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| sslmode | Whether SSL Encryption Is Enabled | Description |
| --- | --- | --- |
| verify-full | Yes | SSL connection is required. In addition to the check scope specified by **verify-ca**, the system checks whether the name of the host where the database resides is the same as that on the certificate. If they are different, modify the **/etc/hosts** file as user **root** and add the IP address and host name of the connected database node to the file. |

**----End**

## Verifying the Data Source Configuration

After the installation, the generated binary file is stored in the **/usr/bin** directory. You can run the **isql -v** *gaussdb* command (*gaussdb* is the data source name).

- If the following information is displayed, the configuration is correct and the connection succeeds.

```
+---------------------------------------+
| Connected!                            |
|                                       |
| sql-statement                         |
| help [tablename]                      |
| quit                                  |
|                                       |
+---------------------------------------+
SQL>
```

- If error information is displayed, the configuration is incorrect. Check the configuration.
- In a cluster environment, you need to copy and configure the unixODBC file on all nodes.

## FAQs

- [UnixODBC][Driver Manager]Can't open lib 'xxx/xxx/psqlodbcw.so' : file not found.

  Possible causes:

  – The path configured in the **odbcinst.ini** file is incorrect.

  Run **ls** to check the path in the error information, and ensure that the **psqlodbcw.so** file exists and you have execute permissions on it.

  – The dependent library of **psqlodbcw.so** does not exist or is not in system environment variables.

  Run the **ldd** command to check the path in the error information. If the UnixODBC library such as **libodbc.so.1** is missing, reconfigure UnixODBC according to the operation procedure, ensure that the **lib** directory in the installation path is added to **LD_LIBRARY_PATH**. If the problem persists after reinstallation, manually copy the contents in the **unixodbc/lib**

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directory of the database installation package to the **lib** directory in the installation path of the UnixODBC. If other libraries are missing, add the **lib** directory in the ODBC driver package to **LD_LIBRARY_PATH**.

- [UnixODBC]connect to server failed: no such file or directory

  Possible causes:

  – An incorrect or unreachable database IP address or port was configured.

    Check the **Servername** and **Port** configuration items in data sources.

  – Server monitoring is improper.

    If **Servername** and **Port** are correctly configured, ensure the proper network adapter and port are monitored by following the database server configurations in the procedure in this section.

  – Firewall and network gatekeeper settings are improper.

    Check firewall settings, and ensure that the database communication port is trusted.

    Check to ensure network gatekeeper settings are proper (if any).

- [unixODBC]The password-stored method is not supported.

  Possible causes:

  The **sslmode** configuration item is not configured in the data sources.

  Solution:

  Set the configuration item to **allow** or a higher level. For details, see **Table 6-11**.

- Server common name "xxxx" does not match host name "xxxxx"

  Possible causes:

  When **verify-full** is used for SSL encryption, the driver checks whether the host name in certificates is the same as the actual one.

  Solution:

  To solve this problem, use **verify-ca** to stop checking host names, or generate a set of server certificates containing the actual host names.

- Driver's SQLAllocHandle on SQL_HANDLE_DBC failed

  Possible causes:

  The executable file (such as the **isql** tool of unixODBC) and the database driver (**psqlodbcw.so**) depend on different library versions of ODBC, such as **libodbc.so.1** and **libodbc.so.2**. You can verify this problem by using the following method:

  ```
  ldd `which isql` | grep odbc
  ldd psqlodbcw.so | grep odbc
  ```

  If the suffix digits of the outputs **libodbc.so** are different or indicate different physical disk files, this problem exists. Both **isql** and **psqlodbcw.so** load **libodbc.so**. If different physical files are loaded, different ODBC libraries with the same function list conflict with each other in a visible domain. As a result, the database driver cannot be loaded.

  Solution:

  Uninstall the unnecessary unixODBC, such as libodbc.so.2, and create a soft link with the same name and the .so.2 suffix for the remaining libodbc.so.1 library.

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- FATAL: Forbid remote connection with trust method!

  For security purposes, the database CN forbids access from other nodes in the cluster without authentication.

  To access the CN from inside the cluster, deploy the ODBC program on the host where the CN is located and use 127.0.0.1 as the server address. It is recommended that the service system be deployed outside the cluster. If it is deployed inside, database performance may be affected.

- [unixODBC][Driver Manager]Invalid attribute value

  This problem occurs when you use SQL on other GaussDB. The possible cause is that the unixODBC version is not the recommended one. You are advised to run the **odbcinst --version** command to check the unixODBC version.

- authentication method 10 not supported.

  If this error occurs on an open-source client, the cause may be:

  The database stores only the SHA-256 hash of the password, but the open-source client supports only MD5 hashes.

  NOTE

  - The database stores the hashes of user passwords instead of actual passwords.
  - If a password is updated or a user is created, both types of hashes will be stored, compatible with open-source authentication protocols.
  - An MD5 hash can only be generated using the original password, but the password cannot be obtained by reversing its SHA-256 hash. Passwords in the old version will only have SHA-256 hashes and not support MD5 authentication.
  - The MD5 encryption algorithm has lower security and poses security risks. Therefore, you are advised to use a more secure encryption algorithm.

  To solve this problem, you can update the user password (see **12.14.37 ALTER USER**) or create a user (see **12.14.88 CREATE USER**) having the same permissions as the faulty user.

- unsupported frontend protocol 3.51: server supports 1.0 to 3.0

  The database version is too early or the database is an open-source database. Use the driver of the required version to connect to the database.

- isql: error while loading shared libraries: xxx

  The dynamic library does not exist in the environment. You need to install the corresponding library.

## 6.4.3 Configuring a Data Source in the Windows OS

Configure an ODBC data source using the ODBC data source manager preinstalled in the Windows OS.

### Procedure

**Step 1** Replace the GaussDB client driver.

Decompress **GaussDB-Kernel-*VxxxRxxxCxx*-Windows-Odbc.tar.gz** and install **psqlodbc.exe** (for the 32-bit OS) as required.

**Step 2** Open Driver Manager.

Use the ODBC Driver Manager for the 32-bit OS to configure the data source. (Currently, only the ODBC Driver Manager for the 32-bit OS is supported. The

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following description assumes that the OS is installed on drive C. If the OS is installed on another drive, change the path accordingly.)

- For a 64-bit OS, open **C:\Windows\SysWOW64\odbcad32.exe**. Do not choose **Control Panel** > **Administrative Tools** > **Data Sources (ODBC)**.

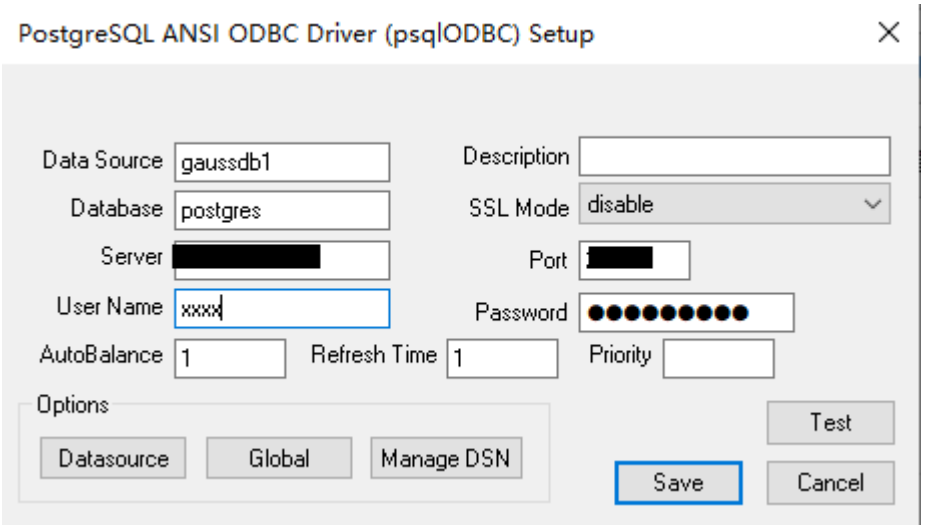
  NOTE

  WoW64 is short for Windows 32-bit on Windows 64-bit. **C:\Windows\SysWOW64** stores the 32-bit environment on a 64-bit system. **C:\Windows\System32** stores the environment consistent with the current OS. For technical details, see Windows technical documents.

- For a 32-bit OS, open **C:\Windows\System32\odbcad32.exe** or choose **Computer** > **Control Panel** > **Administrative Tools** > **Data Sources (ODBC)** to open Driver Manager.

**Step 3** Configure a data source.

On the **User DSN** tab, click **Add** and choose **PostgreSQL Unicode** for setup.




NOTICE

The entered username and password will be recorded in the Windows registry and you do not need to enter them again when connecting to the database next time. For security purposes, you are advised to delete sensitive information before clicking **Save** and enter the required username and password again when using ODBC APIs to connect to the database.

**Step 4** Enable the SSL mode.

Copy the **client.crt**, **client.key**, **client.key.cipher**, and **client.key.rand** files in the certificate file folder to the manually created directory **%APPDATA%\postgresql**. Change **client** in the file names to **postgres**, for example, change **client.key** to **postgres.key**. Copy the **cacert.pem** file to the **%APPDATA%\postgresql** directory and change its name to **root.crt**.

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NOTE

**%APPDATA%** is located in **C:\Users\[username]\AppData** by default, and its values is specified by customers during installation.

Change the value of **SSL Mode** in Step 2 to **require**.

**Table 6-12** sslmode options and description

| sslmode | Whether SSL Encryption Is Enabled | Description |
| --- | --- | --- |
| disable | No | SSL connection is not enabled. |
| allow | Possible | If the database server requires SSL connection, SSL connection can be enabled. However, authenticity of the database server will not be verified. |
| prefer | Possible | If the database supports SSL connection, SSL connection is preferred. However, authenticity of the database server will not be verified. |
| require | Yes | SSL connection is required and data is encrypted. However, authenticity of the database server will not be verified. |
| verify-ca | Yes | SSL connection is required and whether the database has a trusted certificate will be verified. Currently, Windows ODBC does not support the cert authentication. |
| verify-full | Yes | SSL connection is required. In addition to the check scope specified by **verify-ca**, the system checks whether the name of the host where the database resides is the same as that in the certificate. Currently, Windows ODBC does not support the cert authentication. |

**----End**

## Verifying the Data Source Configuration

Click **Test**.

- If the following information is displayed, the configuration is correct and the connection succeeds.

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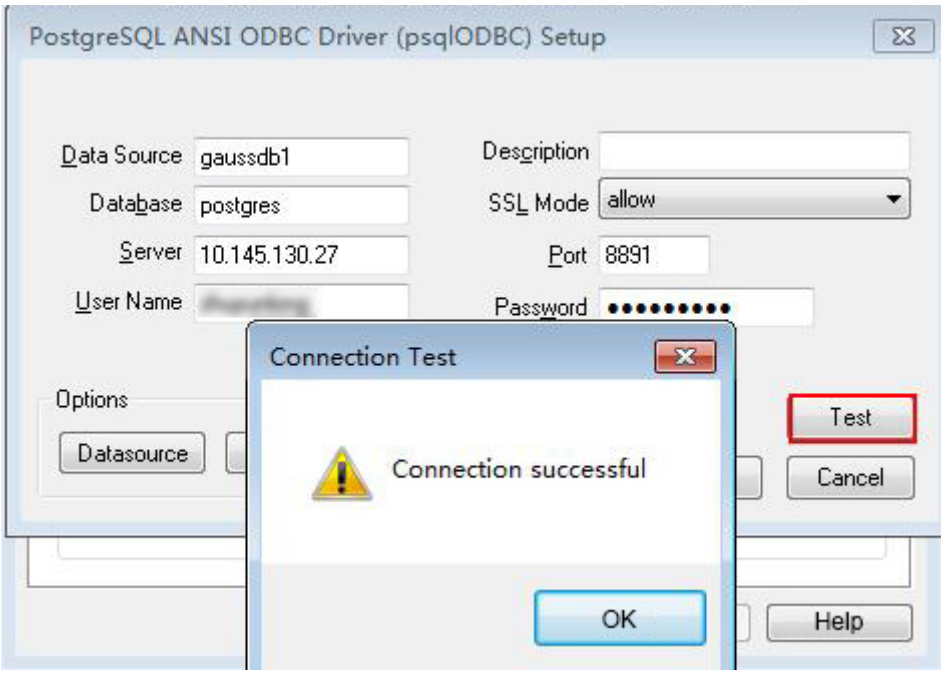


- If error information is displayed, the configuration is incorrect. Check the configuration.

## FAQs

- connect to server failed: no such file or directory

  Possible causes:

  – An incorrect or unreachable database IP address or port was configured.

  Check the **Servername** and **Port** configuration items in data sources.

  – Server monitoring is improper.

  If **Servername** and **Port** are correctly configured, ensure the proper network adapter and port are monitored by following the database server configurations in the procedure in this section.

  – Firewall and network gatekeeper settings are improper.

  Check firewall settings, and ensure that the database communication port is trusted.

  Check to ensure network gatekeeper settings are proper (if any).

- The password-stored method is not supported.

  Possible causes:

  **sslmode** is not configured for the data source. Set this configuration item to **allow** or a higher level to enable SSL connections. For details on **sslmode**, see **Table 6-12**.

- authentication method 10 not supported.

  If this error occurs on an open-source client, the cause may be:

  The database stores only the SHA-256 hash of the password, but the open-source client supports only MD5 hashes.

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NOTE

- The database stores the hashes of user passwords instead of actual passwords.
- If a password is updated or a user is created, both types of hashes will be stored, compatible with open-source authentication protocols.
- An MD5 hash can only be generated using the original password, but the password cannot be obtained by reversing its SHA-256 hash. Passwords in the old version will only have SHA-256 hashes and not support MD5 authentication.
- The MD5 encryption algorithm has lower security and poses security risks. Therefore, you are advised to use a more secure encryption algorithm.

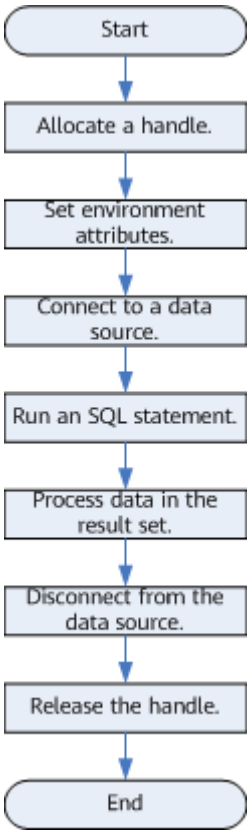
To solve this problem, you can update the user password (see **12.14.37 ALTER USER**) or create a user (see **12.14.88 CREATE USER**) having the same permissions as the faulty user.

- unsupported frontend protocol 3.51: server supports 1.0 to 3.0

  The database version is too early or the database is an open-source database. Use the driver of the required version to connect to the database.

## 6.4.4 Development Process

**Figure 6-3** ODBC-based application development process

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## APIs Involved in the Development Process

**Table 6-13** API description

| Function | API |
| --- | --- |
| Allocate a handle | **21.2.3 SQLAllocHandle** is a generic function for allocating a handle. It can replace the following functions:<br>• **21.2.1 SQLAllocEnv**: allocate an environment handle<br>• **21.2.2 SQLAllocConnect**: allocate a connection handle<br>• **21.2.4 SQLAllocStmt**: allocate a statement handle |
| Set environment attributes | **21.2.21 SQLSetEnvAttr** |
| Set connection attributes | **21.2.20 SQLSetConnectAttr** |
| Set statement attributes | **21.2.22 SQLSetStmtAttr** |
| Connect to a data source | **21.2.8 SQLConnect** |
| Bind a buffer to a column in the result set | **21.2.5 SQLBindCol** |
| Bind the parameter marker of an SQL statement to a buffer | **21.2.6 SQLBindParameter** |
| Return the error message of the last operation | **21.2.19 SQLGetDiagRec** |
| Prepare an SQL statement for execution | **21.2.17 SQLPrepare** |
| Run a prepared SQL statement | **21.2.11 SQLExecute** |
| Run an SQL statement directly | **21.2.10 SQLExecDirect** |
| Fetch the next row (or rows) from the result set | **21.2.12 SQLFetch** |
| Return data in a column of the result set | **21.2.18 SQLGetData** |
| Get the column information from a result set | **21.2.7 SQLColAttribute** |
| Disconnect from a data source | **21.2.9 SQLDisconnect** |

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| Function | API |
| --- | --- |
| Release a handle | 21.2.15 SQLFreeHandle is a generic function for releasing a handle. It can replace the following functions:<br>• 21.2.16 SQLFreeEnv: release an environment handle<br>• 21.2.14 SQLFreeConnect: release a connection handle<br>• 21.2.13 SQLFreeStmt: release a statement handle |

NOTE

If an execution request (not in a transaction block) received in the database contains multiple statements, the request is packed into a transaction. If one of the statements fails, the entire request will be rolled back.

WARNING

ODBC connects applications to the database and delivers the SQL statements sent by an application to the database. It does not parse the SQL syntax. Therefore, when confidential information (such as a plaintext password) is written into the SQL statement sent by an application, the confidential information is exposed in the driver log.

## 6.4.5 Example: Common Functions and Batch Binding

### Code for Common Functions

```
//The following example shows how to obtain data from GaussDB through the ODBC interface.
// DBtest.c (compile with: libodbc.so)
#include <stdlib.h>
#include <stdio.h>
#include <sqlext.h>
#ifdef WIN32
#include <windows.h>
#endif
SQLHENV       V_OD_Env;        // Handle ODBC environment
SQLHSTMT      V_OD_hstmt;      // Handle statement
SQLHDBC       V_OD_hdbc;       // Handle connection
char          typename[100];
SQLINTEGER    value = 100;
SQLINTEGER    V_OD_erg,V_OD_buffer,V_OD_err,V_OD_id;
int main(int argc,char *argv[])
{
    // 1. Allocate an environment handle.
    V_OD_erg = SQLAllocHandle(SQL_HANDLE_ENV,SQL_NULL_HANDLE,&V_OD_Env);
    if ((V_OD_erg != SQL_SUCCESS) && (V_OD_erg != SQL_SUCCESS_WITH_INFO))
    {
        printf("Error AllocHandle\n");
        exit(0);
    }
    // 2. Set environment attributes (version information).
    SQLSetEnvAttr(V_OD_Env, SQL_ATTR_ODBC_VERSION, (void*)SQL_OV_ODBC3, 0);
```

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```
    // 3. Allocate a connection handle.
    V_OD_erg = SQLAllocHandle(SQL_HANDLE_DBC, V_OD_Env, &V_OD_hdbc);
    if ((V_OD_erg != SQL_SUCCESS) && (V_OD_erg != SQL_SUCCESS_WITH_INFO))
    {
        SQLFreeHandle(SQL_HANDLE_ENV, V_OD_Env);
        exit(0);
    }
    // 4. Set connection attributes.
    SQLSetConnectAttr(V_OD_hdbc, SQL_ATTR_AUTOCOMMIT, SQL_AUTOCOMMIT_ON, 0);
   // 5. Connect to the data source. userName and password indicate the username and password for connecting to the database. Set them as needed.
    // If the username and password have been set in the odbc.ini file, you do not need to set userName or password here, retaining "" for them. However, you are not advised to do so because the username and password will be disclosed if the permission for odbc.ini is abused.
    V_OD_erg = SQLConnect(V_OD_hdbc, (SQLCHAR*) "gaussdb", SQL_NTS,
                          (SQLCHAR*) "userName", SQL_NTS,  (SQLCHAR*) "password", SQL_NTS);
    if ((V_OD_erg != SQL_SUCCESS) && (V_OD_erg != SQL_SUCCESS_WITH_INFO))
    {
        printf("Error SQLConnect %d\n",V_OD_erg);
        SQLFreeHandle(SQL_HANDLE_ENV, V_OD_Env);
        exit(0);
    }
    printf("Connected !\n");
    // 6. Set statement attributes.
    SQLSetStmtAttr(V_OD_hstmt,SQL_ATTR_QUERY_TIMEOUT,(SQLPOINTER *)3,0);
     // 7. Allocate a statement handle.
    SQLAllocHandle(SQL_HANDLE_STMT, V_OD_hdbc, &V_OD_hstmt);
    // 8. Run SQL statements.
    SQLExecDirect(V_OD_hstmt,"drop table IF EXISTS customer_t1",SQL_NTS);
    SQLExecDirect(V_OD_hstmt,"CREATE TABLE customer_t1(c_customer_sk INTEGER, c_customer_name VARCHAR(32));",SQL_NTS);
    SQLExecDirect(V_OD_hstmt,"insert into customer_t1 values(25,'li')",SQL_NTS);
    // 9. Prepare for execution.
    SQLPrepare(V_OD_hstmt,"insert into customer_t1 values(?)",SQL_NTS);
    // 10. Bind parameters.
    SQLBindParameter(V_OD_hstmt,1,SQL_PARAM_INPUT,SQL_C_SLONG,SQL_INTEGER,0,0,
                     &value,0,NULL);
    // 11. Run prepared statements.
    SQLExecute(V_OD_hstmt);
    SQLExecDirect(V_OD_hstmt,"select c_customer_sk from customer_t1",SQL_NTS);
    // 12. Obtain attributes of a specific column in the result set.
    SQLColAttribute(V_OD_hstmt,1,SQL_DESC_TYPE,typename,100,NULL,NULL);
    printf("SQLColAtrribute %s\n",typename);
    // 13. Bind the result set.
    SQLBindCol(V_OD_hstmt,1,SQL_C_SLONG, (SQLPOINTER)&V_OD_buffer,150,
            (SQLLEN *)&V_OD_err);
    // 14. Obtain data in the result set by executing SQLFetch.
    V_OD_erg=SQLFetch(V_OD_hstmt);
    // 15. Obtain and return data by executing SQLGetData.
    while(V_OD_erg != SQL_NO_DATA)
    {
        SQLGetData(V_OD_hstmt,1,SQL_C_SLONG,(SQLPOINTER)&V_OD_id,0,NULL);
        printf("SQLGetData ----ID = %d\n",V_OD_id);
        V_OD_erg=SQLFetch(V_OD_hstmt);
    };
    printf("Done !\n");
    // 16. Disconnect data source connections and release handles.
    SQLFreeHandle(SQL_HANDLE_STMT,V_OD_hstmt);
    SQLDisconnect(V_OD_hdbc);
    SQLFreeHandle(SQL_HANDLE_DBC,V_OD_hdbc);
    SQLFreeHandle(SQL_HANDLE_ENV, V_OD_Env);
    return(0);
}
```

## Code for Batch Processing

```
/*****************************************************************
*Enable UseBatchProtocol in the data source and set the database parameter support_batch_bind
*to on.
```

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```
*The CHECK_ERROR command is used to check and print error information.
*This example is used to interactively obtain the DSN, data volume to be processed, and volume of ignored data from users, and insert required data into the test_odbc_batch_insert table.
**************************************************************************/
#include <stdio.h>
#include <stdlib.h>
#include <sql.h>
#include <sqlext.h>
#include <string.h>

void Exec(SQLHDBC hdbc, SQLCHAR* sql)
{
    SQLRETURN retcode;                  // Return status
    SQLHSTMT hstmt = SQL_NULL_HSTMT;    // Statement handle
    SQLCHAR     loginfo[2048];

    // Allocate Statement Handle
    retcode = SQLAllocHandle(SQL_HANDLE_STMT, hdbc, &hstmt);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLAllocHandle(SQL_HANDLE_STMT) failed");
        return;
    }

    // Prepare Statement
    retcode = SQLPrepare(hstmt, (SQLCHAR*) sql, SQL_NTS);
    sprintf((char*)loginfo, "SQLPrepare log: %s", (char*)sql);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLPrepare(hstmt, (SQLCHAR*) sql, SQL_NTS) failed");
        return;
    }

    // Execute Statement
    retcode = SQLExecute(hstmt);
    sprintf((char*)loginfo, "SQLExecute stmt log: %s", (char*)sql);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLExecute(hstmt) failed");
        return;
    }
    // Free Handle
    retcode = SQLFreeHandle(SQL_HANDLE_STMT, hstmt);
    sprintf((char*)loginfo, "SQLFreeHandle stmt log: %s", (char*)sql);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLFreeHandle(SQL_HANDLE_STMT, hstmt) failed");
        return;
    }
}

int main ()
{
    SQLHENV  henv  = SQL_NULL_HENV;
    SQLHDBC  hdbc  = SQL_NULL_HDBC;
    int      batchCount = 1000; // Amount of data that is bound in batches
    SQLLEN   rowsCount = 0;
    int      ignoreCount = 0; // Amount of data that is not imported to the database among the data that is bound in batches

    SQLRETURN   retcode;
    SQLCHAR     dsn[1024] = {'\0'};
    SQLCHAR     loginfo[2048];

    do
    {
        if (ignoreCount > batchCount)
        {
            printf("ignoreCount(%d) should be less than batchCount(%d)\n", ignoreCount, batchCount);
```

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```
    }
}while(ignoreCount > batchCount);

retcode = SQLAllocHandle(SQL_HANDLE_ENV, SQL_NULL_HANDLE, &henv);

if (!SQL_SUCCEEDED(retcode)) {
    printf("SQLAllocHandle failed");
    goto exit;
}

// Set ODBC Verion
retcode = SQLSetEnvAttr(henv, SQL_ATTR_ODBC_VERSION,
                                (SQLPOINTER*)SQL_OV_ODBC3, 0);

if (!SQL_SUCCEEDED(retcode)) {
    printf("SQLSetEnvAttr failed");
    goto exit;
}

// Allocate Connection
retcode = SQLAllocHandle(SQL_HANDLE_DBC, henv, &hdbc);

if (!SQL_SUCCEEDED(retcode)) {
    printf("SQLAllocHandle failed");
    goto exit;
}

// Set Login Timeout
retcode = SQLSetConnectAttr(hdbc, SQL_LOGIN_TIMEOUT, (SQLPOINTER)5, 0);

if (!SQL_SUCCEEDED(retcode)) {
    printf("SQLSetConnectAttr failed");
    goto exit;
}

// Set Auto Commit
retcode = SQLSetConnectAttr(hdbc, SQL_ATTR_AUTOCOMMIT,
                                (SQLPOINTER)(1), 0);

if (!SQL_SUCCEEDED(retcode)) {
    printf("SQLSetConnectAttr failed");
    goto exit;
}

// Connect to DSN
// gaussdb indicates the name of the data source used by users.
sprintf(loginfo, "SQLConnect(DSN:%s)", dsn);
retcode = SQLConnect(hdbc, (SQLCHAR*) "gaussdb", SQL_NTS,
                        (SQLCHAR*) NULL, 0, NULL, 0);

if (!SQL_SUCCEEDED(retcode)) {
    printf("SQLConnect failed");
    goto exit;
}

// init table info.
Exec(hdbc, "drop table if exists test_odbc_batch_insert");
Exec(hdbc, "create table test_odbc_batch_insert(id int primary key, col varchar2(50))");

// The following code constructs the data to be inserted based on the data volume entered by users:
{
    SQLRETURN retcode;
    SQLHSTMT hstmtinesrt = SQL_NULL_HSTMT;
    int          i;
    SQLCHAR      *sql = NULL;
    SQLINTEGER   *ids  = NULL;
    SQLCHAR      *cols = NULL;
    SQLLEN       *bufLenIds = NULL;
    SQLLEN       *bufLenCols = NULL;
```

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```
    SQLUSMALLINT *operptr = NULL;
    SQLUSMALLINT *statusptr = NULL;
    SQLULEN      process = 0;

    // Data is constructed by column. Each column is stored continuously.
    ids = (SQLINTEGER*)malloc(sizeof(ids[0]) * batchCount);
    cols = (SQLCHAR*)malloc(sizeof(cols[0]) * batchCount * 50);
    // Data size in each row for a column
    bufLenIds = (SQLLEN*)malloc(sizeof(bufLenIds[0]) * batchCount);
    bufLenCols = (SQLLEN*)malloc(sizeof(bufLenCols[0]) * batchCount);
    // Whether this row needs to be processed. The value is SQL_PARAM_IGNORE or
SQL_PARAM_PROCEED.
    operptr = (SQLUSMALLINT*)malloc(sizeof(operptr[0]) * batchCount);
    memset(operptr, 0, sizeof(operptr[0]) * batchCount);
    // Processing result of the row
    // Note: In the database, a statement belongs to one transaction. Therefore, data is processed as a
unit. Either all data is inserted successfully or all data fails to be inserted.
    statusptr = (SQLUSMALLINT*)malloc(sizeof(statusptr[0]) * batchCount);
    memset(statusptr, 88, sizeof(statusptr[0]) * batchCount);

    if (NULL == ids || NULL == cols || NULL == bufLenCols || NULL == bufLenIds)
    {
        fprintf(stderr, "FAILED:\tmalloc data memory failed\n");
        goto exit;
    }

    for (int i = 0; i < batchCount; i++)
    {
        ids[i] = i;
        sprintf(cols + 50 * i, "column test value %d", i);
        bufLenIds[i] = sizeof(ids[i]);
        bufLenCols[i] = strlen(cols + 50 * i);
        operptr[i] = (i < ignoreCount) ? SQL_PARAM_IGNORE : SQL_PARAM_PROCEED;
    }

    // Allocate Statement Handle
    retcode = SQLAllocHandle(SQL_HANDLE_STMT, hdbc, &hstmtinesrt);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLAllocHandle failed");
        goto exit;
    }

    // Prepare Statement
    sql = (SQLCHAR*)"insert into test_odbc_batch_insert values(?, ?)";
    retcode = SQLPrepare(hstmtinesrt, (SQLCHAR*) sql, SQL_NTS);
    sprintf((char*)loginfo, "SQLPrepare log: %s", (char*)sql);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLPrepare failed");
        goto exit;
    }

    retcode = SQLSetStmtAttr(hstmtinesrt, SQL_ATTR_PARAMSET_SIZE, (SQLPOINTER)batchCount,
sizeof(batchCount));

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLSetStmtAttr failed");
        goto exit;
    }

    retcode = SQLBindParameter(hstmtinesrt, 1, SQL_PARAM_INPUT, SQL_C_SLONG, SQL_INTEGER,
sizeof(ids[0]), 0,&(ids[0]), 0, bufLenIds);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLBindParameter failed");
        goto exit;
    }
```

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```
    retcode = SQLBindParameter(hstmtinesrt, 2, SQL_PARAM_INPUT, SQL_C_CHAR, SQL_CHAR, 50, 50,
cols, 50, bufLenCols);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLBindParameter failed");
        goto exit;
    }

    retcode = SQLSetStmtAttr(hstmtinesrt, SQL_ATTR_PARAMS_PROCESSED_PTR, (SQLPOINTER)&process,
sizeof(process));

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLSetStmtAttr failed");
        goto exit;
    }

    retcode = SQLSetStmtAttr(hstmtinesrt, SQL_ATTR_PARAM_STATUS_PTR, (SQLPOINTER)statusptr,
sizeof(statusptr[0]) * batchCount);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLSetStmtAttr failed");
        goto exit;
    }

    retcode = SQLSetStmtAttr(hstmtinesrt, SQL_ATTR_PARAM_OPERATION_PTR, (SQLPOINTER)operptr,
sizeof(operptr[0]) * batchCount);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLSetStmtAttr failed");
        goto exit;
    }

    retcode = SQLExecute(hstmtinesrt);
    sprintf((char*)loginfo, "SQLExecute stmt log: %s", (char*)sql);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLExecute(hstmtinesrt) failed");
        goto exit;

    retcode = SQLRowCount(hstmtinesrt, &rowsCount);

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLRowCount failed");
        goto exit;
    }

    if (rowsCount != (batchCount - ignoreCount))
    {
        sprintf(loginfo, "(batchCount - ignoreCount)(%d) != rowsCount(%d)", (batchCount - ignoreCount),
rowsCount);

        if (!SQL_SUCCEEDED(retcode)) {
            printf("SQLExecute failed");
            goto exit;
        }
    }
    else
    {
        sprintf(loginfo, "(batchCount - ignoreCount)(%d) == rowsCount(%d)", (batchCount - ignoreCount),
rowsCount);

        if (!SQL_SUCCEEDED(retcode)) {
            printf("SQLExecute failed");
            goto exit;
        }
    }

    // check row number returned
    if (rowsCount != process)
```

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```
    {
        sprintf(loginfo, "process(%d) != rowsCount(%d)", process, rowsCount);

        if (!SQL_SUCCEEDED(retcode)) {
            printf("SQLExecute failed");
            goto exit;
        }
    }
    else
    {
        sprintf(loginfo, "process(%d) == rowsCount(%d)", process, rowsCount);

        if (!SQL_SUCCEEDED(retcode)) {
            printf("SQLExecute failed");
            goto exit;
        }
    }

    for (int i = 0; i < batchCount; i++)
    {
        if (i < ignoreCount)
        {
            if (statusptr[i] != SQL_PARAM_UNUSED)
            {
                sprintf(loginfo, "statusptr[%d](%d) != SQL_PARAM_UNUSED", i, statusptr[i]);

                if (!SQL_SUCCEEDED(retcode)) {
                    printf("SQLExecute failed");
                    goto exit;
                }
            }
        }
        else if (statusptr[i] != SQL_PARAM_SUCCESS)
        {
            sprintf(loginfo, "statusptr[%d](%d) != SQL_PARAM_SUCCESS", i, statusptr[i]);

            if (!SQL_SUCCEEDED(retcode)) {
                printf("SQLExecute failed");
                goto exit;
            }
        }
    }

    retcode = SQLFreeHandle(SQL_HANDLE_STMT, hstmtinesrt);
    sprintf((char*)loginfo, "SQLFreeHandle hstmtinesrt");

    if (!SQL_SUCCEEDED(retcode)) {
        printf("SQLFreeHandle failed");
        goto exit;
    }
  }


exit:
  (void) printf ("\nComplete.\n");

  // Connection
  if (hdbc != SQL_NULL_HDBC) {
      SQLDisconnect(hdbc);
      SQLFreeHandle(SQL_HANDLE_DBC, hdbc);
  }

  // Environment
  if (henv != SQL_NULL_HENV)
      SQLFreeHandle(SQL_HANDLE_ENV, henv);

  return 0;
}
```

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# 6.4.6 Typical Application Scenarios and Configurations

## Log Diagnosis

ODBC logs are classified into unixODBC driver manager logs and psqlODBC driver logs. The former is used to trace whether the application API is successfully executed, and the latter is used to locate problems based on DFX logs generated during underlying implementation.

The unixODBC log needs to be configured in the **odbcinst.ini** file:

```
[ODBC]
Trace=Yes
TraceFile=/path/to/odbctrace.log

[GaussMPP]
Driver64=/usr/local/lib/psqlodbcw.so
setup=/usr/local/lib/psqlodbcw.so
```

You only need to add the following information to the **odbc.ini** file:

```
[gaussdb]
Driver=GaussMPP
Servername=10.10.0.13 (database server IP address)
...
Debug=1 (Enable the debug log function of the driver.)
```

NOTE

The unixODBC logs are generated in the path configured by **TraceFile**. The psqlODBC generates the **mylog**_*xxx*.**log** file in the **/tmp/** directory.

## High Performance

If a large amount of data needs to be inserted, you are advised to perform the following operations:

- Set **UseBatchProtocol** to **1** in **odbc.ini** and set **support_batch_bind** in the database.
- Set the ODBC program binding type to be the same as that in the database.
- Set the character set of the client to be the same as that in the database.
- Commit the transaction manually.

**odbc.ini** configuration file:

```
[gaussdb]
Driver=GaussMPP
Servername=10.10.0.13 (database server IP address)
...
UseBatchProtocol=1 (enabled by default)
ConnSettings=set client_encoding=UTF8 (Set the character code on the client to be the same as that on the server.)
```

Binding type case:

```
#include <stdio.h>
#include <stdlib.h>
#include <sql.h>
#include <sqlext.h>
#include <string.h>
#include <sys/time.h>

#define MESSAGE_BUFFER_LEN  128
SQLHANDLE   h_env = NULL;
SQLHANDLE   h_conn = NULL;
```

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```
SQLHANDLE   h_stmt = NULL;
void print_error()
{
    SQLCHAR     Sqlstate[SQL_SQLSTATE_SIZE+1];
    SQLINTEGER  NativeError;
    SQLCHAR     MessageText[MESSAGE_BUFFER_LEN];
    SQLSMALLINT TextLength;
    SQLRETURN   ret = SQL_ERROR;

    ret = SQLGetDiagRec(SQL_HANDLE_STMT, h_stmt, 1, Sqlstate, &NativeError, MessageText,
MESSAGE_BUFFER_LEN, &TextLength);
    if ( SQL_SUCCESS == ret)
    {
        printf("\n STMT ERROR-%05d %s", NativeError, MessageText);
        return;
    }

    ret = SQLGetDiagRec(SQL_HANDLE_DBC, h_conn, 1, Sqlstate, &NativeError, MessageText,
MESSAGE_BUFFER_LEN, &TextLength);
    if ( SQL_SUCCESS == ret)
    {
        printf("\n CONN ERROR-%05d %s", NativeError, MessageText);
        return;
    }

    ret = SQLGetDiagRec(SQL_HANDLE_ENV, h_env, 1, Sqlstate, &NativeError, MessageText,
MESSAGE_BUFFER_LEN, &TextLength);
    if ( SQL_SUCCESS == ret)
    {
        printf("\n ENV ERROR-%05d %s", NativeError, MessageText);
        return;
    }

    return;
}

/* Expect the function to return SQL_SUCCESS. */
#define RETURN_IF_NOT_SUCCESS(func) \
{\
    SQLRETURN ret_value = (func);\
    if (SQL_SUCCESS != ret_value)\
    {\
        print_error();\
        printf("\n failed line = %u: expect SQL_SUCCESS, but ret = %d", __LINE__, ret_value);\
        return SQL_ERROR; \
    }\
}

/* Expect the function to return SQL_SUCCESS. */
#define RETURN_IF_NOT_SUCCESS_I(i, func) \
{\
    SQLRETURN ret_value = (func);\
    if (SQL_SUCCESS != ret_value)\
    {\
        print_error();\
        printf("\n failed line = %u (i=%d): : expect SQL_SUCCESS, but ret = %d", __LINE__, (i), ret_value);\
        return SQL_ERROR; \
    }\
}

/* Expect the function to return SQL_SUCCESS_WITH_INFO. */
#define RETURN_IF_NOT_SUCCESS_INFO(func) \
{\
    SQLRETURN ret_value = (func);\
    if (SQL_SUCCESS_WITH_INFO != ret_value)\
    {\
        print_error();\
        printf("\n failed line = %u: expect SQL_SUCCESS_WITH_INFO, but ret = %d", __LINE__, ret_value);\
        return SQL_ERROR; \
```

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```
    }\
}

/* Expect the values are the same. */
#define RETURN_IF_NOT(expect, value) \
if ((expect) != (value))\
{\
    printf("\n failed line = %u: expect = %u, but value = %u", __LINE__, (expect), (value)); \
    return SQL_ERROR;\
}

/* Expect the character strings are the same. */
#define RETURN_IF_NOT_STRCMP_I(i, expect, value) \
if (( NULL == (expect) ) || (NULL == (value)))\
{\
    printf("\n failed line = %u (i=%u): input NULL pointer !", __LINE__, (i)); \
    return SQL_ERROR; \
}\
else if (0 != strcmp((expect), (value)))\
{\
    printf("\n failed line = %u (i=%u): expect = %s, but value = %s", __LINE__, (i), (expect), (value)); \
    return SQL_ERROR;\
}


// prepare + execute SQL statement
int execute_cmd(SQLCHAR *sql)
{
    if ( NULL == sql )
    {
        return SQL_ERROR;
    }

    if ( SQL_SUCCESS != SQLPrepare(h_stmt, sql, SQL_NTS))
    {
        return SQL_ERROR;
    }

    if ( SQL_SUCCESS != SQLExecute(h_stmt))
    {
        return SQL_ERROR;
    }

    return SQL_SUCCESS;
}
// execute + commit handle
int commit_exec()
{
    if ( SQL_SUCCESS != SQLExecute(h_stmt))
    {
        return SQL_ERROR;
    }

     // Manual committing
    if ( SQL_SUCCESS != SQLEndTran(SQL_HANDLE_DBC, h_conn, SQL_COMMIT))
    {
        return SQL_ERROR;
    }

    return SQL_SUCCESS;
}

int begin_unit_test()
{
    SQLINTEGER    ret;

    /* Allocate an environment handle. */
    ret = SQLAllocHandle(SQL_HANDLE_ENV, SQL_NULL_HANDLE, &h_env);
    if ((SQL_SUCCESS != ret) && (SQL_SUCCESS_WITH_INFO != ret))
```

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```
    {
        printf("\n begin_unit_test::SQLAllocHandle SQL_HANDLE_ENV failed ! ret = %d", ret);
        return SQL_ERROR;
    }

    /* Set the version number before connection. */
    if (SQL_SUCCESS != SQLSetEnvAttr(h_env, SQL_ATTR_ODBC_VERSION, (SQLPOINTER)SQL_OV_ODBC3,
0))
    {
        print_error();
        printf("\n begin_unit_test::SQLSetEnvAttr SQL_ATTR_ODBC_VERSION failed ! ret = %d", ret);
        SQLFreeHandle(SQL_HANDLE_ENV, h_env);
        return SQL_ERROR;
    }

    /* Allocate a connection handle. */
    ret = SQLAllocHandle(SQL_HANDLE_DBC, h_env, &h_conn);
    if (SQL_SUCCESS != ret)
    {
        print_error();
        printf("\n begin_unit_test::SQLAllocHandle SQL_HANDLE_DBC failed ! ret = %d", ret);
        SQLFreeHandle(SQL_HANDLE_ENV, h_env);
        return SQL_ERROR;
    }

    /* Establish a connection. */
 ret = SQLConnect(h_conn, (SQLCHAR*) "gaussdb", SQL_NTS,
                          (SQLCHAR*) NULL, 0, NULL, 0);
    if (SQL_SUCCESS != ret)
    {
        print_error();
        printf("\n begin_unit_test::SQLConnect  failed ! ret = %d", ret);
        SQLFreeHandle(SQL_HANDLE_DBC, h_conn);
        SQLFreeHandle(SQL_HANDLE_ENV, h_env);
        return SQL_ERROR;
    }

    /* Allocate a statement handle. */
    ret = SQLAllocHandle(SQL_HANDLE_STMT, h_conn, &h_stmt);
    if (SQL_SUCCESS != ret)
    {
        print_error();
        printf("\n begin_unit_test::SQLAllocHandle SQL_HANDLE_STMT failed ! ret = %d", ret);
        SQLFreeHandle(SQL_HANDLE_DBC, h_conn);
        SQLFreeHandle(SQL_HANDLE_ENV, h_env);
        return SQL_ERROR;
    }

    return SQL_SUCCESS;
}

void end_unit_test()
{
    /* Release a statement handle. */
    if (NULL != h_stmt)
    {
        SQLFreeHandle(SQL_HANDLE_STMT, h_stmt);
    }

    /* Release a connection handle. */
    if (NULL != h_conn)
    {
        SQLDisconnect(h_conn);
        SQLFreeHandle(SQL_HANDLE_DBC, h_conn);
    }

    /* Release an environment handle. */
    if (NULL != h_env)
    {
```

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```
        SQLFreeHandle(SQL_HANDLE_ENV, h_env);
    }

    return;
}

int main()
{
 // begin test
 if (begin_unit_test() != SQL_SUCCESS)
    {
        printf("\n begin_test_unit failed.");
        return SQL_ERROR;
    }
    // The handle configuration is the same as that in the preceding case
    int         i = 0;
    SQLCHAR*    sql_drop   = "drop table if exists test_bindnumber_001";
    SQLCHAR*    sql_create = "create table test_bindnumber_001("
                             "f4 number, f5 number(10, 2)"
                             ")";
    SQLCHAR*    sql_insert = "insert into test_bindnumber_001 values(?, ?)";
    SQLCHAR*    sql_select = "select * from test_bindnumber_001";
    SQLLEN      RowCount;
    SQL_NUMERIC_STRUCT st_number;
    SQLCHAR     getValue[2][MESSAGE_BUFFER_LEN];

    /* Step 1. Create a table. */
    RETURN_IF_NOT_SUCCESS(execute_cmd(sql_drop));
    RETURN_IF_NOT_SUCCESS(execute_cmd(sql_create));

    /* Step 2.1 Bind parameters using the SQL_NUMERIC_STRUCT structure. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));

    // First line: 1234.5678
    memset(st_number.val, 0, SQL_MAX_NUMERIC_LEN);
    st_number.precision = 8;
    st_number.scale = 4;
    st_number.sign = 1;
    st_number.val[0] = 0x4E;
    st_number.val[1] = 0x61;
    st_number.val[2] = 0xBC;

    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_NUMERIC,
SQL_NUMERIC, sizeof(SQL_NUMERIC_STRUCT), 4, &st_number, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_NUMERIC,
SQL_NUMERIC, sizeof(SQL_NUMERIC_STRUCT), 4, &st_number, 0, NULL));

    // Disable the automatic commit function.
    SQLSetConnectAttr(h_conn, SQL_ATTR_AUTOCOMMIT, (SQLPOINTER)SQL_AUTOCOMMIT_OFF, 0);

    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    // Second line: 12345678
    memset(st_number.val, 0, SQL_MAX_NUMERIC_LEN);
    st_number.precision = 8;
    st_number.scale = 0;
    st_number.sign = 1;
    st_number.val[0] = 0x4E;
    st_number.val[1] = 0x61;
    st_number.val[2] = 0xBC;

    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_NUMERIC,
SQL_NUMERIC, sizeof(SQL_NUMERIC_STRUCT), 0, &st_number, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_NUMERIC,
SQL_NUMERIC, sizeof(SQL_NUMERIC_STRUCT), 0, &st_number, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
```

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```
    RETURN_IF_NOT(1, RowCount);

    // Third line: 12345678
    memset(st_number.val, 0, SQL_MAX_NUMERIC_LEN);
    st_number.precision = 0;
    st_number.scale = 4;
    st_number.sign = 1;
    st_number.val[0] = 0x4E;
    st_number.val[1] = 0x61;
    st_number.val[2] = 0xBC;

    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_NUMERIC,
SQL_NUMERIC, sizeof(SQL_NUMERIC_STRUCT), 4, &st_number, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_NUMERIC,
SQL_NUMERIC, sizeof(SQL_NUMERIC_STRUCT), 4, &st_number, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);


    /* Step 2.2 Bind parameters by using the SQL_C_CHAR character string in the fourth line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    SQLCHAR*    szNumber = "1234.5678";
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_CHAR,
SQL_NUMERIC, strlen(szNumber), 0, szNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_CHAR,
SQL_NUMERIC, strlen(szNumber), 0, szNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    /* Step 2.3 Bind parameters by using SQL_C_FLOAT in the fifth line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    SQLREAL    fNumber = 1234.5678;
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_FLOAT,
SQL_NUMERIC, sizeof(fNumber), 4, &fNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_FLOAT,
SQL_NUMERIC, sizeof(fNumber), 4, &fNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    /* Step 2.4 Bind parameters by using SQL_C_DOUBLE in the sixth line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    SQLDOUBLE   dNumber = 1234.5678;
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_DOUBLE,
SQL_NUMERIC, sizeof(dNumber), 4, &dNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_DOUBLE,
SQL_NUMERIC, sizeof(dNumber), 4, &dNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    SQLBIGINT   bNumber1 = 0xFFFFFFFFFFFFFFFF;
    SQLBIGINT   bNumber2 = 12345;

    /* Step 2.5 Bind parameters by using SQL_C_SBIGINT in the seventh line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_SBIGINT,
SQL_NUMERIC, sizeof(bNumber1), 4, &bNumber1, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_SBIGINT,
SQL_NUMERIC, sizeof(bNumber2), 4, &bNumber2, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    /* Step 2.6 Bind parameters by using SQL_C_UBIGINT in the eighth line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_UBIGINT,
```

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```
SQL_NUMERIC, sizeof(bNumber1), 4, &bNumber1, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_UBIGINT,
SQL_NUMERIC, sizeof(bNumber2), 4, &bNumber2, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    SQLLEN  lNumber1 = 0xFFFFFFFFFFFFFFFF;
    SQLLEN  lNumber2 = 12345;

    /* Step 2.7 Bind parameters by using SQL_C_LONG in the ninth line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_LONG,
SQL_NUMERIC, sizeof(lNumber1), 0, &lNumber1, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_LONG,
SQL_NUMERIC, sizeof(lNumber2), 0, &lNumber2, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    /* Step 2.8 Bind parameters by using SQL_C_ULONG in the tenth line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_ULONG,
SQL_NUMERIC, sizeof(lNumber1), 0, &lNumber1, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_ULONG,
SQL_NUMERIC, sizeof(lNumber2), 0, &lNumber2, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    SQLSMALLINT sNumber = 0xFFFF;

    /* Step 2.9 Bind parameters by using SQL_C_SHORT in the eleventh line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_SHORT,
SQL_NUMERIC, sizeof(sNumber), 0, &sNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_SHORT,
SQL_NUMERIC, sizeof(sNumber), 0, &sNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    /* Step 2.10 Bind parameters by using SQL_C_USHORT in the twelfth line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_USHORT,
SQL_NUMERIC, sizeof(sNumber), 0, &sNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_USHORT,
SQL_NUMERIC, sizeof(sNumber), 0, &sNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    SQLCHAR cNumber = 0xFF;

    /* Step 2.11 Bind parameters by using SQL_C_TINYINT in the thirteenth line. */
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_TINYINT,
SQL_NUMERIC, sizeof(cNumber), 0, &cNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_TINYINT,
SQL_NUMERIC, sizeof(cNumber), 0, &cNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    /* Step 2.12 Bind parameters by using SQL_C_UTINYINT in the fourteenth line.*/
    RETURN_IF_NOT_SUCCESS(SQLPrepare(h_stmt, sql_insert, SQL_NTS));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 1, SQL_PARAM_INPUT, SQL_C_UTINYINT,
SQL_NUMERIC, sizeof(cNumber), 0, &cNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(SQLBindParameter(h_stmt, 2, SQL_PARAM_INPUT, SQL_C_UTINYINT,
```

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```
SQL_NUMERIC, sizeof(cNumber), 0, &cNumber, 0, NULL));
    RETURN_IF_NOT_SUCCESS(commit_exec());
    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(1, RowCount);

    /* Use the character string type to unify the expectation. */
    SQLCHAR*    expectValue[14][2] = {{"1234.5678",            "1234.57"},
                                      {"12345678",             "12345678"},
                                      {"0",                    "0"},
                                      {"1234.5678",            "1234.57"},
                                      {"1234.5677",            "1234.57"},
                                      {"1234.5678",            "1234.57"},
                                      {"-1",                   "12345"},
                                      {"18446744073709551615",  "12345"},
                                      {"-1",                   "12345"},
                                      {"4294967295",           "12345"},
                                      {"-1",                   "-1"},
                                      {"65535",                "65535"},
                                      {"-1",                   "-1"},
                                      {"255",                  "255"},
                                      };

    RETURN_IF_NOT_SUCCESS(execute_cmd(sql_select));
    while ( SQL_NO_DATA != SQLFetch(h_stmt))
    {
        RETURN_IF_NOT_SUCCESS_I(i, SQLGetData(h_stmt, 1, SQL_C_CHAR, &getValue[0],
MESSAGE_BUFFER_LEN, NULL));
        RETURN_IF_NOT_SUCCESS_I(i, SQLGetData(h_stmt, 2, SQL_C_CHAR, &getValue[1],
MESSAGE_BUFFER_LEN, NULL));

        //RETURN_IF_NOT_STRCMP_I(i, expectValue[i][0], getValue[0]);
        //RETURN_IF_NOT_STRCMP_I(i, expectValue[i][1], getValue[1]);
        i++;
    }

    RETURN_IF_NOT_SUCCESS(SQLRowCount(h_stmt, &RowCount));
    RETURN_IF_NOT(i, RowCount);
 SQLCloseCursor(h_stmt);
    /* Final step. Delete the table and restore the environment. */
    RETURN_IF_NOT_SUCCESS(execute_cmd(sql_drop));

    end_unit_test();
}
```

**NOTE**

In the example, the number column is defined. When the SQLBindParameter API is called, the performance of binding SQL_NUMERIC is higher than that of SQL_LONG. If char is used, the data type needs to be converted when data is inserted to the database server, causing a performance bottleneck.

## Load Balancing

Load balancing can be enabled when there are a large number of concurrent applications.

- Randomly distribute concurrent connections to all CNs to enable load balancing, preventing a single CN from being overloaded and achieving high performance.
- Set **AutoBalance** to **1** to enable load balancing.
- Set **RefreshCNListTime** to **5** as required. The default refresh interval is 10 seconds.
- Set **Priority** to **1** as required. In this case, concurrent connections are preferentially sent to the CNs configured in the configuration file. If all the

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configured CNs are unavailable, the connections are distributed to the remaining CNs.

Example:

Six CNs, namely, CN1, CN2, CN3, CN4, CN5, and CN6, are configured in the cluster, and four CNs, namely, CN1, CN2, CN3, and CN4, are configured in the configuration file.

Example content of the configuration file:

```
[gaussdb]
Driver=GaussMPP
Servername=10.145.130.26,10.145.130.27,10.145.130.28,10.145.130.29 (IP address of the database server)
Database=postgres  (database name)
Username=omm  (database username)
Password=    (user password of the database)
Port=8000 (database listening port)
Sslmode=allow
AutoBalance=1
RefreshCNListTime=3
Priority=1
```

If the configuration file and cluster environment are the same as those in the example, concurrent connections are randomly and evenly distributed to CN1, CN2, CN3, and CN4. When CN1, CN2, CN3, and CN4 are all unavailable, concurrent connections are randomly and evenly sent to CN5 and CN6. If any CN among CN1, CN2, CN3, and CN4 becomes available, the connections are not sent to CN5 and CN6 but to the available CN.

## 6.4.7 ODBC Interface Reference

For details, see **21.2 ODBC Interface Reference**.

# 6.5 Development Based on libpq

**libpq** is a C application programming interface to GaussDB. libpq contains a set of library functions that allow client programs to send query requests to GaussDB servers and obtain query results. It is also the underlying engine of other GaussDB application interfaces, such as ODBC. This chapter provides two examples to show how to write code using **libpq**.

## 6.5.1 Dependent Header Files of libpq

Client programs that use libpq must include the header file **libpq-fe.h** and must link with the libpq library.

## 6.5.2 Development Process

To compile and connect to a libpq source program, perform the following operations:

- Decompress the **GaussDB-Kernel-VxxxRxxxCxx-xxxxx-64bit-Libpq.tar.gz** file. The required header file is stored in the **include** folder, and the **lib** folder contains the required libpq library file.

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> **NOTE**
>
> In addition to **libpq-fe.h**, the **include** folder contains the header files **postgres_ext.h**, **gs_thread.h**, and **gs_threadlocal.h** by default. These three header files are the dependency files of **libpq-fe.h**.

- Include the **libpq-fe.h** header file.
  ```
  #include <libpq-fe.h>
  ```
- Provide the **-I** *directory* option to provide the installation location of the header file. (Sometimes the compiler looks for the default directory, so this option can be ignored.) Example:
  ```
  gcc -I (Directory where the header file is located) -L (Directory where the libpq library is located)
  testprog.c -lpq
  ```
- If the makefile is used, add the following option to variables *CPPFLAGS*, *LDFLAGS*, and *LIBS*:
  ```
  CPPFLAGS += -I (Directory of the header file)
  LDFLAGS += -L (Directory of the libpq library)
  LIBS += -lpq
  ```

# 6.5.3 Example

## Code for Common Functions

Example 1:

```
/*
 * testlibpq.c
 */
#include <stdio.h>
#include <stdlib.h>
#include <libpq-fe.h>

static void
exit_nicely(PGconn *conn)
{
    PQfinish(conn);
    exit(1);
}

int
main(int argc, char **argv)
{
    const char *conninfo;
    PGconn     *conn;
    PGresult   *res;
    int         nFields;
    int         i,j;

    /*
     * This value is used when the user provides the value of the conninfo character string in the command
line.
     * Otherwise, the environment variables or the default values
     * are used for all other connection parameters.
     */
    if (argc > 1)
        conninfo = argv[1];
    else
        conninfo = "dbname=postgres port=42121 host='10.44.133.171' application_name=test
connect_timeout=5 sslmode=allow user='test' password='test_1234'";

    /* Connect to the database. */
    conn = PQconnectdb(conninfo);

    /* Check whether the backend connection was successfully established. */
    if (PQstatus(conn) != CONNECTION_OK)
```

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```
{
    fprintf(stderr, "Connection to database failed: %s",
            PQerrorMessage(conn));
    exit_nicely(conn);
}

/*
 * Since a cursor is used in the test case, a transaction block is required.
 * Put all data in one "select * from pg_database"
 * PQexec() is too simple and is not recommended.
 */

/* Start a transaction block. */
res = PQexec(conn, "BEGIN");
if (PQresultStatus(res) != PGRES_COMMAND_OK)
{
    fprintf(stderr, "BEGIN command failed: %s", PQerrorMessage(conn));
    PQclear(res);
    exit_nicely(conn);
}

/*
 * PQclear PGresult should be executed when it is no longer needed, to avoid memory leakage.
 */
PQclear(res);

/*
 * Fetch data from the pg_database system catalog.
 */
res = PQexec(conn, "DECLARE myportal CURSOR FOR select * from pg_database");
if (PQresultStatus(res) != PGRES_COMMAND_OK)
{
    fprintf(stderr, "DECLARE CURSOR failed: %s", PQerrorMessage(conn));
    PQclear(res);
    exit_nicely(conn);
}
PQclear(res);

res = PQexec(conn, "FETCH ALL in myportal");
if (PQresultStatus(res) != PGRES_TUPLES_OK)
{
    fprintf(stderr, "FETCH ALL failed: %s", PQerrorMessage(conn));
    PQclear(res);
    exit_nicely(conn);
}

/* First, print out the attribute name. */
nFields = PQnfields(res);
for (i = 0; i < nFields; i++)
    printf("%-15s", PQfname(res, i));
printf("\n\n");

/*Print lines.*/
for (i = 0; i < PQntuples(res); i++)
{
    for (j = 0; j < nFields; j++)
        printf("%-15s", PQgetvalue(res, i, j));
    printf("\n");
}

PQclear(res);

/* Close the portal. We do not need to check for errors. */
res = PQexec(conn, "CLOSE myportal");
PQclear(res);

/* End the transaction. */
res = PQexec(conn, "END");
PQclear(res);
```

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```
    /* Close the database connection and clean up the database. */
    PQfinish(conn);

    return 0;
}
```

Example 2:

```
/*
 * testlibpq2.c
 *      Test out-of-line parameters and binary I/Os.
 *
 * Before running this example, run the following command to populate a database:
 *
 *
 * CREATE TABLE test1 (i int4, t text);
 *
  * INSERT INTO test1 values (2, 'ho there');
 *
 * Expected output:
 *
 *
 * tuple 0: got
 *  i = (4 bytes) 2
 *  t = (8 bytes) 'ho there'
 *
 */
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sys/types.h>
#include <libpq-fe.h>

/* for ntohl/htonl */
#include <netinet/in.h>
#include <arpa/inet.h>

static void
exit_nicely(PGconn *conn)
{
    PQfinish(conn);
    exit(1);
}

/*
 * This function is used to print out the query results. The results are in binary format
* and fetched from the table created in the comment above.
 */
static void
show_binary_results(PGresult *res)
{
    int         i;
    int         i_fnum,
                t_fnum;

    /* Use PQfnumber to avoid assumptions about field order in the result. */
    i_fnum = PQfnumber(res, "i");
    t_fnum = PQfnumber(res, "t");

    for (i = 0; i < PQntuples(res); i++)
    {
        char       *iptr;
        char       *tptr;
        int         ival;

       /* Obtain the field value (ignore the possibility that the field value may be empty). */
        iptr = PQgetvalue(res, i, i_fnum);
        tptr = PQgetvalue(res, i, t_fnum);
```

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```
        /*
         * The binary representation of INT4 is the network byte order,
         * which is better to be replaced with the local byte order.
         */
        ival = ntohl(*((uint32_t *) iptr));

        /*
         * The binary representation of TEXT is text. Since libpq can append a zero byte to it,
         *  and think of it as a C string.
         *
         */

        printf("tuple %d: got\n", i);
        printf(" i = (%d bytes) %d\n",
               PQgetlength(res, i, i_fnum), ival);
        printf(" t = (%d bytes) '%s'\n",
               PQgetlength(res, i, t_fnum), tptr);
        printf("\n\n");
    }
}

int
main(int argc, char **argv)
{
    const char *conninfo;
    PGconn     *conn;
    PGresult   *res;
    const char *paramValues[1];
    int         paramLengths[1];
    int         paramFormats[1];
    uint32_t    binaryIntVal;

    /*
     * If the user provides a parameter on the command line,
     * The value of this parameter is a conninfo character string. Otherwise,
    * Use environment variables or default values.
     */
    if (argc > 1)
        conninfo = argv[1];
    else
        conninfo = "dbname=postgres port=42121 host='10.44.133.171' application_name=test
connect_timeout=5 sslmode=allow user='test' password='test_1234'";

    /* Connect to the database. */
    conn = PQconnectdb(conninfo);

     /* Check whether the connection to the server was successfully established. */
    if (PQstatus(conn) != CONNECTION_OK)
    {
        fprintf(stderr, "Connection to database failed: %s",
                PQerrorMessage(conn));
        exit_nicely(conn);
    }

    /* Convert the integer value "2" to the network byte order. */
    binaryIntVal = htonl((uint32_t) 2);

    /* Set the parameter array for PQexecParams. */
    paramValues[0] = (char *) &binaryIntVal;
    paramLengths[0] = sizeof(binaryIntVal);
    paramFormats[0] = 1;        /* Binary */

    res = PQexecParams(conn,
                       "SELECT * FROM test1 WHERE i = $1::int4",
                       1,       /* One parameter */
                       NULL,    /* Enable the backend to deduce the parameter type. */
                       paramValues,
                       paramLengths,
                       paramFormats,
```

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```
                    1);     /* Binary result is required. */

    if (PQresultStatus(res) != PGRES_TUPLES_OK)
    {
        fprintf(stderr, "SELECT failed: %s", PQerrorMessage(conn));
        PQclear(res);
        exit_nicely(conn);
    }

    show_binary_results(res);

    PQclear(res);

    /* Close the database connection and clean up the database. */
    PQfinish(conn);

    return 0;
}
```

Example 3:

```
/*
 * testlibpq3.c Test PQprepare
 * /
#include <stdio.h>
#include <stdlib.h>
#include <libpq-fe.h>
int main(int argc, char * argv[])
{
    PGconn *conn;
    PGresult * res;
    ConnStatusType pgstatus;
    char connstr[1024];
    char cmd_sql[2048];
    int nParams = 0;
    int paramLengths[5];
    int paramFormats[5];
    Oid paramTypes[5];
    char * paramValues[5];
    int i, cnt;
    char cid[32];
    int k;
    sprintf(connstr,
            "hostaddr=%s dbname=%s port=%d user=%s password=%s",
            "8.92.5.173", "postgres", 5432, "bot", "Gauss_234");
    conn = PQconnectdb(connstr);
    pgstatus = PQstatus(conn);
    if (pgstatus == CONNECTION_OK)
    {
        printf("Connect database success!\n");
    }
    else
    {
        printf("Connect database fail:%s\n",PQerrorMessage(conn));
        return -1;
    }
    sprintf(cmd_sql, "SELECT b FROM t01 WHERE a = $1");
    paramTypes[0] = 23;
    res = PQprepare(conn,
                    "pre_name",
                    cmd_sql,
                    1,
                    paramTypes);
  if( PQresultStatus(res) != PGRES_COMMAND_OK )
    {
        printf("Failed to prepare SQL : %s\n: %s\n",cmd_sql, PQerrorMessage(conn));
        PQfinish(conn);
        return -1;
    }
    PQclear(res);
```

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```
    paramValues[0] = cid;
    for (k=0; k<2; k++)
    {
        sprintf(cid, "%d", 1);
        paramLengths[0] = 6;
        paramFormats[0] = 0;
        res = PQexecPrepared(conn,
                             "pre_name",
                             1,
                             paramValues,
                             paramLengths,
                             paramFormats,
                             0);
        if( (PQresultStatus(res) != PGRES_COMMAND_OK ) && (PQresultStatus(res) != PGRES_TUPLES_OK))
        {
            printf("%s\n",PQerrorMessage(conn));
            PQclear(res);
            PQfinish(conn);
            return -1;
        }
        cnt = PQntuples(res);
        printf("return %d rows\n", cnt);
        for (i=0; i<cnt; i++)
        {
            printf("row %d: %s\n", i, PQgetvalue(res, i, 0));
        }
        PQclear(res);
    }
    PQfinish(conn);
    return 0;
}
```

## 6.5.4 libpq Interface Reference

For details, see **21.3 libpq Interface Reference**.

## 6.5.5 Link Parameters

**Table 6-14** Link parameters

| Parameter | Description |
| --- | --- |
| host | Name of the host to connect to. If the host name starts with a slash (/), Unix-domain socket communications instead of TCP/IP communications are used. The value is the directory where the socket file is stored. If **host** is not specified, the default behavior is to connect to the Unix-domain socket in the **/tmp** directory (or the socket directory specified during GaussDB installation). On a machine without a Unix-domain socket, the default behavior is to connect to **localhost**. |

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| Parameter | Description |
| --- | --- |
| hostaddr | IP address of the host to connect to. The value is in standard IPv4 address format, for example, 172.28.40.9. If a non-null character string is specified, TCP/IP communications are used.<br>Replacing **host** with **hostaddr** can prevent applications from querying host names, which may be important for applications with time constraints. However, a host name is required for GSSAPI or SSPI authentication methods. Therefore, the following rules are used:<br>1. If **host** is specified but **hostaddr** is not, a query for the host name will be executed.<br>2. If **hostaddr** is specified but **host** is not, the value of **hostaddr** is the server network address. If the host name is required by authentication, the connection attempt fails.<br>3. If both **host** and **hostaddr** are specified, the value of **hostaddr** is the server network address. The value of **host** is ignored unless it is required by authentication, in which case it is used as the host name.<br>**NOTICE**<br>• If **host** is not the server name in the network address specified by **hostaddr**, the authentication may fail.<br>• If neither **host** nor **hostaddr** is specified, libpq will use a local Unix-domain socket for connection. If the machine does not have a Unix-domain socket, it will attempt to connect to **localhost**. |
| port | Port number of the host server, or the socket file name extension for Unix-domain connections. |
| user | Name of the user to connect as. By default, the username is the same as the operating system name of the user running the application. |
| dbname | Database name. The default value is the same as the username. |
| password | Password to be used if the server requires password authentication. |
| connect_timeout | Maximum timeout period of the connection, in seconds (in decimal integer string). The value **0** or null indicates infinity. You are not advised to set the connection timeout period to a value less than 2 seconds. |
| client_encoding | Client encoding for the connection. In addition to the values accepted by the corresponding server options, you can use **auto** to determine the correct encoding from the current environment in the client (the **LC_CTYPE** environment variable in the Unix system). |
| tty | This parameter can be ignored. (This parameter was used to specify the location to which the debugging output of the server was sent). |
| options | Adds command-line options to send to the server at runtime. |

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| Parameter | Description |
| --- | --- |
| application_name | Current user identity. |
| fallback_application_name | Specifies a backup value for the **application_name** parameter. This value is used if no value is set for **application_name** through a connection parameter or the *PGAPPNAME* environment variable. It is useful to specify a backup value in a common tool program that wants to set a default application name but does not want it to be overwritten by the user. |
| keepalives | Whether TCP keepalive is enabled on the client side. The default value is **1**, indicating that the function is enabled. The value **0** indicates that the function is disabled. Ignore this parameter for Unix-domain connections. |
| keepalives_idle | The number of seconds of inactivity after which TCP should send a keepalive message to the server. The value **0** indicates that the default value is used. Ignore this parameter for Unix-domain connections or if keep-alive is disabled. |
| keepalives_interval | The number of seconds after which a TCP keepalive message that is not acknowledged by the server should be retransmitted. The value **0** indicates that the default value is used. Ignore this parameter for Unix-domain connections or if keep-alive is disabled. |
| keepalives_count | Controls the number of times that keepalive messages are sent through TCP. The value **0** indicates that the default value is used. Ignore this parameter for Unix-domain connections or if keep-alive is disabled. |
| tcp_user_timeout | Specifies the maximum duration for which transmitted data can remain unacknowledged before the TCP connection is forcibly closed on an operating system that supports the **TCP_USER_TIMEOUT** socket option. The value **0** indicates that the default value is used. Ignore this parameter for Unix-domain connections. |
| rw_timeout | Sets the read and write timeout interval of the client connection. |

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| Parameter | Description |
| --- | --- |
| sslmode | SSL encryption mode:<br>• **disable**: SSL connection is not enabled.<br>• **allow**: If the database server requires SSL connection, SSL connection can be enabled. However, authenticity of the database server will not be verified.<br>• **prefer**: If the database supports SSL connection, SSL connection is preferred. However, authenticity of the database server will not be verified.<br>• **require**: SSL connection is required and data is encrypted. However, authenticity of the database server will not be verified.<br>• **verify-ca**: SSL connection is required. Currently, Windows ODBC does not support cert authentication.<br>• **verify-full**: SSL connection is required. Currently, Windows ODBC does not support cert authentication. |
| sslcompression | If this parameter is set to **1** (default value), the data transmitted over the SSL connection is compressed (this requires that the OpenSSL version be 0.9.8 or later). If set to **0**, compression will be disabled (this requires OpenSSL 1.0.0 or later). If a connection without SSL is established, this parameter is ignored. If the OpenSSL version in use does not support this parameter, it will also be ignored. Compression takes up CPU time, but it increases throughput when the bottleneck is the network. If CPU performance is a limiting factor, disabling compression can improve response time and throughput. |
| sslcert | This parameter specifies the file name of the client SSL certificate. It replaces the default **~/.postgresql/postgresql.crt**. If no SSL connection is established, this parameter is ignored. |
| sslkey | This parameter specifies the location of the key used for the client certificate. It can specify the name of a file used to replace the default **~/.postgresql/postgresql.key**, or specify a key obtained from an external "engine" that is a loadable module of OpenSSL. An external engine description should consist of a colon-separated engine name and an engine-related key identifier. If no SSL connection is established, this parameter is ignored. |
| sslrootcert | This parameter specifies the name of a file that contains the SSL Certificate Authority (CA) certificate. If the file exists, the system authenticates the server certificate issued by one of these authorities. The default value is **~/.postgresql/root.crt**. |
| sslcrl | This parameter specifies the file name of the SSL Certificate Revocation List (CRL). If a certificate listed in this file exists, the server certificate authentication will be rejected. The default value is **~/.postgresql/root.crl**. |

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| Parameter | Description |
| --- | --- |
| requirepeer | This parameter specifies the OS user of the server, for example, **requirepeer=postgres**. When a Unix-domain socket connection is established, if this parameter is set, the client checks whether the server process is running under the specified user name at the beginning of the connection. If not, the connection will be interrupted by an error. This parameter can be used to provide server authentication similar to that of the SSL certificate on TCP/IP connections. (Note that if the Unix domain socket is in **/tmp** or another public writable location, any user can start a server for listening on the location. Use this parameter to ensure that you are connected to a server that is run by a trusted user.) This option is supported only on platforms that implement the peer authentication method. |
| krbsrvname | This parameter specifies the Kerberos service name used for GSSAPI authentication. For successful Kerberos authentication, this value must match the service name specified in the server configuration. |
| gsslib | This parameter specifies the GSS library used for GSSAPI authentication. It is used only in the Windows OS. If this parameter is set to **gssapi**, the libpq is forced to use the GSSAPI library to replace the default SSPI for authentication. |
| service | This parameter specifies the name of the service for which the additional parameter is used. It specifies a service name in **pg_service.conf** that holds the additional connection parameters. This allows the application to specify only one service name so that the connection parameters can be centrally maintained. |
| authtype | **authtype** is no longer used, so it is marked as a parameter not to be displayed. It is retained in an array so as not to reject the **conninfo** string from old applications that might still try to set it. |
| remote_nodename | Specifies the name of the remote node connected to the local node. |
| localhost | Specifies the local host in a connection channel. |
| localport | Specifies the local port in a connection channel. |
| fencedUdfRPCMode | Specifies whether the fenced udf RPC protocol uses UNIX domain sockets or special socket file names. The default value is **0**, indicating that the UNIX domain socket mode is used and the file type is .s.PGSQL.%d. To use the fenced UDF mode, set this parameter to **1**. In this case, the file type is .s.fencedMaster_unixdomain. |

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| Parameter | Description |
| --- | --- |
| replication | Specifies whether the connection should use replication protocols instead of common protocols. Protocols with this parameter configured are internal protocols used for PostgreSQL replication connections and tools such as **pg_basebackup**, while they can also be used by third-party applications. The following values, which are case-insensitive, are supported:<br>• **true**, **on**, **yes**, and **1**<br>Specify whether the physical replication mode is connected.<br>• database<br>Specifies that the logical replication mode and the database specified by **dbname** are connected.<br>• **false**, **off**, **no**, and **0**<br>Specify that the connection is a regular connection, which is the default behavior.<br>In physical or logical replication mode, only simple query protocols can be used. |
| backend_version | Specifies the backend version to be passed to the remote end. |
| prototype | Sets the current protocol level. The default value is **PROTO_TCP**. |
| enable_ce | Specifies whether a client is allowed to connect to a fully-encrypted database. The default value is **0**. To enable this function, change the value to **1**. |
| connection_info | The value of **connection_info** is a JSON character string consisting of **driver_name**, **driver_version**, **driver_path**, and **os_user**.<br>If the value is not null, use **connection_info** and ignore **connectionExtraInf**.<br>If the value is null, a connection information string related to **libpq** is generated. When **connectionExtraInf** is set to **false**, the value of **connection_info** consists of only **driver_name** and **driver_version**. |
| connectionExtraInf | Specifies whether the value of **connection_info** contains extension information. The default value is **0**. If the value contains other information, set this parameter to **1**. |

# 6.6 Psycopg-based Development

Psycopg is a Python API used to execute SQL statements and provides a unified access API for PostgreSQL and GaussDB. Applications can perform data operations based on psycopg. Psycopg2 is an encapsulation of libpq and is implemented using the C language, which is efficient and secure. It provides cursors on both clients and servers, asynchronous communication and notification, and the COPY

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TO and COPY FROM functions. Psycopg2 supports multiple types of Python out-of-the-box and adapts to PostgreSQL data types. Through the flexible object adaptation system, you can extend and customize the adaptation. Psycopg2 is compatible with Unicode and Python 3.

GaussDB supports Psycopg2 features and allows Psycopg2 to be connected in SSL mode.

**Table 6-15** Platforms supported by Psycopg

| OS | Platform |
| --- | --- |
| EulerOS 2.5 | x86_64 |
| EulerOS 2.8 | ARM64 |
| Kylin | x86_64 |
| Kylin | ARM64 |

**NOTICE**

OpenSSL of GaussDB is linked during Psycopg2 compilation. It may be incompatible with OpenSSL of the operating system. If incompatibility occurs, for example, "version 'OPENSSL_1_1_1f' not found" is displayed, use the environment variable **LD_LIBRARY_PATH** to isolate the OpenSSL provided by the operating system and the OpenSSL on which GaussDB depends.

For example, when the application software **client.py** that invokes Psycopg2 is executed, the environment variable is explicitly assigned to the application software.

```
export LD_LIBRARY_PATH=/path/to/gaussdb/libs:$LD_LIBRARY_PATH python client.py
```

In the preceding command, **/path/to/pyscopg2/lib** indicates the directory where the OpenSSL library on which GaussDB depends is located. Change it as required.

## 6.6.1 Psycopg Package

The psycopg package is obtained from the release package. Its name is **GaussDB-Kernel-*VxxxRxxxCxx*-*OS version number*-64bit-Python.tar.gz**.

After the decompression, the following folders are generated:

- **psycopg2**: **psycopg2** library file
- **lib**: **lib** library file

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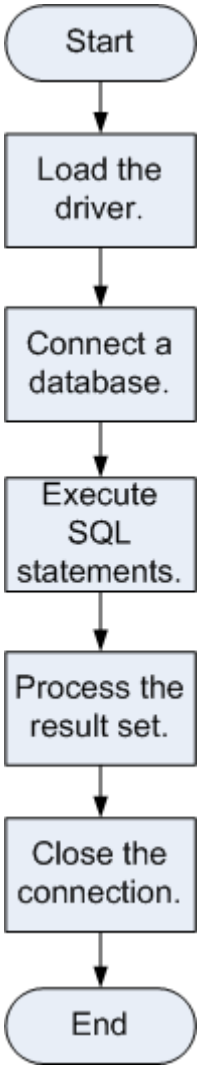
## 6.6.2 Development Process

**Figure 6-4** Application development process based on psycopg2




## 6.6.3 Loading a Driver

- Before using the driver, perform the following operations:
  a. Decompress the driver package of the corresponding version and copy psycopg2 to the **site-packages** folder in the Python installation directory as the **root** user.
  b. Change the **psycopg2** directory permission to **755**.
  c. Add the **psycopg2** directory to the environment variable *$PYTHONPATH* and validate it.
  d. For non-database users, configure the **lib** directory in *LD_LIBRARY_PATH* after decompression.
- Load the database driver before creating a database connection.

```
import  psycopg2
```

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## 6.6.4 Connecting a Database

1. Use the **psycopg2.connect** function to obtain the connection object.
2. Use the connection object to create a cursor object.

## 6.6.5 Executing SQL Statements

1. Construct an operation statement and use **%s** as a placeholder. During execution, psycopg2 will replace the placeholder with the parameter value. You can add the RETURNING clause to obtain the automatically generated column values.
2. The **cursor.execute** method is used to perform operations on one row, and the **cursor.executemany** method is used to perform operations on multiple rows.

## 6.6.6 Processing the Result Set

1. **cursor.fetchone()**: Fetches the next row in a query result set and returns a sequence. If no data is available, null is returned.
2. **cursor.fetchall()**: Fetches all remaining rows in a query result and returns a list. An empty list is returned when no rows are available.

NOTE

For GaussDB-specific data types, such as tinyint, the corresponding fields in the query result are character strings.

## 6.6.7 Closing the Connection

After you complete required data operations in a database, close the database connection. Call the close method such as **connection.close()** to close the connection.

CAUTION

This method closes the database connection and does not automatically call **commit()**. If you just close the database connection without calling **commit()** first, changes will be lost.

## 6.6.8 Connecting the Database (Using SSL)

When you use psycopy2 to connect to the GaussDB server, you can enable SSL to encrypt the communications between the client and server. To enable SSL, you must have the server certificate, client certificate, and private key files. For details on how to obtain these files, see related documents and commands of OpenSSL.

1. Use the .ini file (the **configparser** package of Python can parse this type of configuration file) to save the configuration information about the database connection.
2. Add SSL connection parameters **sslmode**, **sslcert**, **sslkey**, and **sslrootcert** to the connection options.

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a. **sslmode**: Table 6-16
b. **sslcert**: client certificate path
c. **sslkey**: client key path
d. **sslrootcert**: root certificate path

3. Use the **psycopg2.connect** function to obtain the connection object.
4. Use the connection object to create a cursor object.

**Table 6-16** sslmode options

| sslmode | Whether SSL Encryption Is Enabled | Description |
| --- | --- | --- |
| disable | No | SSL connection is not enabled. |
| allow | Possible | If the database server requires SSL connection, SSL connection can be enabled. However, authenticity of the database server will not be verified. |
| prefer | Possible | If the database supports SSL connection, SSL connection is preferred. However, authenticity of the database server will not be verified. |
| require | Yes | SSL connection is required and data is encrypted. However, authenticity of the database server will not be verified. |
| verify-ca | Yes | The SSL connection must be enabled. |
| verify-full | Yes | The SSL connection must be enabled, which is not supported by GaussDB currently. |

## 6.6.9 Example: Common Operations

```
import psycopg2

# Create a connection object.
conn=psycopg2.connect(database="postgres",user="user",password="password",host="localhost",port=port)
cur=conn.cursor() # Create a pointer object.

# Create a connection object (using SSL).
conn = psycopg2.connect(dbname="postgres", user="user", password="password", host="localhost",
port=port,
        sslmode="verify-ca", sslcert="client.crt",sslkey="client.key",sslrootcert="cacert.pem")
Note: If sslcert, sslkey, and sslrootcert are not set, the following files in the .postgresql directory of the
current user are used by default: client.crt,
        client.key, and root.crt.


# Create a table.
cur.execute("CREATE TABLE student(id integer,name varchar,sex varchar);")

# Insert data.
```

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```
cur.execute("INSERT INTO student(id,name,sex) VALUES(%s,%s,%s)",(1,'Aspirin','M'))
cur.execute("INSERT INTO student(id,name,sex) VALUES(%s,%s,%s)",(2,'Taxol','F'))
cur.execute("INSERT INTO student(id,name,sex) VALUES(%s,%s,%s)",(3,'Dixheral','M'))

# Obtain the result.
cur.execute('SELECT * FROM student')
results=cur.fetchall()
print (results)

# Close the connection.
conn.commit()
cur.close()
conn.close()

Common connection modes of psycopg2
1. conn = psycopg2.connect(dbname="postgres", user="user", password="password", host="localhost",
port=port)
2. conn = psycopg2.connect("dbname=postgres user=user password=password  host=localhost port=port")
3. Using logs
import logging
import psycopg2
from psycopg2.extras import LoggingConnection

logging.basicConfig(level=logging.DEBUG) # Log level
logger = logging.getLogger(__name__)

db_settings = {
    "user": "user",
    "password": "password",
    "host": "localhost",
    "database": "postgres",
    "port": port
}
conn = psycopg2.connect(connection_factory=LoggingConnection, **db_settings)
conn.initialize(logger)
```

## 6.6.10 Psycopg API Reference

For details, see **21.4 Psycopg API Reference**.

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# 7 Database Security Management

## 7.1 Checking the Number of Database Connections

### Background

If the number of connections reaches its upper limit, new connections cannot be created. Therefore, if a user fails to connect a database, the administrator must check whether the number of connections has reached the upper limit. The following are details about database connections:

- The maximum number of global connections is specified by the **max_connections** parameter.
- The number of a user's connections is specified by **CONNECTION LIMIT connlimit** in the **CREATE ROLE** statement and can be changed using **CONNECTION LIMIT connlimit** in the **ALTER ROLE** statement.
- The number of a database's connections is specified by the **CONNECTION LIMIT connlimit** parameter in the **CREATE DATABASE** statement.
- Some connections need to be reserved for the **gs_clean** tool to remove residual transactions as the residual transactions may affect system operation. In a cluster with *n* CNs, at least *n* connections need to be reserved for the **gs_clean** tool on the CNs.

### Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** View the upper limit of the number of global connections.

```
openGauss=# SHOW max_connections;
 max_connections
-----------------
 800
(1 row)
```

**800** is the maximum number of session connections.

**Step 3** View the number of session connections that have been used.

For details, see **Table 7-1**.

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**NOTICE**

Except for database and usernames that are enclosed in double quotation marks (") during creation, uppercase letters are not allowed in the database and usernames in the commands in the following table.

**Table 7-1** Viewing the number of session connections

| Description | Command |
| --- | --- |
| View the maximum number of sessions connected to a specific user. | Run the following command to view the upper limit of the number of user **omm**'s connections. **-1** indicates that no upper limit is set for user **omm**.<br>openGauss=# **SELECT ROLNAME,ROLCONNLIMIT FROM PG_ROLES WHERE ROLNAME='omm';**<br>rolname \| rolconnlimit<br>----------+--------------<br>omm \| -1<br>(1 row) |
| View the number of session connections that have been used by a user. | Run the following command to view the number of session connections that have been used by user **omm**: **1** indicates that one connection has been used by user **omm**.<br>openGauss=# **SELECT COUNT(*) FROM dv_sessions WHERE USERNAME='omm';**<br>count<br>-------<br>1<br>(1 row) |
| View the maximum number of sessions connected to a specific database. | Run the following commands to view the upper limit of the number of **postgres**'s session connections: **-1** indicates that no upper limit is set for the number of **postgres**'s session connections.<br>openGauss=# **SELECT DATNAME,DATCONNLIMIT FROM PG_DATABASE WHERE DATNAME='postgres';**<br>datname \| datconnlimit<br>----------+--------------<br>postgres \| -1<br>(1 row) |
| View the number of session connections that have been used by a specific database. | Run the following commands to view the number of session connections that have been used by **postgres**: **1** indicates the number of session connections that have been used by **postgres**.<br>openGauss=# **SELECT COUNT(*) FROM PG_STAT_ACTIVITY WHERE DATNAME='postgres';**<br>count<br>-------<br>1<br>(1 row) |

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| Description | Command |
| --- | --- |
| View the number of session connections that have been used by all users. | Run the following commands to view the number of session connections that have been used by all users:<br>openGauss=# **SELECT COUNT(*) FROM dv_sessions;**<br> count<br>-------<br> 10<br>(1 row) |

**----End**

# 7.2 Managing Users and Their Permissions

## 7.2.1 Default Permission Mechanism

A user who creates an object is the owner of this object. By default, **7.2.3 Separation of Duties** is disabled after cluster installation. A database system administrator has the same permissions as object owners. After an object is created, only the object owner or system administrator can query, modify, and delete the object, and grant permissions for the object to other users through **12.14.140 GRANT** by default.

To enable another user to use the object, grant required permissions to the user or the role that contains the user.

GaussDB supports the following permissions: SELECT, INSERT, UPDATE, DELETE, TRUNCATE, REFERENCES, CREATE, CONNECT, EXECUTE, USAGE, ALTER, DROP, COMMENT, INDEX, and VACUUM. Permission types are associated with object types. For permission details, see **12.14.140 GRANT**.

To remove permissions, run **12.14.154 REVOKE**. Object owners have implicit permissions (such as ALTER, DROP, COMMENT, INDEX, VACUUM, GRANT, and REVOKE) on objects. That is, once becoming the owner of an object, the owner is immediately granted the implicit permissions on the object. Object owners can remove their own common permissions, for example, making tables read-only to themselves or others.

System catalogs and views are visible to either system administrators or all users. System catalogs and views that require system administrator permissions can be queried only by system administrators. For details, see **16 Schemas**.

The database provides the object isolation feature. If this feature is enabled, users can view only the objects (tables, views, columns, and functions) that they have the permission to access. System administrators are not affected by this feature. For details, see **12.14.5 ALTER DATABASE**.

You are not advised to modify the permissions on system catalogs or system views.

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# 7.2.2 Administrator

## Initial User

The account automatically generated during the cluster installation is called the initial user. The initial user is also the system administrator, monitor administrator, O&M administrator, and security policy administrator. It has the highest permissions in the system and can perform all operations. If the initial user name is not set during the installation, the user name is the same as the name of the OS user who installs the cluster. If the password of the initial user is not set during the cluster installation, the password is empty after the installation. In this case, you need to set the password of the initial user on the gsql client before performing other operations. If the initial user password is empty, you cannot perform other SQL operations, such as upgrade, capacity expansion, and node replacement, except changing the password.

An initial user bypasses all permission checks. You are advised to use an initial user as a database administrator only for database management other than service running.

## System Administrator

A system administrator is an account with the SYSADMIN attribute. By default, a system administrator has the same permissions as the object owner but does not have the object permissions in the **dbe_perf** schema or the permission to use Roach to perform backup and restoration.

To create a database administrator, connect to the database as an administrator and run the **12.14.88 CREATE USER** or **12.14.37 ALTER USER** statement with **SYSADMIN** specified.

```
openGauss=# CREATE USER sysadmin WITH SYSADMIN password "xxxxxxxxxx";
```

or

```
openGauss=# ALTER USER joe SYSADMIN;
```

To run the **ALTER USER** statement, the user must exist.

## Monitor Administrator

A monitor administrator is an account with the **MONADMIN** attribute and has the permission to view views and functions in the **dbe_perf** schema. The monitor administrator can also grant or revoke object permissions in the **dbe_perf** schema.

To create a monitor administrator, connect to the database as a system administrator and run the **12.14.88 CREATE USER** or **12.14.37 ALTER USER** statement with **MONADMIN** specified.

```
openGauss=# CREATE USER monadmin WITH MONADMIN password "xxxxxxxxxx";
```

or

```
openGauss=# ALTER USER joe MONADMIN;
```

To run the **ALTER USER** statement, the user must exist.

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### O&M Administrator

An O&M administrator is an account with the **OPRADMIN** attribute and has the permission to use Roach to perform backup and restoration.

To create an O&M administrator, connect to the database as an initial user and run the **12.14.88 CREATE USER** or **12.14.37 ALTER USER** statement with **OPRADMIN** specified.

```
openGauss=# CREATE USER opradmin WITH OPRADMIN password "xxxxxxxxxx";
```

or

```
openGauss=# ALTER USER joe OPRADMIN;
```

To run the **ALTER USER** statement, the user must exist.

### Security Policy Administrator

A security policy administrator is an account with the **POLADMIN** attribute and has the permission to create resource tags, anonymization policies, and unified audit policies.

To create a security policy administrator, connect to the database as an administrator and run the **12.14.88 CREATE USER** or **12.14.37 ALTER USER** statement with **POLADMIN** specified.

```
openGauss=# CREATE USER poladmin WITH POLADMIN password "xxxxxxxxxx";
```

or

```
openGauss=# ALTER USER joe POLADMIN;
```

To run the **ALTER USER** statement, the user must exist.

### Logical Cluster Administrator

Common users in the logical cluster administrator role have the following more permissions than common users: (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

- Create, modify, and delete resource pools in the associated logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)
- Grant the access permission on the associated logical cluster to other users or roles, or revoke the access permission from those users or roles.

For details about logical cluster user and permission management, see section "Logical Cluster Management > Managing Users and Permissions in a Logical Cluster" in *Administrator Guide*.

## 7.2.3 Separation of Duties

Descriptions in **7.2.1 Default Permission Mechanism** and **7.2.2 Administrator** are about the initial situation after a cluster is created. By default, a system administrator with the **SYSADMIN** attribute has the highest-level permissions.

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To avoid risks caused by centralized permissions, you can enable separation of duties to assign the system administrator's user management permission to security administrators and audit management permission to audit administrators.

After separation of duties is enabled, the system administrator does not have the **CREATEROLE** attribute (security administrator) or the **AUDITADMIN** attribute (audit administrator). That is, the system administrator can neither create roles or users, nor view or maintain database audit logs. For details about the **CREATEROLE** and **AUDITADMIN** attributes, see **12.14.74 CREATE ROLE**.

Separation of duties does not take effect for an initial user. Therefore, you are advised to use an initial user as a database administrator only for database management other than service running.

To enable separation of duties, set **enableSeparationOfDuty** to **on**.

**WARNING**

If you need to use the separation of duties model, specify it during database initialization. You are not advised to switch the permission management model back and forth. In particular, if you want to switch from a non-separation-of-duties permission management model to the separation-of-duties permission management model, you need to review the permission set of existing users. If a user has the system administrator permission and audit administrator permission, the permissions need to be tailored.

After separation of duties, the system administrator does not have permissions for non-system schemas of other users. Therefore, the system administrator cannot access the objects in other users' schemas before being granted the permissions. For details about permission changes before and after enabling separation of duties, see **Table 7-2** and **Table 7-3**.

**Table 7-2** Default user permissions

| Object Name | Initial User (ID: 10) | System Administrator | Security Administrator | Audit Administrator | Common User |
|---|---|---|---|---|---|
| Tablespaces | Has all permissions except the one to access private tables. | Can create, modify, delete, access, or grant permissions for tablespaces. | Cannot create, modify, delete, or grant permissions for tablespaces and can access tablespaces if the access permission is granted. | | |
| Schemas | | Has all permissions for all schemas except **dbe_perf**. | Has all permissions for their own schemas, but does not have permissions for non-system schemas of other users. | | |
| User-defined functions | | Has all permissions for all user-defined functions. | Has all permissions for their own functions, and has only the call permission for other users' functions. | | |

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| Object Name | Initial User (ID: 10) | System Administrator | Security Administrator | Audit Administrator | Common User |
|---|---|---|---|---|---|
| User-defined tables or views | | Has all permissions for all user-defined tables or views. | Has all permissions for their own tables or views, but does not have permissions for other users' tables or views. | | |

**Table 7-3** Changes in permissions after separation of duties

| Object Name | Initial User (ID: 10) | System Administrator | Security Administrator | Audit Administrator | Common User |
|---|---|---|---|---|---|
| Tablespaces | N/A<br>Has all permissions except the one to access private tables. | N/A | No change | | |
| Schemas | | Permissions reduced<br>Has all permissions for their own schemas, but does not have permissions for non-system schemas of other users. | No change | | |
| User-defined functions | | Cannot access functions in non-system schemas of other users before being granted the permissions. | No change | | |
| User-defined tables or views | | Cannot access tables or views in non-system schemas of other users before being granted the permissions. | No change | | |

**NOTICE**

**PG_STATISTIC** and **PG_STATISTIC_EXT** store sensitive information about statistical objects, such as high-frequency MCVs. After separation of duties is enabled, the system administrator can still access the two system catalogs to obtain the statistics.

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# 7.2.4 Users

You can use **CREATE USER** and **ALTER USER** to create and manage database users, respectively. A database cluster can have one or more databases. Users and roles are shared within the entire cluster, but their data is not shared. That is, a user can connect to any database, but after the connection is successful, any user can access only the database declared in the connection request.

In non-**separation-of-duties** scenarios, GaussDB user accounts can be created and deleted only by a system administrator or a security administrator with the **CREATEROLE** attribute. In separation-of-duties scenarios, a user account can be created only by an initial user or a security administrator.

When a user logs in, GaussDB authenticates the user. A user can own databases and database objects (such as tables), and grant permissions of these objects to other users and roles. In addition to system administrators, users with the **CREATEDB** attribute can create databases and grant permissions on these databases.

## Adding, Modifying, and Deleting Users

- To create a user, use the SQL statement **12.14.88 CREATE USER**.

  For example, create a user **joe** and set the **CREATEDB** attribute for the user.

  ```
  openGauss=# CREATE USER joe WITH CREATEDB PASSWORD "xxxxxxxxxx";
  CREATE ROLE
  ```

- To create a system administrator, use the **12.14.88 CREATE USER** statement with the **SYSADMIN** parameter.
- To delete an existing user, use **12.14.131 DROP USER**.
- To change a user account (for example, rename the user or change the password), use **12.14.37 ALTER USER**.
- To view a user list, query the **PG_USER** view.

  ```
  openGauss=# SELECT * FROM pg_user;
  ```

- To view user attributes, query the system catalog **15.2.42 PG_AUTHID**.

  ```
  openGauss=# SELECT * FROM pg_authid;
  ```

## Private Users

If multiple service departments use different database user accounts to perform service operations and a database maintenance department at the same level uses database administrator accounts to perform maintenance operations, service departments may require that database administrators, without specific authorization, can perform the DROP, ALTER, and TRUNCATE operations on their data but cannot perform the INSERT, DELETE, UPDATE, SELECT, and COPY operations on the data. That is, the management permissions of database administrators for tables need to be isolated from their access permissions to improve the data security of common users.

In **separation-of-duties** mode, a database administrator does not have permissions for the tables in schemas of other users. In this case, database administrators have neither management permissions nor access permissions, which does not meet the requirements of the service departments mentioned above. Therefore, GaussDB provides private users to solve the problem. That is, create private users with the **INDEPENDENT** attribute in non-separation-of-duties

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mode. Users with the CREATEROLE permission or the system administrator permission can create private users or change the attributes of common users to private users. Common users can also change their own attributes to private users.

```
openGauss=# CREATE USER user_independent WITH INDEPENDENT IDENTIFIED BY "1234@abc";
```

System administrators can manage (DROP, ALTER, and TRUNCATE) table objects of private users but cannot access (INSERT, DELETE, SELECT, UPDATE, COPY, GRANT, REVOKE, and ALTER OWNER) the objects before being authorized.

**NOTICE**

**PG_STATISTIC** and **PG_STATISTIC_EXT** store sensitive information about statistical objects, such as high-frequency MCVs. The system administrator can still access the two system catalogs to obtain the statistics of the tables to which private users belong.

### Permanent User

GaussDB provides the permanent user solution. That is, create a permanent user with the **PERSISTENCE** attribute.

```
openGauss=# CREATE USER user_persistence WITH PERSISTENCE IDENTIFIED BY "1234@abc";
```

Only the initial user is allowed to create, modify, and delete permanent users with the **PERSISTENCE** attribute.

## 7.2.5 Roles

A role is a set of users. After a role is granted to a user through **GRANT**, the user will have all the permissions of the role. It is recommended that roles be used to efficiently grant permissions. For example, you can create different roles of design, development, and maintenance personnel, grant the roles to users, and then grant specific data permissions required by different users. When permissions are granted or revoked at the role level, these changes take effect on all members of the role.

GaussDB provides an implicitly defined group **PUBLIC** that contains all roles. By default, all new users and roles have the permissions of **PUBLIC**. For details about the default permissions of **PUBLIC**, see **12.14.140 GRANT**. To revoke permissions of **PUBLIC** from a user or role, or re-grant these permissions to them, add the **PUBLIC** keyword in the **REVOKE** or **GRANT** statement.

To view all roles, query the system catalog **PG_ROLES**.

```
SELECT * FROM PG_ROLES;
```

### Adding, Modifying, and Deleting Roles

In non-**separation-of-duties** scenarios, a role can be created, modified, and deleted only by a system administrator or a user with the **CREATEROLE** attribute. In separation-of-duties scenarios, a role can be created, modified, and deleted only by an initial user or a user with the **CREATEROLE** attribute.

- To create a role, use **12.14.74 CREATE ROLE**.

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- To add or delete users in an existing role, use **12.14.22 ALTER ROLE**.
- To delete a role, use **12.14.119 DROP ROLE**. **DROP ROLE** deletes only a role, rather than member users in the role.

## Built-in Roles

GaussDB provides a group of default roles whose names start with **gs_role_**. These roles are provided to access to specific, typically high-privileged operations. You can grant these roles to other users or roles within the database so that they can use specific functions. These roles should be given with great care to ensure that they are used where they are needed. **Table 7-4** describes the permissions of built-in roles.

**Table 7-4** Permission description of built-in roles

| Roles | Permission |
| --- | --- |
| gs_role_copy_files | Permission to run the **copy... to/from filename** command. However, the GUC parameter **enable_copy_server_files** must be set first to enable the function of copying server files. |
| gs_role_signal_backend | Permission to call the **pg_cancel_backend**, **pg_terminate_backend**, and **pg_terminate_session** functions to cancel or terminate other sessions. However, this role cannot perform operations on sessions of the initial user or **PERSISTENCE** user. |
| gs_role_tablespace | Permission to create a tablespace. |
| gs_role_replication | Permission to call logical replication functions, such as **kill_snapshot**, **pg_create_logical_replication_slot**, **pg_create_physical_replication_slot**, **pg_drop_replication_slot**, **pg_replication_slot_advance**, **pg_create_physical_replication_slot_extern**, **pg_logical_slot_get_changes**, **pg_logical_slot_peek_changes**, **pg_logical_slot_get_binary_changes**, and **pg_logical_slot_peek_binary_changes**. |
| gs_role_account_lock | Permission to lock and unlock users. However, this role cannot lock or unlock the initial user or **PERSISTENCE** user. |
| gs_role_pldebugger | Permission to debug functions in **dbe_pldebugger**. |
| gs_role_directory_create | Permission to create directory objects. However, this role needs to enable the GUC parameter **enable_access_server_directory** first. |
| gs_role_directory_drop | Permission to delete directory objects. However, this role needs to enable the GUC parameter **enable_access_server_directory** first. |

The restrictions on built-in roles are as follows:

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- The role names starting with **gs_role_** are reserved for built-in roles in the database. Do not create users or roles starting with **gs_role_** or rename existing users or roles starting with **gs_role_**.
- Do not perform **ALTER** or **DROP** operations on built-in roles.
- By default, built-in roles do not have the **LOGIN** permission and do not have preset passwords.
- The **gsql** meta-commands **\du** and **\dg** do not display information about built-in roles. However, if *pattern* is set to a specific built-in role, the information is displayed.
- When separation-of-duty is disabled, the initial user, users with the **SYSADMIN** permission, and users with the **ADMIN OPTION** built-in role permission have the permission to perform **GRANT** and **REVOKE** operations on built-in roles. When separation of duty is enabled, the initial user and users with the **ADMIN OPTION** built-in role permission have the permission to perform **GRANT** and **REVOKE** operations on built-in roles. Example:

```
GRANT gs_role_signal_backend TO user1;
REVOKE gs_role_signal_backend FROM user1;
```

## 7.2.6 Schemas

Schemas allow multiple users to use the same database without interference. In this way, database objects can be organized into logical groups that are easy to manage, and third-party applications can be added to corresponding schemas without causing conflicts.

Each database has one or more schemas. Each schema contains tables and other types of objects. When a database is created, a public schema named **public** is created by default, and all users have the **USAGE** permission on this schema. In addition, each database has a **pg_catalog** schema, which contains system catalogs and all built-in data types, functions, and operators. Only the system administrator and initial user can create functions, stored procedures, and synonyms under the **public** and **pg_catalog** schemas. Other users cannot create these objects even if they are granted with the CREATE permission on the **public** and **pg_catalog** schemas. You can group database objects by schema. A schema is similar to an OS directory but cannot be nested. By default, only the initial user can create objects under the **pg_catalog** schema.

The same database object name can be used in different schemas of the same database without causing conflicts. For example, both **a_schema** and **b_schema** can contain a table named **mytable**. Users with required permissions can access objects across multiple schemas of the same database.

When you run the **CREATE USER** command to create a user, the system creates a schema with the same name as the user in the database where the command is executed.

Database objects are generally created in the first schema in a database search path. For details about the first schema and how to change the schema order, see **Search Path**.

### Creating, Modifying, and Deleting Schemas

- To create a schema, use **12.14.76 CREATE SCHEMA**. By default, the initial user and system administrator can create schemas. Other users can create

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schemas in the database only when they have the CREATE permission on the database. For details about how to grant the permission, see the syntax in **12.14.140 GRANT**.

- To change the name or owner of a schema, use **12.14.24 ALTER SCHEMA**. The schema owner can change the schema.
- To delete a schema and its objects, use **12.14.121 DROP SCHEMA**. Schema owners can delete schemas.
- To create a table in a schema, use the *schema_name*.*table_name* format to specify the table. If *schema_name* is not specified, the table will be created in the first schema in **search path**.
- To view the owner of a schema, perform the following join query on the system catalogs **PG_NAMESPACE** and **PG_USER**. Replace *schema_name* in the statement with the name of the schema to be queried.

```
openGauss=# SELECT s.nspname,u.usename AS nspowner FROM pg_namespace s, pg_user u WHERE nspname='schema_name' AND s.nspowner = u.usesysid;
```

- To view a list of all schemas, query the system catalog **PG_NAMESPACE**.

```
openGauss=# SELECT * FROM pg_namespace;
```

- To view a list of tables in a schema, query the system catalog **PG_TABLES**. For example, the following query will return a table list from **PG_CATALOG** in the schema.

```
openGauss=# SELECT distinct(tablename),schemaname from pg_tables where schemaname = 'pg_catalog';
```

### Search Path

A search path is defined in the **search_path** parameter. The parameter value is a list of schema names separated by commas (,). If no target schema is specified during object creation, the object will be added to the first schema listed in the search path. If there are objects with the same name across different schemas and no schema is specified for an object query, the object will be returned from the first schema containing the object in the search path.

- To view the current search path, use **12.14.166 SHOW**.

```
openGauss=# SHOW SEARCH_PATH;
 search_path
----------------
 "$user",public
(1 row)
```

  The default value of **search_path** is **"*$user*",public**. *$user* indicates the name of the schema with the same name as the current session user. If the schema does not exist, *$user* will be ignored. By default, after a user connects to a database that has schemas with the same name, objects will be added to all the schemas. If there are no such schemas, objects will be added to only to the **public** schema.

- To change the default schema of the current session, run the **SET** statement.

  Run the following command to set **search_path** to **myschema** and **public** (**myschema** will be searched first):

```
openGauss=# SET SEARCH_PATH TO myschema, public;
SET
```

## 7.2.7 Setting User Permissions

- To grant permissions for an object to a user, use **12.14.140 GRANT**.

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When permissions for a table or view in a schema are granted to a user or role, the **USAGE** permission of the schema must be granted together. Otherwise, the user or role can only see these objects but cannot access them.

In the following example, permissions for the schema **tpcds** are first granted to user **joe**, and then the **SELECT** permission for the **tpcds.web_returns** table is also granted.

```
openGauss=# GRANT USAGE ON SCHEMA tpcds TO joe;
openGauss=# GRANT SELECT ON TABLE tpcds.web_returns to joe;
```

- Grant a role to a user to allow the user to inherit the object permissions of the role.

  a. Create a role.

     Create a role **lily** and grant the system permission **CREATEDB** to the role.

     ```
     openGauss=# CREATE ROLE lily WITH CREATEDB PASSWORD "xxxxxxxxxx";
     ```

  b. Grant object permissions to the role by using **12.14.140 GRANT**.

     For example, first grant permissions for the schema **tpcds** to the role **lily**, and then grant the **SELECT** permission of the **tpcds.web_returns** table to **lily**.

     ```
     openGauss=# GRANT USAGE ON SCHEMA tpcds TO lily;
     openGauss=# GRANT SELECT ON TABLE tpcds.web_returns to lily;
     ```

  c. Grant the role permissions to a user.

     ```
     openGauss=# GRANT lily to joe;
     ```

     NOTE

     When the permissions of a role are granted to a user, the attributes of the role are not transferred together.

- To revoke user permissions, use **12.14.154 REVOKE**.

## 7.2.8 Row-Level Access Control

The row-level access control feature enables database access control to be accurate to each row of data tables. In this way, the same SQL query may return different results for different users.

You can create a row-level access control policy for a data table. The policy defines an expression that takes effect only for specific database users and SQL operations. When a database user accesses the data table, if a SQL statement meets the specified row-level access control policies of the data table, the expressions that meet the specified condition will be combined by using **AND** or **OR** based on the attribute type (**PERMISSIVE** | **RESTRICTIVE**) and applied to the execution plan in the query optimization phase.

Row-level access control is used to control the visibility of row-level data in tables. By predefining filters for data tables, the expressions that meet the specified condition can be applied to execution plans in the query optimization phase, which will affect the final execution result. Currently, the SQL statements that can be affected include **SELECT**, **UPDATE**, and **DELETE**.

Scenario 1: A table summarizes the data of different users. Users can view only their own data.

```
-- Create users alice, bob, and peter.
openGauss=# CREATE USER alice PASSWORD 'xxxxxxxxx';
openGauss=# CREATE USER bob PASSWORD 'xxxxxxxxx';
```

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```
openGauss=# CREATE USER peter PASSWORD 'xxxxxxxxx';

-- Create the all_data table that contains user information.
openGauss=# CREATE TABLE all_data(id int, role varchar(100), data varchar(100));

-- Insert data into the data table.
openGauss=# INSERT INTO all_data VALUES(1, 'alice', 'alice data');
openGauss=# INSERT INTO all_data VALUES(2, 'bob', 'bob data');
openGauss=# INSERT INTO all_data VALUES(3, 'peter', 'peter data');

-- Grant the read permission for the all_data table to users alice, bob, and peter.
openGauss=# GRANT SELECT ON all_data TO alice, bob, peter;

-- Enable row-level access control.
openGauss=# ALTER TABLE all_data ENABLE ROW LEVEL SECURITY;

-- Create a row-level access control policy to specify that the current user can view only their own data.
openGauss=# CREATE ROW LEVEL SECURITY POLICY all_data_rls ON all_data USING(role =
CURRENT_USER);

-- View table details.
openGauss=# \d+ all_data
                        Table "public.all_data"
 Column |          Type          | Modifiers | Storage  | Stats target | Description
--------+------------------------+-----------+----------+--------------+-------------
 id     | integer                |           | plain    |              |
 role   | character varying(100) |           | extended |              |
 data   | character varying(100) |           | extended |              |
Row Level Security Policies:
    POLICY "all_data_rls"
      USING (((role)::name = "current_user"()))
Has OIDs: no
Distribute By: HASH(id)
Location Nodes: ALL DATANODES
Options: orientation=row, compression=no, enable_rowsecurity=true

-- Switch to user alice and run SELECT * FROM public.all_data.
openGauss=# SELECT * FROM public.all_data;
 id | role  |    data
----+-------+------------
  1 | alice | alice data
(1 row)

openGauss=# EXPLAIN(COSTS OFF) SELECT * FROM public.all_data;
                        QUERY PLAN
-----------------------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Seq Scan on all_data
         Filter: ((role)::name = 'alice'::name)
 Notice: This query is influenced by row level security feature
(5 rows)

-- Switch to user peter and run SELECT * FROM public.all_data.
openGauss=# SELECT * FROM public.all_data;
 id | role  |    data
----+-------+------------
  3 | peter | peter data
(1 row)

openGauss=# EXPLAIN(COSTS OFF) SELECT * FROM public.all_data;
                        QUERY PLAN
-----------------------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Seq Scan on all_data
         Filter: ((role)::name = 'peter'::name)
 Notice: This query is influenced by row level security feature
(5 rows)
```

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NOTICE

PG_STATISTIC and PG_STATISTIC_EXT store sensitive information about statistical objects, such as high-frequency MCVs. If the permission to query the two system catalogs is granted to a common user after the row-level security policy is created, the common user can still access the two system catalogs to obtain the information in the statistical objects.

# 7.2.9 Setting Security Policies

## 7.2.9.1 Setting Account Security Policies

### Background

For data security purposes, GaussDB provides a series of security measures, such as automatically locking and unlocking accounts, manually locking and unlocking abnormal accounts, and deleting accounts that are no longer used.

### Automatically Locking and Unlocking Accounts

- If the number of incorrect password attempts (**failed_login_attempts**) of an account reaches the upper limit (**10** by default), the system automatically locks the account. Smaller parameter values result in higher account security. However, if the value of this parameter is set too small, inconvenience may occur.
- If the time during which a user is locked exceeds the preset value (**password_lock_time**, one day by default), the system automatically unlocks the user. Larger parameter values bring higher account security. However, if the value of this parameter is set too large, inconvenience may occur.

  NOTE

  - The integer part of the **password_lock_time** parameter indicates the number of days, and the decimal part can be converted into hours, minutes, and seconds. For example, **password_lock_time=1.5** indicates one day and 12 hours.
  - If the **failed_login_attempts** parameter is set to **0**, an account is never locked due to incorrect password attempts. If the **password_lock_time** parameter is set to **0**, an account is quickly unlocked after it is locked due to incorrect password attempts. Therefore, only when both parameters are set to positive values, the following operations can be performed: password failure check, account locking, and account unlocking.
  - The default values of the two parameters meet the security requirements. You can change the parameter values as needed for higher security. You are advised to retain the default values.
- The database provides two account locking modes.
  - Single CN mode: During cluster deployment, one CN is configured as an interface to provide external services.
  - Multi-CN mode: During cluster deployment, multiple CNs are configured to work as external interfaces.

  In security mode, a single CN provides the account locking mechanism. In high concurrency mode, each CN provides account locking independently and

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does not share their locking information. In this mode, you are advised to limit the number of CNs to prevent brute-force attacks. The automatic account unlocking time for each node depends on their system clocks. During cluster deployment, ensure clock synchronization between cluster nodes (for example, use the NTP). If the nodes are out of synchronization, the account unlocking time for each node will be different.

## Manually Locking and Unlocking Accounts

Once detecting that an account is stolen or the account is used to access the database without being authorized, administrators can manually lock the account. Administrators can manually unlock the account if the account becomes normal again.

For details about how to create a user, see **7.2.4 Users**. To manually lock and unlock user **joe**, run commands in the following format:

- To manually lock the account, run the following command:
  ```
  openGauss=# ALTER USER joe ACCOUNT LOCK;
  ALTER ROLE
  ```
- To manually unlock the account, run the following command:
  ```
  openGauss=# ALTER USER joe ACCOUNT UNLOCK;
  ALTER ROLE
  ```

## Deleting Accounts That Are No Longer Used

Administrators can delete an account that is no longer used. This operation cannot be rolled back.

When an account to be deleted is in the active state, it is deleted after the session is disconnected.

For example, if you want to delete account **joe**, run the following command:

```
openGauss=# DROP USER joe  CASCADE;
DROP ROLE
In the scenario where multiple users, databases, and schemas are assigned permissions, if you drop a user, the following error message is displayed because the user has the permissions granted by other users.
openGauss=# drop user test1 cascade;
ERROR: role "test1" cannot be dropped because some objects depend on it
In this scenario, you can drop user only after querying the system catalog to find the permissions granted to the user by other users and logging in to the system as other users to manually delete the permissions. The following is an example:
Log in to the system database and check the user OID.
openGauss=#  select oid from pg_roles where rolname='test1';
  oid
-------
 16386
(1 row)
Check the pg_shdepend view to obtain the permissions granted to the user. You can find that the user has two permissions granted by other users. Handle the first permission first.
openGauss=# select * from pg_shdepend where refobjid='16386';
 dbid  | classid | objid | objsubid | refclassid | refobjid | deptype | objfile
-------+---------+-------+----------+------------+----------+---------+---------
 16394 |     826 | 16400 |        0 |       1260 |    16386 | a       |
 16394 |     2615 | 16399 |        0 |       1260 |    16386 | a       |

Check the pg_database view to obtain the database where the view is located. The test database is displayed.
openGauss=#    select * from pg_database where oid='16394'
 datname | datdba | encoding | datcollate  |  datctype   | datistemplate | datallowconn | datconnlimit |
datlastsysoid | datfrozenxid | dattablespace | datcompatibility |                    datacl
```

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```
            | datfrozenxid64
---------+--------+----------+-------------+-------------+---------------+--------------+--------------+---------------
+-------------+---------------+-----------------+-----------------------------------
-------------+----------------
 test    |    10 |        7 | en_US.UTF-8 | en_US.UTF-8 | f             | t            |           -1 |         16268 |
1985          |          1663 | MYSQL             | {=Tc/test,test=CTc/test,admi
n=c/test} |           1985
(1 row)
```

Log in to the **test** database.

```
[test@euler_phy_194 opengauss]$ gsql -p 3730 -d test
gsql((GaussDB Kernel VxxxRxxxCxx build f521c606) compiled at 2021-09-16 14:55:22 commit 2935 last mr
6385 release)
Non-SSL connection (SSL connection is recommended when requiring high-security)
Type "help" for help.
```

Check the permission type using pg_class. The value of **where oid** is the value of **classid** queried in the pg_shdepend view.

```
test=# select * from pg_class where oid = 826;
    relname     | relnamespace | reltype | reloftype | relowner | relam | relfilenode | reltablespace | relpages |
reltuples | relallvisible | reltoastrelid | reltoastidxid | reldeltarelid | reldeltaidx | rel
cudescrelid | relcudescidx | relhasindex | relisshared | relpersistence | relkind | relnatts | relchecks | relhasoids
| relhaspkey | relhasrules | relhastriggers | relhassubclass | relcmprs | relhasclusterkey
 | relrowmovement | parttype | relfrozenxid |    relacl    | reloptions | relreplident | relfrozenxid64 | relbucket |
relbucketkey
----------------+--------------+---------+-----------+----------+-------+-------------+---------------+----------
+-----------+---------------+---------------+---------------+---------------+-------------+----
------------+--------------+-------------+-------------+----------------+---------+----------+-----------+------------
+------------+-------------+----------------+----------------+----------+-----------------
-+----------------+----------+-------------+-------------+-----------+-------------+----------------+-----------
+--------------
 pg_default_acl |           11 |   11810 |         0 |       10 |     0 |       16063 |             0 |        0 |         0 |
0 |             0 |             0 |             0 |           0 |
         0 |           0 | t          | f          | p             | r       |        4 |         0 | t          | f          | f           |
f             | f             | 0        | f
 | f             | n        | 0           | {=r/test} |           | n           |           1985 |           |
(1 row)
```

The preceding information indicates that the user has been granted the default ACL permission on the table or view by other users. Check the pg_default_acl view. The value of **oid** is the value of **objid** in the pg_shdepend table.

```
test=#  select * from pg_default_acl oid = 16400;;
 defaclrole | defaclnamespace | defaclobjtype |               defaclacl               |  oid
------------+-----------------+---------------+---------------------------------------+-------
      16395 |           16399 | r             | {test=arwd/admin,test1=arwd/admin} | 16400
(1 row)
```

According to the defaclacl column of the view, user **test1** is granted with the default permission by user **admin**. Then, find the object (table or view) to which the permission is granted.

View the object name using pg_namespace. The value of **oid** is the value of **defaclnamespace** queried in pg_default_acl. The view shows that user **test1** has been granted the schema test_schema_1 permission by user **admin**.

```
test=# select * from pg_namespace where oid = 16399;
    nspname    | nspowner | nsptimeline |                nspacl                 | in_redistribution | nspblockchain
---------------+----------+-------------+---------------------------------------+-------------------+---------------
 test_schema_1 |       10 |           0 | {test=UC/test,admin=UC/test} | n                 | f
(1 row)
```

Log in to the **test** database as user **admin**. To revoke the default schema permission granted by the user **admin** to user **test1**, run **ALTER DEFAULT PRIVILEGES IN SCHEMA test_schema_1 revoke all privileges ON TABLES from test1;**.

```
test=#   ALTER DEFAULT PRIVILEGES IN SCHEMA test_schema_1 revoke all privileges ON TABLES from test1;
ALTER DEFAULT PRIVILEGES
```

Log in to the system database and check the **pg_database** view to obtain the database where the view is located. The **test** database is displayed.

```
openGauss=#   select * from pg_database where oid='16394'
 datname | datdba | encoding | datcollate  |  datctype   | datistemplate | datallowconn | datconnlimit |
datlastsysoid | datfrozenxid | dattablespace | datcompatibility |                    datacl
            | datfrozenxid64
---------+--------+----------+-------------+-------------+---------------+--------------+--------------+---------------
+--------------+---------------+-----------------+-----------------------------------
-------------+----------------
 test    |    10 |        7 | en_US.UTF-8 | en_US.UTF-8 | f             | t            |           -1 |         16268 |
```

```
1985         |          1663 | MYSQL            | {=Tc/test,test=CTc/test,admi
n=c/test} |           1985
(1 row)
Log in to the test database.
[test@euler_phy_194 opengauss]$ gsql -p 3730 -d test

Check the pg_class view. In the view, the value of oid is the value of classid in the second row of the
pg_shdepend table.
openGauss=#  select * from pg_class where oid='2615';
   relname    | relnamespace | reltype | reloftype | relowner | relam | relfilenode | reltablespace | relpages |
reltuples | relallvisible | reltoastrelid | reltoastidxid | reldeltarelid | reldeltaidx | relcu
descrelid | relcudescidx | relhasindex | relisshared | relpersistence | relkind | relnatts | relchecks | relhasoids |
relhaspkey | relhasrules | relhastriggers | relhassubclass | relcmprs | relhasclusterkey |
 relrowmovement | parttype | relfrozenxid |    relacl    | reloptions | relreplident | relfrozenxid64 | relbucket |
relbucketkey
--------------+--------------+---------+-----------+----------+-------+-------------+---------------+----------
+-----------+---------------+---------------+---------------+---------------+-------------+------
----------+-------------+-------------+-------------+----------------+---------+----------+-----------+------------
+------------+-------------+----------------+----------------+----------+------------------+
----------------+----------+--------------+--------------+------------+--------------+----------------+-----------
+--------------
 pg_namespace |          11 |   11787 |        0 |      10 |    0 |      15947 |            0 |       1 |       20
|            1 |            0 |            0 |            0 |           0 |
       0 |           0 | t          | f          | p            | r      |       6 |        0 | t          | f          | f          |
f            | f            | 0       | f              |
 f            | n       | 0          | {=r/test} |          | n           |          1985 |          |
(1 row)

The result shows that the type is pg_namespace. Check the pg_namespace system view. The value of oid is
the value of objid in the second line of pg_shdepend.
test=# select * from pg_namespace where oid='16399';
    nspname    | nspowner | nsptimeline |                    nspacl                    | in_redistribution |
nspblockchain
---------------+----------+-------------+----------------------------------------------------+-------------------
+---------------
 test_schema_1 |       10 |           0 | {test=UC/test,admin=UC/test,test1=U/test} | n                 | f
(1 row)

The nspacl column shows that the test_schema_1 view of user test1 is granted permissions by user test. To
revoke the permissions granted to user test1, log in to the test database as user test and run revoke all on
schema test_schema_1 from test1.
test=# revoke all on schema test_schema_1 from test1;
REVOKE

By now, the permissions granted to user test1 by other users have been cleared. You only need to run the
drop user command.
openGauss=# drop user test1 cascade;
DROP ROLE
```

### 7.2.9.2 Setting the Validity Period of an Account

## Precautions

When creating a user, you need to specify the validity period of the user, including the start time and end time.

To enable a user not within the validity period to use its account, set a new validity period.

## Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** Run the following command to create a user and specify the start time and end time:

```
openGauss=# CREATE USER joe WITH PASSWORD 'xxxxxxxxxx' VALID BEGIN '2015-10-10 08:00:00' VALID UNTIL '2016-10-10 08:00:00';
```

The user is created if the following information is displayed:

```
CREATE ROLE
```

**Step 3** If the user is not within the specified validity period, run the following command to set the start time and end time of a new validity period.

```
openGauss=# ALTER USER joe WITH VALID BEGIN '2016-11-10 08:00:00' VALID UNTIL '2017-11-10 08:00:00';
```

The start time and end time of the new validity period is set successfully if the following information is displayed:

```
ALTER ROLE
```

**----End**

NOTE

If **VALID BEGIN** is not specified in the **CREATE ROLE** or **ALTER ROLE** statement, the start time of the validity period is not limited. If **VALID UNTIL** is not specified, the end time of the validity period is not limited. If both of the parameters are not specified, the user is always valid.

## 7.2.9.3 Setting Password Security Policies

## Procedure

User passwords are stored in the system catalog **pg_authid**. To prevent password leakage, GaussDB encrypts user passwords before storing them. The encryption algorithm is determined by the configuration parameter **password_encryption_type**.

- If the **password_encryption_type** parameter is set to **0**, passwords are encrypted using MD5. The MD5 encryption algorithm is not recommended because it has lower security and poses security risks.
- If the **password_encryption_type** parameter is set to **1**, passwords are encrypted using SHA-256 and MD5. The MD5 encryption algorithm is not recommended because it has lower security and poses security risks.
- If parameter **password_encryption_type** is set to **2**, passwords are encrypted using SHA-256. This is the default configuration.
- If parameter **password_encryption_type** is set to **3**, passwords are encrypted using SM3.

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** View the configured encryption algorithm.

```
openGauss=# SHOW password_encryption_type;
 password_encryption_type
--------------------------
 2
(1 row)
```

**Step 3** Configure password security parameters.

- Password complexity

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You need to specify a password when initializing a database, creating a user, or modifying a user. The password must meet the complexity check rules (see **password_policy**). Otherwise, you are prompted to enter the password again.

- If parameter **password_policy** is set to **1**, the default password complexity rule is used to check passwords.
- If **password_policy** is set to **0**, the password complexity rule is not used. However, the password cannot be empty and must contain only valid characters, including uppercase letters (A–Z), lowercase letters (a–z), digits (0–9), and special characters (see **Table 7-5**). You are not advised to set this parameter to **0** because this operation poses security risks. If the setting is required, you must set **password_policy** to **0** on all cluster nodes.

Configure the **password_policy** parameter.

The password complexity and length requirements are as follows:

- Minimum number of uppercase letters (A-Z) (**password_min_uppercase**)
- Minimum number of lowercase letters (a-z) (**password_min_lowercase**)
- Minimum number of digits (0-9) (**password_min_digital**)
- Minimum number of special characters (**password_min_special**) (**Table 7-5** lists special characters.)
- Minimum length of a password (**password_min_length**)
- Maximum length of a password (**password_max_length**)

  NOTE

  For details, see "GUC Parameters" in *Developer Guide*.

- A password must contain at least three types of the characters (uppercase letters, lowercase letters, digits, and special characters).
- A password is case insensitive and cannot be the username or the username spelled backwards.
- A new password cannot be the current password and the current password spelled backwards.
- It must be a strong password.

  - Weak passwords are weak passwords that are easy to crack. The definition of weak passwords may vary with users or user groups. Users can define their own weak passwords.
  - Passwords in the weak password dictionary are stored in the **gs_global_config** system catalog. When a user is created or modified, the password set by the user is compared with the password stored in the weak password dictionary. If the password is matched, a message is displayed, indicating that the password is weak and the password fails to be set.
  - The weak password dictionary is empty by default. You can add or delete weak passwords using the following syntax:

    CREATE WEAK PASSWORD DICTIONARY WITH VALUES ('password1'), ('password2');

    DROP WEAK PASSWORD DICTIONARY;

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- Password reuse

  An old password can be reused only when it meets the requirements on reuse days (**password_reuse_time**) and reuse times (**password_reuse_max**). **Table 7-6** lists the parameter configurations.

  NOTE

  The default values of the **password_reuse_time** and **password_reuse_max** parameters are **0**, respectively. Large values of the two parameters bring higher security. However, if the values of the parameters are set too large, inconvenience may occur. The default values of the two parameters meet the security requirements. You can change the parameter values as needed for higher security.

  Configure the **password_reuse_time** parameter.

  Configure the **password_reuse_max** parameter.

- Password validity period

  A validity period (**password_effect_time**) is set for each database user password. If the password is about to expire (**password_notify_time**), the system displays a message to remind the user to change it upon login.

  NOTE

  Considering the usage and service continuity of a database, the database still allows a user to log in after the password expires. A password change notification is displayed every time the user logs in to the database until the password is changed.

  Configure the **password_effect_time** parameter.

  Configure the **password_notify_time** parameter.

- Password change
  - During database installation, an OS user with the same name as the initial user is created. The password of the OS user needs to be periodically changed for account security.

    To change the password of user **user1**, run the following command:

    ```
    passwd user1
    ```

    Change the password as prompted.
  - System administrators and common users need to periodically change their passwords to prevent the accounts from being stolen.

    For example, to change the password of user **user1**, connect to the database as the system administrator and run the following commands:

    ```
    openGauss=# ALTER USER user1 IDENTIFIED BY "1234@abc" REPLACE "5678@def";
    ALTER ROLE
    ```

    NOTE

    **1234@abc** and **5678@def** represent the new password and the original password of user **user1**, respectively. If the new password does not have the required complexity, the change will not take effect.
  - Administrators can change their own and common users' passwords. If common users forget their passwords, they can ask administrators to change the passwords.

    To change the password of user **joe**, run the following command:

    ```
    openGauss=# ALTER USER joe IDENTIFIED BY "abc@1234";
    ALTER ROLE
    ```

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NOTE

- System administrators are not allowed to change passwords for each other.
- A system administrator can change the password of a common user without being required to provide the common user's old password.
- A system administrator can change their own password but is required to provide the old password.

- Password verification

  Password verification is required when you set the user or role in the current session. If the entered password is inconsistent with the stored password of the user, an error is reported.

  If user **joe** needs to be set, run the following command:

```
openGauss=# SET ROLE joe PASSWORD "abc@1234";
ERROR:  Invalid username/password,set role denied.
```

**Table 7-5** Special characters

| No. | Character | No. | Character | No. | Character | No. | Character |
|---|---|---|---|---|---|---|---|
| 1 | ~ | 9 | * | 17 | \| | 25 | < |
| 2 | ! | 10 | ( | 18 | [ | 26 | . |
| 3 | @ | 11 | ) | 19 | { | 27 | > |
| 4 | # | 12 | N/A | 20 | } | 28 | / |
| 5 | $ | 13 | _ | 21 | ] | 29 | ? |
| 6 | % | 14 | = | 22 | ; | N/A | N/A |
| 7 | ^ | 15 | + | 23 | : | N/A | N/A |
| 8 | & | 16 | \ | 24 | , | N/A | N/A |

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**Table 7-6** Parameter description for reuse days and reuse times

| Parameter | Value Range | Description |
| --- | --- | --- |
| Number of days during which a password cannot be reused (**password_reuse_time**) | Positive number or **0**. The integral part of a positive number indicates the number of days and its decimal part can be converted into hours, minutes, and seconds.<br>The default value is **0**. | • If the parameter value is changed to a smaller one, new password will be checked based on the new parameter value.<br>• If the parameter value is changed to a larger one (for example, changed from **a** to **b**), the historical passwords before **b** days probably can be reused because these historical passwords may have been deleted. New passwords will be checked based on the new parameter value.<br>**NOTE**<br>The absolute time is used. Historical passwords are recorded using absolute time and unaffected by local time changes. |
| Number of consecutive times that a password cannot be reused (**password_reuse_max**) | Positive integer or **0**.<br>The value **0** indicates that the number of consecutive times that a password cannot be reused is not checked. | • If the parameter value is changed to a smaller one, new password will be checked based on the new parameter value.<br>• If the parameter value is changed to a larger one (for example, changed from **a** to **b**), the historical passwords before the last **b** passwords probably can be reused because these historical passwords may have been deleted. New passwords will be checked based on the new parameter value. |

**Step 4** Set user password expiration.

When creating a user, a user with the CREATEROLE permission can force the user password to expire. After logging in to the database for the first time, a new user can perform query operations only after changing the password. The command format is as follows:

```
openGauss=# CREATE USER joe PASSWORD "abc@1234" EXPIRED;
CREATE ROLE
```

A user with the CREATEROLE permission can force a user password to expire or force a user to change the forcibly expired password. The command format is as follows:

```
openGauss=# ALTER USER joe PASSWORD EXPIRED;
ALTER ROLE
openGauss=# ALTER USER joe PASSWORD "abc@2345" EXPIRED;
ALTER ROLE
```

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NOTE

- After a user whose password is invalid logs in to the database, the system prompts the user to change the password when the user performs a simple or extended query. The user can then execute the statement after changing the password.
- Only initial users, system administrators (**sysadmin**), and users who have the permission to create users (**CREATEROLE**) can invalidate user passwords. System administrators can invalidate their own passwords or the passwords of other system administrators. The password of initial users cannot be invalidated.

**----End**

# 7.3 Configuring Database Audit

## 7.3.1 Overview

### Background

Database security is essential for a database system. GaussDB writes all user operations in the database into audit logs. Database security administrators can use the audit logs to reproduce a series of events that cause faults in the database and identify unauthorized users, unauthorized operations, and the time when these operations are performed.

You need to know the following about the audit function:

- The overall audit switch **audit_enabled** supports dynamic loading. After you change the switch status when the database is running, the change takes effect immediately and you do not need to restart the database. Its default value is **on**, indicating that the audit function is enabled.
- In addition to the overall audit switch, each audit item has an independent switch. An audit item is available only after its own switch is turned on.
- The switch of each audit supports dynamic loading. After changing the audit switch status when the database is running, the modification takes effect immediately without restarting the database.

Table 7-7 lists the audit items supported by GaussDB. For details, see the GUC parameter description in the links.

**Table 7-7** Audit items

| Parameter | Description |
| --- | --- |
| User login and logout audit | Parameter: **audit_login_logout**<br>Its default value is **7**, which indicates that the function of user login and logout audit is enabled. **0** indicates that the function of user login and logout audit is disabled. Other values are not recommended. |

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| Parameter | Description |
| --- | --- |
| Database startup, stop, recovery, and switchover audit | Parameter: **audit_database_process**<br>Its default value is **1**, which indicates that the audit of database startup, stop, recovery, and switchover is enabled. |
| User locking and unlocking audit | Parameter: **audit_user_locked**<br>Its default value is **1**, which indicates that the audit of user locking and unlocking is enabled. |
| Unauthorized access audit | Parameter: **audit_user_violation**<br>Its default value is **0**, which indicates that the audit of unauthorized access disabled. |
| Permission granting and revoking audit | Parameter: **audit_grant_revoke**<br>Its default value is **1**, which indicates that the audit of permission granting and revoking is enabled. |
| Audit of CREATE, ALTER, and DROP operations on database objects | Parameter: **audit_system_object**<br>Its default value is **67121159**, which indicates that only the CREATE, ALTER, and DROP operations on databases, schemas, users, data sources, and node groups are audited. |
| Audit of INSERT, UPDATE, and DELETE operations on a specific table | Parameter: **audit_dml_state**<br>Its default value is **0**, which indicates that the audit of DML operations (except SELECT) on a specific table is disabled. |
| SELECT operation audit | Parameter: **audit_dml_state_select**<br>Its default value is **0**, which indicates that the audit of the SELECT operation is disabled. |
| COPY operation audit | Parameter: **audit_copy_exec**<br>Its default value is **1**, which indicates that the audit of the COPY operation is enabled. |
| Execution of stored procedures and customized functions | Parameter: **audit_function_exec**<br>Its default value is **0**, which indicates that no execution audit logs of stored procedures and customized functions are recorded. |
| SET operation audit | Parameter: **audit_set_parameter**<br>Its default value is **0**, which indicates that the audit of the SET operation is disabled. |
| Transaction ID record | Parameter: **audit_xid_info**<br>Its default value is **0**, which indicates that the function of recording transaction IDs in audit logs is disabled. |

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Table 7-8 lists security-related parameters and their default values.

**Table 7-8** Security-related parameters

| Parameter | Description |
| --- | --- |
| ssl | Specifies whether the SSL connection is enabled. |
| require_ssl | Specifies whether the server requires the SSL connection. |
| ssl_ciphers | Encryption algorithm list supported by the SSL |
| ssl_cert_file | File containing the SSL server certificate |
| ssl_key_file | File containing the SSL private key |
| ssl_ca_file | File containing CA information |
| ssl_crl_file | File containing CRL information |
| ssl_cert_notify_time | Specifies the number of days prior to SSL server certificate expiration that a user will receive a reminder. |
| password_policy | Specifies whether to check the password complexity. |
| password_reuse_time | Specifies whether to check the reuse days of a new password. |
| password_reuse_max | Specifies whether to check the reuse times of a new password. |
| password_lock_time | Duration before a locked account is automatically unlocked |
| failed_login_attempts | If the number of consecutive login attempts with incorrect passwords reaches this value, the account is locked. |
| password_encryption_type | Password storage encryption mode |
| password_min_uppercase | Minimum number of uppercase letters in a password |
| password_min_lowercase | Minimum number of lowercase letters in a password |
| password_min_digital | Minimum number of digits in a password |
| password_min_special | Minimum number of special characters in a password |

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| Parameter | Description |
| --- | --- |
| password_min_length | Minimum password length<br>**NOTE**<br>The value of this parameter must be less than or equal to that of **password_max_length**. Otherwise, a password length error message is displayed upon all password-related operations. |
| password_max_length | Maximum password length<br>**NOTE**<br>The value of this parameter must be greater than or equal to that of **password_min_length**. Otherwise, a password length error message is displayed upon all password-related operations. |
| password_effect_time | Password validity period |
| password_notify_time | Number of days prior to account password expiration that a user is notified |
| audit_enabled | Specifies whether the audit process is enabled or disabled. |
| audit_directory | Audit file storage directory |
| audit_data_format | Audit log file format. Currently, only the binary format is supported. |
| audit_rotation_interval | Time interval of creating an audit log file. If the difference between the current time and the time when the previous audit log file is created is greater than the value of this parameter, a new audit log file will be generated. |
| audit_rotation_size | Maximum capacity of an audit log file. If the total number of messages in an audit log exceeds the value of **audit_rotation_size**, the server will generate a new audit log file. |
| audit_resource_policy | Policy for determining whether audit logs are preferentially stored by space or time. **on** indicates that audit logs are preferentially stored by space. |
| audit_file_remain_time | Minimum duration required for recording audit logs. This parameter is valid only when audit_resource_policy is set to **off**. |
| audit_space_limit | Maximum total size of audit log files in a disk |
| audit_file_remain_threshold | Maximum number of audit files in the audit directory |
| audit_login_logout | Specifies whether to audit user logins (including login successes and failures) and logouts. |
| audit_database_process | Specifies whether to audit database startup, stop, switchover, and restoration operations. |

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| Parameter | Description |
| --- | --- |
| audit_user_locked | Specifies whether to audit database user locking and unlocking. |
| audit_user_violation | Specifies whether to audit beyond-authority operations of a database user. |
| audit_grant_revoke | Specifies whether to audit user permission granting and reclaiming operations. |
| audit_system_object | Specifies whether to audit the CREATE, DROP, and ALTER operations on database objects. |
| audit_dml_state | Specifies whether to audit the INSERT, UPDATE, and DELETE operations on a specific table. |
| audit_dml_state_select | Specifies whether to audit the SELECT operation. |
| audit_copy_exec | Specifies whether to audit the COPY operation. |
| audit_function_exec | Specifies whether to record audit information during execution of stored procedures, anonymous blocks, or customized functions (excluding system functions). |
| audit_set_parameter | Specifies whether to audit the SET operation. |
| enableSeparationOfDuty | Specifies whether the separation of duties is enabled. |
| session_timeout | If the duration of a connection session exceeds the parameter value, the session is automatically disconnected. |
| auth_iteration_count | Number of iterations during the generation of encrypted information for authentication |

## Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** Check the status of the overall audit switch.

Run the **show** command to view the value of **audit_enabled**.

```
openGauss=# SHOW audit_enabled;
```

**----End**

# 7.3.2 Querying Audit Results

## Prerequisites

- Audit has been enabled.
- Audit of required items has been enabled.

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- The database is running properly and a series of addition, modification, deletion, and query operations have been executed in the database. Otherwise, no audit result is generated.
- Audit logs are separately recorded on the database nodes.

## Background

- Only users with the **AUDITADMIN** permission can view audit records. For details about database users and how to create users, see **7.2.4 Users**.
- The SQL function **pg_query_audit** is provided by the database for audit query. Its syntax is as follows:

  ```
  pg_query_audit(timestamptz startime,timestamptz endtime,audit_log)
  ```

  **startime** and **endtime** indicate the start time and end time of the audit record, respectively. **audit_log** indicates the physical file path of the queried audit logs. If **audit_log** is not specified, the audit log information of the current instance is queried.

  You can use the SQL function **pgxc_query_audit** to query audit logs of all CNs. Its syntax is as follows:

  ```
  pgxc_query_audit(timestamptz startime,timestamptz endtime)
  ```

  NOTE

  The difference between the values of the **startime** and **endtime** parameters indicates the query period, which can be any value ranging from 00:00:00 of the **startime** parameter to 23:59:59 of the **endtime** parameter. Therefore, the **startime** and **endtime** parameters must be properly set to ensure that the required audit information is displayed.

## Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** Run the following command to query the audit record:

```
openGauss=# SELECT * FROM pg_query_audit('2021-03-03 21:30:00', '2021-03-03 22:00:00') where type = 'login_success' and username = 'user1';
```

The command output is similar to the following:

```
         time          |     type      | result | userid | username | database | client_conninfo | object_name
|                  detail_info                   | node_name |
         thread_id           | local_port | remote_port
-----------------------+---------------+--------+--------+----------+----------+-----------------+-------------
+------------------------------------------------+-----------+--
-------------------------------+-------------+-------------
 2021-03-03 21:30:31+08 | login_success | ok     | 16398  | user1    | postgres | gsql@[local]    | postgres    |
login db(postgres) success, SSL=off| cn_5001    | 1
39634608699136@668093431256149 | 18000       | null
(1 row)
```

This record indicates that user **user1** logged in to the **postgres** database at 2021-03-03 21:30:31+08. After the host specified by **log_hostname** is started and a client is connected to its IP address, the host name found by reverse DNS resolution is displayed following the at sign (@) in the value of **client_conninfo**.

**Step 3** Query the audit records of all CNs.

```
openGauss=# SELECT * FROM pgxc_query_audit('2021-03-03 21:30:00', '2021-03-03 22:00:00') where type = 'login_success' and username = 'user1';
```

The command output is similar to the following:

```
         time          |     type      | result | userid | username | database | client_conninfo | object_name
|                 detail_info                  | node_name |
         thread_id           | local_port | remote_port
-----------------------+---------------+--------+--------+----------+----------+-----------------+-------------
+----------------------------------------------------+-----------+--
-------------------------------+------------+-------------
 2021-03-03 21:30:31+08 | login_success | ok     | 16398  | user1    | postgres | gsql@[local]    | postgres    |
login db(postgres) success, SSL=off | cn_5001    | 1
39634608699136@668093431256149 | 18000      | null
 2021-03-03 21:36:09+08 | login_success | ok     | 16398  | user1    | postgres | gsql@[local]    | postgres    |
login db(postgres) success, SSL=off | cn_5003    | 1
39779716937472@668093769836394 | 18000      | null
(2 rows)
```

The query result shows the successful login records of **user1** in to cn_5001 and cn_5003.

NOTE

SSL information is recorded at the end of the audit log **detail_info**. **SSL=on** indicates that the client is connected using SSL, and **SSL=off** indicates that the client is not connected using SSL.

**----End**

## 7.3.3 Maintaining Audit Logs

### Prerequisites

You have the audit permission.

### Background

- Table 7-9 lists the configuration parameters related to audit logs and the parameter descriptions.

**Table 7-9** Configuration parameters of audit logs

| Parameter | Description | Default Value |
| --- | --- | --- |
| audit_directory | Audit file storage directory | $GAUSSLOG/pg_audit |
| audit_resource_policy | Policy for saving audit logs | **on** (indicating that the space configuration policy is used) |
| audit_space_limit | Maximum storage space occupied by audit files | 1 GB |
| audit_file_remain_time | Minimum period for storing audit log files | 90 |
| audit_file_remain_threshold | Maximum number of audit files in the audit directory | 1048576 |

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NOTE

If **gs_om** is used for cluster deployment, audit logs are stored in *$GAUSSLOG*/**pg_audit**.

- The **pg_delete_audit** function is used to delete audit logs and is an internal SQL function of the database. Its syntax is as follows:

```
pg_delete_audit(timestamp startime,timestamp endtime)
```

**startime** and **endtime** indicate the audit record start time and end time, respectively.

- Audit content is commonly recorded to database tables or OS files. **Table 7-10** lists the advantages and disadvantages of the two record methods.

**Table 7-10** Comparison between the two record methods

| Mode | Benefit | Drawback |
| --- | --- | --- |
| Record in tables | Users do not need to maintain audit logs. | Any users having certain permissions to access database objects can access the audit tables. If a user illegally performs operations on the audit tables, the audit records may become inaccurate. |
| Record in OS files | This method has higher security because a user with the permission to access the database may not have the permission to access the OS files. | Users need to maintain audit logs. |

For database security purposes, GaussDB adopts the second method to save audit results for reliability.

## Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** Select a method to maintain audit logs.

- Automatic deletion of audit logs

  If the storage space occupied by audit files or the number of audit files reaches the upper limit, the system automatically deletes the oldest audit files and records deletion information to audit logs.

  NOTE

  By default, the allowed maximum storage space that can be occupied by audit files is set to **1024 MB**. Users can set the value as required.

  Configure the allowed maximum size of storage space occupied by audit files (**audit_space_limit**).

  Configure the maximum number of audit files (**audit_file_remain_threshold**).

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- Manual backup of audit files

  If the storage space occupied by audit files or the number of audit logs exceeds the threshold specified by the configuration file, the system automatically deletes the oldest audit files. Therefore, you are advised to periodically save important audit logs.

  a. Run the **show** command to view the directory (**audit_directory**) where audit files are saved.

  ```
  openGauss=# SHOW audit_directory;
  ```

  b. Copy the entire audit directory elsewhere to save it.

- Manual deletion of audit logs

  Run the **pg_delete_audit** command to manually delete the audit logs generated during a specified period of time.

  For example, manually delete the audit logs generated from September 20, 2020 to September 21, 2020.

  ```
  openGauss=# SELECT pg_delete_audit('2020-09-20 00:00:00','2020-09-21 23:59:59');
  ```

**----End**

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# 8 Importing Data

You can use **GDS**, **INSERT**, **COPY**, or **\copy** (a **gsql** meta-command) to import data to GaussDB. **GDS** has high efficiency because of its parallel import and is used to import large volume of data. The rest statements and commands are used to import small volume of data. For details, see **Table 8-1**.

**Table 8-1** Import modes

| Method | Feature |
| --- | --- |
| GDS | Multiple DNs are used for parallel import, improving the efficiency. It is recommended for importing a large volume of data. |
| INSERT | Insert one or more rows of data, or insert data from a specified table. |
| COPY | Run the **COPY FROM STDIN** statement to write data into GaussDB.<br>Service data does not need to be stored in files when it is written from other databases to GaussDB through the CopyManager interface driven by JDBC. |
| **\copy**, a **gsql** meta-command | Different from the SQL **COPY** statement, the **\copy** command can read data from or write data into only local files on a **gsql** client.<br>**NOTE**<br>**\copy** applies only to small-scale data import in good format. It does not preprocess invalid characters or provide error tolerance. Therefore, **\copy** cannot be used in scenarios where abnormal data exists. **GDS** or **COPY** is preferred for data import. |

## 8.1 Importing Data in Parallel Using Foreign Tables

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# 8.1.1 Parallel Data Import

The INSERT (**8.2 Running the INSERT Statement to Insert Data**) and COPY (**8.3 Running the COPY FROM STDIN Statement to Import Data**) statements can be used only for serially importing a small volume of data. To import a large volume of data to GaussDB, you can import data in parallel through a foreign table. To import foreign tables in parallel, you must enable the stream operator (controlled by the GUC parameter **enable_stream_operator**).

## Overview

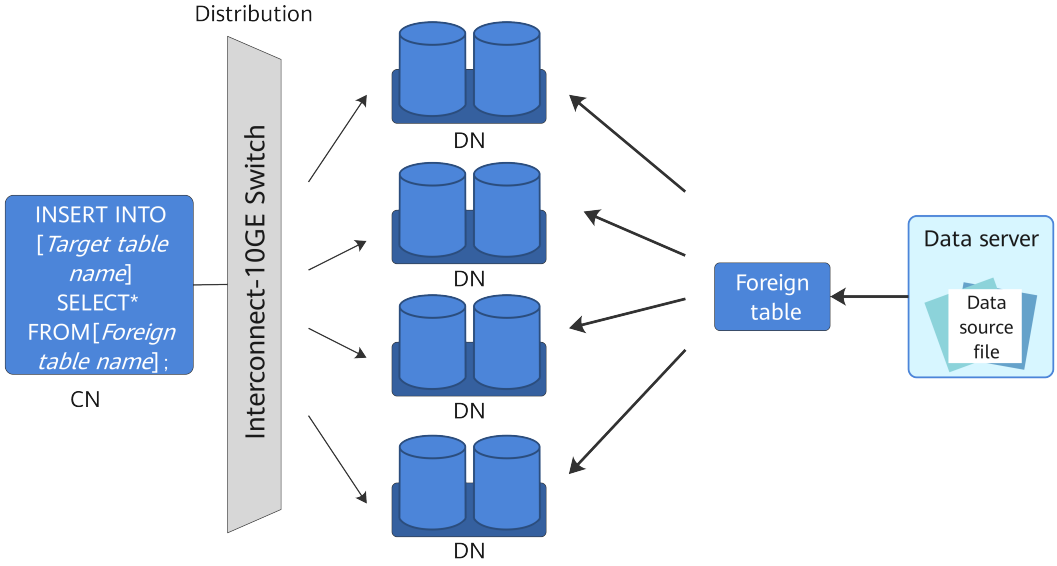
GDS imports data in parallel from the common file system of a server to GaussDB.

Source data files to import are specified based on the import policy and data formats set in a foreign table. Data is imported in parallel through multiple DNs from source data files to the database, which improves overall data import performance. **Figure 8-1** shows an example.

- The CN only plans data import tasks and delivers the tasks to DNs. Then the CN is released to process other tasks.
- In this way, the computing capacities and bandwidths of all the DNs are fully leveraged to import data, improving import efficiency.

You can preprocess data (such as invalid character replacement and fault tolerance processing) by setting parameters in a foreign table. For details, see **12.14.60 CREATE FOREIGN TABLE (for Import and Export)**.

**Figure 8-1** Importing data in parallel




The concepts mentioned in this figure are as follows:

- **CN**: coordinator node of GaussDB. After receiving import SQL requests from an application or client, the CN plans import tasks and delivers the tasks to DNs.

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- **DN**: data node of GaussDB. After receiving import tasks delivered by the CN, DNs import data from the source data file to the target table in the database through a foreign table.
- **Source data file**: a file that stores data to import.
- **Data server**: a server that stores source data files. For security purposes, it is recommended that the data server and GaussDB cluster be on the same intranet.
- **Foreign table**: a table that stores information, such as the current location, format, destination location, encoding format, and data delimiter of a source data file. It is used to associate source data files with the target table.
- **Target table**: a table in the database. It can be a row-store table or column-store table. Data in the source data files will be imported to this table.

## Loading Policies

To fully use computing resources for parallel import, import tasks are pushed down to DNs. The CN delivers tasks but does not import data. In this case, user data managers, correct and unique data allocation to DNs, and the uniqueness of data imported into databases must be first considered. GaussDB provides the following import policies:

- **Normal**: GDS is used to load source data into DNs. This policy is used for importing data to a cluster from hosts outside the cluster.
- **Shared**: The network file system (NFS) is used to load source data into DNs. After you configure NFS on a data server, mount the data server to the same directory of each DN. This policy is used for importing data to a cluster from hosts outside the cluster. In this policy, the CN scans all data files during task planning and evenly allocates source data files to each DN.
- **Private**: Users upload source data files to each DN. Before uploading data files, create a directory named after the DN name on each DN. Each DN searches for unloaded data files in its corresponding directory and loads them, until all data has been loaded.

As shown in **Table 8-2**, the Normal policy is recommended because it is scalable, easy to prepare, and has no limit on the size of a single row of data to be imported. The foreign tables in Private and Shared modes require the initial user permissions or the O&M administrator permissions in **operation_mode**. This section describes how to use GDS to import data in parallel. For details on the other policies, see **8.1.9.2 Example 2: Importing Data in Shared Mode** and **8.1.9.3 Example 3: Importing Data in Private Mode**.

**Table 8-2** Import policies

| Import Policy | Preparation for Data Import | Data Format |
| --- | --- | --- |
| Normal | Deploy GDS on data servers. Multi-GDS concurrent import is supported. | CSV, TEXT, and FIXED |

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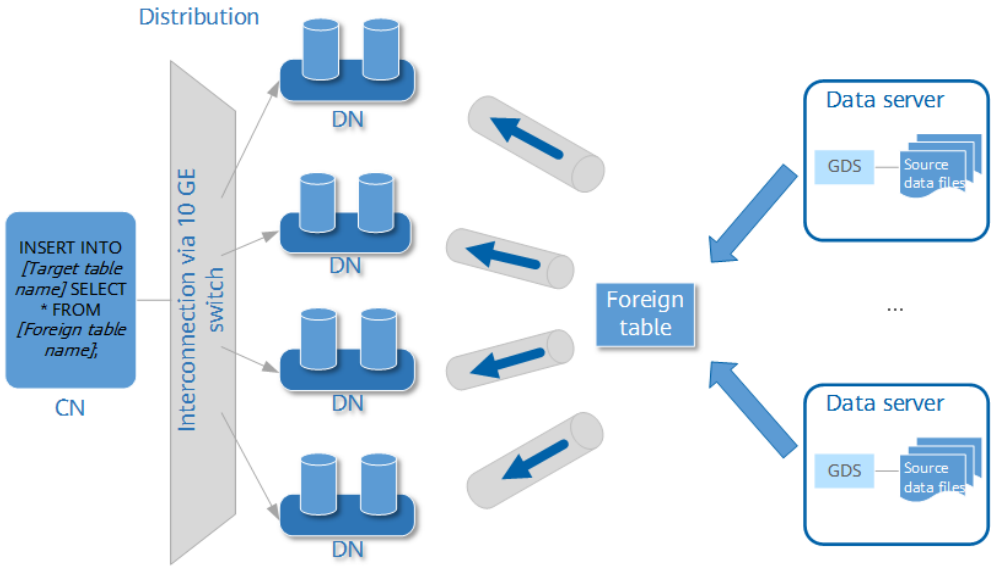
| Import Policy | Preparation for Data Import | Data Format |
| --- | --- | --- |
| Shared | Configure NFS on data servers and mount the data servers to the same directory of each DN. The mount directory on each DN must be the same. | TEXT<br>The size of data in a single row must be less than 1 GB. |
| Private | Evenly allocate source data files to DN servers.<br>Data files in each folder named after a DN name under the same directory of hosts should not be duplicate. | CSV, TEXT, and FIXED<br>The size of data in a single row must be less than 1 GB. |

## Parallel Import Using GDS

- If a large volume of data is stored on multiple servers, deploy, configure, and start GDS on each server. Then, data on all the servers can be imported in parallel, as shown in **Figure 8-2**.

**Figure 8-2** Parallel import from multiple data servers




**NOTICE**

The number of GDS processes cannot exceed that of DNs. If the number of connections exceeds the maximum, one DN may be connected to multiple GDS processes. As a result, some GDS processes may run abnormally, and the error message "Session doesn't exist" may be displayed. If the number of GDSs involved in an import is greater than the number of DNs, a warning "It is recommended that the number of GDS should not be greater than the number of datanode" is returned when the import starts.

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- If data is stored on one data server, and both GaussDB and the data server have available I/O resources, you can use GDS for multi-thread parallel import.

  GDS determines the number of threads based on the number of parallel import transactions. Even if multi-thread import is configured before GDS startup, the import of a single transaction will not be accelerated. By default, an **INSERT** statement is an import transaction.

  Multi-thread parallel import enables you to:

  – Make full use of resources and improve the parallel import efficiency when you import multiple tables to the database.

  – Speed up the import of a table with a large volume of data.

    Table data is split into multiple data files, and multi-thread parallel import is implemented by importing data using multiple foreign tables at the same time. Ensure that a data file is read only by one foreign table.

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## Import Process

**Figure 8-3** Parallel import process

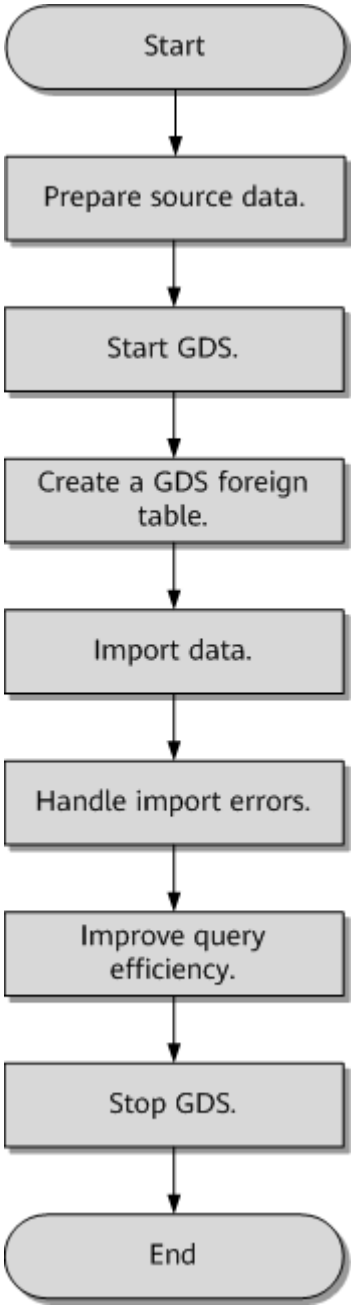


**Table 8-3** Process description

| Process | Description |
| --- | --- |
| Prepare source ata | Prepare source data files to import to the database and upload the files to the data server.<br>For details, see **8.1.3 Preparing Source Data**. |

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| Process | Description |
| --- | --- |
| Start GDS | Install, configure, and enable GDS on the data server.<br>For details, see **8.1.4 Installing, Configuring, and Starting GDS**. |
| Create a foreign table | A foreign table is used to identify data in a source data file. Foreign tables store the location, file format, encoding format, and delimiters information about the data source files.<br>For details, see **8.1.5 Creating a GDS Foreign Table**. |
| Import data | After creating the foreign table, execute the **INSERT** statement to efficiently import data to the target table. For details, see **8.1.6 Importing Data**. |
| Handle import errors | If there are errors during parallel data import, handle errors based on the error information to ensure data integrity.<br>For details, see **8.1.7 Handling Import Errors**. |
| Improve query efficiency | After data is imported, run the **ANALYZE** statement to generate table statistics. The **ANALYZE** statement stores the statistics in the system catalog **PG_STATISTIC**. The statistics data is useful when you run the planner, which provides you with an efficient query execution plan.<br>For details, see **8.8 Analyzing Tables**. |
| Stop GDS | After data import is complete, log in to each data server and stop GDS.<br>For details, see **8.1.8 Stopping GDS**. |

## 8.1.2 Tutorial and Best Practice

**5 Tutorial: Using GDS to Import Data from a Remote Server** guides you through importing data using GDS.

The **Best Practices of GDS Data Import** describes how to maximize system resources to improve import performance. You are advised to read this before planning data import.

## 8.1.3 Preparing Source Data

### Scenarios

Before being imported to a database, data is stored on the related host. The server that stores the data to import is called the data server. In this case, you only need to check the communication between the data server and GaussDB cluster and record the data storage directory on the data server. Check whether the server has robust system resources such as memory, handles, and disk space, based on the load of the import job.

If the data has not been uploaded to the data server, perform the operations described in this section to upload it first.

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### Procedure

**Step 1** Log in to the data server.

**Step 2** Create a file storage directory **/input_data**.

```
mkdir -p /input_data
```

**Step 3** Upload source data files to the created directory.

GDS parallel import supports data only in CSV, TEXT, or FIXED format. Ensure that the source data file meets the format requirements.

**----End**

## 8.1.4 Installing, Configuring, and Starting GDS

### Scenarios

GaussDB uses GDS to allocate source data for parallel data import. GDS needs to be deployed on data servers.

If a large volume of data is stored on multiple servers, deploy, configure, and start GDS on each server. Then, data on all the servers can be imported in parallel. The procedure for installing, configuring, and starting GDS is the same on each data server. This section describes how to perform this procedure on one data server.

### Background

1. GDS can be installed on the following x86/ARM OS: EulerOS 2.5/2.8.
2. The GDS version must be consistent with the database version. Otherwise, the import or export may fail or not respond.

   Therefore, do not use an earlier version of GDS. After the database is upgraded, download the GDS of the new version as instructed in **Procedure**. When the import or export starts, GaussDB checks the GDS version and will display an error message and terminate the import or export if it detects a version mismatch.

   To obtain the GDS version, run the following command in the GDS decompression directory:

   ```
   gds -V
   ```

   To view the database version, run the following SQL statement after connecting to the database:

   ```
   SELECT version();
   ```

- The data server where GDS is deployed must use the recommended OS and communication parameter settings, which are the same as the configuration parameters of the cluster. For proper service running, ensure that the communication between the GDS data server and the cluster is normal.

  To use the inspection package to check system parameters on a data server, perform the following operations:

  a. Copy the inspection package to the GDS data server.

  b. Run the following command to check the system configuration parameters:

  ```
  gs_check -i CheckSysParams -L
  ```

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c. Modify parameter settings as prompted and run the command in the previous steps again.

If the message "Warning reason: variable 'net.ipv4.tcp_retries1' RealValue '3' ExpectedValue '5'." is displayed, run the following commands:

```
vim /etc/sysctl.conf // Set net.ipv4.tcp_retries1=5.
sysctl -p // Make parameter settings take effect.
```

## Procedure

**Step 1** Log in to the data server where GDS is to be installed, and create a GDS user and its user group. This user is used to start GDS and read source data.

```
groupadd gdsgrp
useradd -g gdsgrp gds_user
```

**Step 2** Switch to user **gds_user**.

```
su - gds_user
```

**Step 3** Create the **/opt/bin** directory for storing the GDS package.

```
mkdir -p /opt/bin
```

**Step 4** Change the owner of the GDS package directory and source data file directory to the GDS user.

```
chown -R gds_user:gdsgrp /opt/bin/gds
chown -R gds_user:gdsgrp /input_data
```

**Step 5** Upload the GDS package to the created directory.

Use the SUSE Linux package as an example. Upload the GDS package **GaussDB-Kernel-VxxxRxxxCxx-SUSE11-64bit-Gds.tar.gz** in the software installation package to the newly created directory.

**Step 6** (Optional) If SSL is used, upload the SSL certificates to the directory newly created in Step **Step 1**.

The certificates are stored in the **$GAUSSHOME/share/sslcert/gds** directory of GaussDB. Download and upload the file.

**Step 7** Go to the new directory and decompress the package.

```
cd /opt/bin
tar -zxvf GaussDB-Kernel-VxxxRxxxCxx-SUSE11-64bit-Gds.tar.gz
export LD_LIBRARY_PATH="/opt/bin/lib:$LD_LIBRARY_PATH"  // GDS depends on the Cjson dynamic library. Therefore, you need to configure the path of the dynamic library.
```

**Step 8** Start GDS.

GDS is green software and can be started after being decompressed. You can start it in either of the following ways: One is to run the **gds** command to set startup parameters. The other is to write the startup parameters into the **gds.conf** configuration file and run the **gds_ctl.py** command to start GDS. The **gds** command is recommended when you do not need to import data again. The **gds.conf** configuration file is recommended when you need to import data again.

- Run the **gds** command to start GDS.
  - If data is transmitted in non-SSL mode, run the following command to start GDS:

    ```
    gds -d dir -p ip:port -H address_string -l log_file -D -t worker_num --enable-ssl off
    ```

    Example:

    ```
    /opt/bin/gds/gds -d /input_data/ -p 192.168.0.90:5000 -H 10.10.0.1/24 -l /opt/bin/gds/gds_log.txt -D -t 2 --enable-ssl off
    ```

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- If data is transmitted in SSL mode, run the following command to start GDS:
  ```
  gds -d dir -p ip:port -H address_string -l log_file -D
  -t worker_num --enable-ssl on --ssl-dir Cert_file
  ```
  Example:

  Run the following command to upload the SSL certificate mentioned in **Step 6** to **/opt/bin**:
  ```
  /opt/bin/gds/gds -d /input_data/ -p 192.168.0.90:5000 -H 10.10.0.1/24 -l /opt/bin/gds/
  gds_log.txt -D --enable-ssl on --ssl-dir /opt/bin/
  ```

Replace the information in italic as required.

- **-d** *dir*: directory that stores source data files. It is **/input_data/** in this tutorial.
- **-p** *ip:port*: listening IP address and port for GDS. The default value is **127.0.0.1**. Replace it with the IP address of a 10GE network that can communicate with GaussDB. The listening port can be any one ranging from 1024 to 65535. The default port is **8098**. This parameter is set to **192.168.0.90:5000** in this tutorial.
- **-H** *address_string*: network segment for hosts that can connect to and use GDS. The value must be in CIDR format. Set this parameter to enable the GaussDB cluster to access GDS for data import. Ensure that the network segment covers all hosts in the GaussDB cluster.
- **-l** *log_file*: GDS log directory and log file name. This tutorial uses **/opt/bin/gds/gds_log.txt** as an example.
- **-D**: GDS in daemon mode. This parameter is used only in Linux.
- **-t** *worker_num*: number of concurrent GDS threads. If the data server and GaussDB have robust I/O resources, you can increase the number of concurrent GDS threads.

  GDS determines the number of threads based on the number of parallel import transactions. Even if multi-thread import is configured before GDS startup, the import of a single transaction will not be accelerated. By default, an **INSERT** statement is an import transaction.
- **--enable-ssl**: Data transmission in SSL encryption mode. By default, the value **on** is used to enable the SSL encryption mode. If this parameter is not used, you need to add **--ssl-dir** to specify the SSL certificate directory.
- **--ssl-dir** *Cert_file*: SSL certificate directory. Set it to the certificate directory mentioned in **Step 6**.
- For details on how to set more parameters, see **Server Tools** > **GDS** > **Parameter Description** in the *Tool Reference*.

- Run the **gds_ctl.py** command to start GDS.

  a. Run the following command to go to the **config** directory of the GDS package and modify the **gds.conf** configuration file. In this case, GDS is not in SSL mode. For details on the parameters in the **gds.conf** configuration file, see **Table 8-4**.
  ```
  vim /opt/bin/gds/config/gds.conf
  ```
  Example:

  The **gds.conf** configuration file contains the following information:
  ```
  <?xml version="1.0"?>
  <config>
  <gds name="gds1" ip="192.168.0.90" port="5000" data_dir="/input_data/" err_dir="/err"
  ```

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```
data_seg="100MB" err_seg="100MB" log_file="/log/gds_log.txt" host="10.10.0.1/24"
daemon='true' recursive="true" parallel="32"></gds>
</config>
```

Details are as follows:

- The data server IP address is **192.168.0.90** and the GDS listening port is **5000**.
- Data files are stored in the **/input_data/** directory.
- Error log files are stored in the **/err** directory.
- The size of a single data file is 100 MB.
- The size of a single error log file is 100 MB.
- Run logs are stored in the **/log/gds_log.txt** file.
- Only nodes with the IP address being 10.10.0.* can be connected.
- The GDS process is running in daemon mode.
- Recursive data file directories are used.
- The number of concurrent import threads is 2.

b. Start GDS and check whether it has been started:

```
python3 gds_ctl.py start
```

Example:

```
cd /opt/bin/gds
python3 gds_ctl.py start
Start GDS gds1                  [OK]
gds [options]:
 -d dir            Set data directory.
 -p port           Set GDS listening port.
   ip:port         Set GDS listening ip address and port.
 -l log_file       Set log file.
 -H secure_ip_range
                  Set secure IP checklist in CIDR notation.                  Required for GDS to start.
 -e dir            Set error log directory.
 -E size           Set size of per error log segment.(0 < si                  ze < 1TB)
 -S size           Set size of data segment.(1MB < size < 10                  0TB)
 -t worker_num     Set number of worker thread in multi-thre                  ad mode, the upper
limit is 32. If withou                  t setting, the default value is 1.
 -s status_file    Enable GDS status report.
 -D                Run the GDS as a daemon process.
 -r                Read the working directory recursively.
 -h                Display usage.
```

**----End**

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NOTE

The binary use of GDSs depends on some common library files. If GDSs are deployed on physical nodes outside the cluster and the physical environment where GDSs reside cannot provide such library files or the versions of related library files are incompatible, an error message similar to "/lib64/libstdc++.so.6: version `GLIBCXX_3.4.20' not found" may be displayed during the startup. Log in to the physical node where the cluster resides, copy the corresponding library file (for example, **libstdc++.so.6** or **libgcc_s.so.1**) from the *$GAUSSHOME*/**lib** directory to the directory in step 4, and repeat step 4 to set environment variables. After the setting is successful, restart GDS.

If the problem persists, GDS does not support the current physical environment or platform. You are advised to switch to a supported physical environment and try again.

## gds.conf Parameter Description

**Table 8-4** Attributes in the gds.conf file

| Attribute | Description | Value Range |
| --- | --- | --- |
| name | Identifier | - |
| ip | Listening IP address | The IP address must be valid.<br>Default value: 127.0.0.1 |
| port | Listening port | Value range: an integer ranging from 1024 to 65535<br>Default value: 8098 |
| data_dir | Data file directory | - |
| err_dir | Error log file directory | Default value: data file directory |
| log_file | Log file path | - |
| host | Host IP address allowed to be connected to GDS (The value must in CIDR format and this parameter is set for the Linux OS only.) | - |
| recursive | Whether the data file directories are recursive | Value range:<br>● **true**: recursive<br>● **false**: not recursive<br>Default value: false |
| daemon | Whether a process is running in daemon mode | Value range:<br>● **true**: The server is running in daemon mode.<br>● **false**: The server is not running in daemon mode.<br>Default value: false |

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| Attribute | Description | Value Range |
| --- | --- | --- |
| parallel | Number of concurrent data import threads | Value range: an integer ranging form 0 to 32<br>Default value: 1 |

## 8.1.5 Creating a GDS Foreign Table

Source data information and GDS access information are configured in a foreign table. Then, GaussDB can import data from a data server to a database table based on the configuration in the foreign table.

### Procedure

**Step 1** Collect source data information and GDS access information.

You need to collect the following source data information:

- **format**: CSV, TEXT, and FIXED are supported. Check the format of data to import, for example, CSV format.
- **header**: whether a source data file has a header. This parameter is set only for files in CSV or FIXED format.
- **delimiter**: delimiter in the source data file, for example, comma (,).
- **encoding**: encoding format of the source data file, for example, UTF-8.
- **eol**: line break character in the data file. It can be a default character, such as 0x0D0A or 0X0A, or a customized line break character such as a string **!@#**. This parameter can be set only for TEXT import.
- For details on more source data information configured in a foreign table, see **data format parameters**.

You need to collect the following GDS access information:

**location**: GDS URL. GDS information in **8.1.4 Installing, Configuring, and Starting GDS** is used as an example. In non-SSL mode, **location** is set to **gsfs**://*192.168.0.90:5000*|*/input_data/*. In SSL mode, **location** is set to **gsfss**://*192.168.0.90:5000*|*/input_data/*. **192.168.0.90:5000** is the IP address and port number of GDS. **input_data** is the directory for storing source data files on the data server. Replace the values as required.

**Step 2** Design an error tolerance mechanism for data import.

GaussDB supports the following error tolerance in data import:

- **fill_missing_fields**: This parameter specifies whether to report an error when the last column in a row of the source data file is empty, or to fill the column with null.
- **ignore_extra_data**: When the number of columns in the source data file is greater than that specified in the foreign table, this parameter specifies whether to report an error or ignore the extra columns.
- **per node reject_limit**: This parameter specifies the number of data format errors allowed on each DN. If the number of errors recorded in the error table

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on a DN exceeds the specified value, the import fails and an error message is reported. You can also set it to **unlimited**.

- **compatible_illegal_chars**: When an illegal character is encountered, this parameter specifies whether to import an error, or convert it and proceed with the import.

  The following describes the rules for converting an illegal character:

  - **\0** is converted to a space.
  - Other illegal characters are converted to question marks.
  - If **NULL**, **DELIMITER**, **QUOTE**, or **ESCAPE** is also set to a space or question mark, GaussDB displays an error message, such as "illegal chars conversion may confuse COPY escape 0x20", to prompt you to modify parameter settings that may cause import errors.
- **error_table_name**: This parameter specifies the name of the table that records data format errors. After the parallel import, you can query the table for error details.
- **remote log 'name'**: This parameter specifies whether to store data format errors in files on the GDS server. **name** is the prefix of the error data file.
- For details on more error tolerance parameters, see **error tolerance parameters**.

**Step 3** After connecting to the database using **gsql** or Data Studio, create a GDS foreign table based on the collected and design information.

The command is as follows:

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
)
 SERVER gsmpp_server
 OPTIONS
(
LOCATION 'gsfs://192.168.0.90:5000/input_data | gsfs://192.168.0.91:5000/input_data',
FORMAT 'CSV' ,
DELIMITER ',',
ENCODING 'utf8',
HEADER 'false',
FILL_MISSING_FIELDS 'true',
IGNORE_EXTRA_DATA 'true'
)
LOG INTO product_info_err
PER NODE REJECT LIMIT 'unlimited';
```

The following describes information in this example:

- The columns specified in the foreign table must be the same as those in the target table.
- Retain the value **gsmpp_server** for **SERVER**.
- Set **location** based on the GDS access information collected in **Step 1**. If SSL is used, replace **gsfs** with **gsfss**.
- Set **FORMAT**, **DELIMITER**, **ENCODING**, and **HEADER** based on the source data information collected in **Step 1**.

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- Set **FILL_MISSING_FIELDS**, **IGNORE_EXTRA_DATA**, **LOG INTO**, and **PER NODE REJECT LIMIT** based on the error tolerance mechanism designed in **Step 2**. **LOG INTO** specifies the name of the error table.

For details on the **CREATE FOREIGN TABLE** syntax, see **12.14.60 CREATE FOREIGN TABLE (for Import and Export)**.

**----End**

## Examples

For more examples, see **8.1.9 Examples**.

- Example 1: Create a GDS foreign table named **foreign_tpcds_reasons**. The data format is CSV.

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
)
 SERVER gsmpp_server OPTIONS (location 'gsfs://192.168.0.90:5000/* | gsfs://192.168.0.91:5000/*',
FORMAT 'CSV',MODE 'Normal', ENCODING 'utf8', DELIMITER E'\x20', QUOTE E'\x1b', NULL '');
```

- Example 2: Create a GDS foreign table named **foreign_tpcds_reasons_SSL**. SSL is used and the data format is CSV.

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons_SSL
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
)
 SERVER gsmpp_server OPTIONS (location 'gsfss://192.168.0.90:5000/* | gsfss://192.168.0.91:5000/*',
FORMAT 'CSV',MODE 'Normal', ENCODING 'utf8', DELIMITER E'\x20', QUOTE E'\x1b', NULL '');
```

- Example 3: Create a GDS foreign table named **foreign_tpcds_reasons**. The data format is TEXT.

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
) SERVER gsmpp_server OPTIONS (location 'gsfs://192.168.0.90:5000/* | gsfs://192.168.0.91:5000/*',
FORMAT 'TEXT', delimiter E'\x20',  null '',reject_limit '2',EOL '0x0D') WITH err_foreign_tpcds_reasons;
```

- Example 4: Create a GDS foreign table named **foreign_tpcds_reasons**. The data format is FIXED.

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
(
  r_reason_sk       integer      position(1,2),
  r_reason_id       char(16)     position(3,16),
  r_reason_desc     char(100)    position(19,100)
) SERVER gsmpp_server OPTIONS (location 'gsfs://192.168.0.90:5000/*', FORMAT 'FIXED', ENCODING
'utf8',FIX '119');
```

# 8.1.6 Importing Data

This section describes how to create tables in GaussDB and import data to the tables.

Before importing all the data from a table containing over 10 million records, you are advised to import some of the data and perform operations in **8.7 Checking for Data Skew**. Immediately address data skew problems if any because it is costly to address them after a large amount of data has been imported.

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## Prerequisites

The IP addresses and ports of servers where CNs and DNs reside can connect to those of a GDS server.

## Procedure

**Step 1** Create a target table in GaussDB to store imported data. For details, see **12.14.80 CREATE TABLE**.

**Step 2** (Optional) If the target table has an index, the index information will be incrementally updated during the import, affecting data import performance. You are advised to delete the index from the target table before the import. You can create the indexes again after the import is complete.

1. If there is an ordinary index **product_idx** in the **product_id** column of the target table **product_info**, delete the index from the table before importing data.
   ```
   DROP INDEX product_idx;
   ```
2. After importing the data, create the index again.
   ```
   openGauss=# CREATE INDEX product_idx ON product_info(product_id);
   ```
3. Set **enable_stream_operator** to **on**.
   ```
   openGauss=# set enable_stream_operator=on;
   ```

NOTE

To accelerate the index recreation, add the **maintenance_work_mem** and **psort_work_mem** parameters.

**Step 3** Import data.

```
openGauss=# INSERT INTO [Target table name] SELECT * FROM [Foreign table name]
```

- If information similar to the following is displayed, the data has been imported. Query the error information table to check whether any data format errors occurred. For details, see **8.1.7 Handling Import Errors**.
  ```
  INSERT 0 9
  ```
- If data fails to be loaded, troubleshoot the problem by following the instructions provided in **8.1.7 Handling Import Errors** and try again.

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NOTE

- If a data loading error occurs, the entire data import task will fail.
- Create batch processing scripts to concurrently import data. The degree of parallelism depends on server resource usage. You can test several tables and monitor resource usage to determine whether to increase or reduce the amount. Common resource monitoring commands include **top** for monitoring memory and CPU usage, **iostat** for monitoring I/O usage, and **sar** for monitoring networks. For details on application cases, see **Example: Data Import Using Multiple Threads**.
- If possible, more GDS servers can significantly improve the data import efficiency. For details on application cases, see **Example: Parallel Import from Multiple Data Servers**.
- In a scenario where many GDS servers import data concurrently, you can extend the TCP Keepalive interval for connections between GDS servers and DNs to ensure connection stability. (The recommended interval is 5 minutes.) TCP Keepalive settings of the cluster affect its fault detection response time.
- If **enable_stream_operator** is set to **on**, the performance is affected. If there are other SQL statements to be executed in the session, you are advised to set **enable_stream_operator** to **off**. If there is no SQL statement to be executed in the session, disconnect the session.

**----End**

## Examples

1. Create a target table named **reasons**.
```
openGauss=# CREATE TABLE reasons
(
  r_reason_sk   integer  not null,
  r_reason_id   char(16) not null,
  r_reason_desc char(100)
)
DISTRIBUTE BY HASH (r_reason_sk);
```
2. Delete the index from the target table. Create the indexes again after the import is complete.
   a. If there is an ordinary table index **reasons_idx** in the **r_reason_id** column of the **reasons** table, delete the index from the table before importing data.
   ```
   openGauss=# DROP INDEX reasons_idx;
   ```
   b. After importing the data, create the index again.
   ```
   openGauss=# CREATE INDEX reasons_idx ON reasons(r_reasons_id);
   ```
   c. Set **enable_stream_operator** to **on**.
   ```
   openGauss=# set enable_stream_operator=on;
   ```
3. Import data from source data files through the **foreign_tpcds_reasons** foreign table to the **reasons** table.
```
openGauss=# INSERT INTO reasons SELECT * FROM foreign_tpcds_reasons ;
```

# 8.1.7 Handling Import Errors

## Scenarios

Handle errors that occurred during data import.

## Querying Error Information

Errors that occur when data is imported are divided into data format errors and non-data format errors.

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- Data format errors

  When creating a foreign table, specify **LOG INTO** *error_table_name*. Data format errors during data import will be written into the specified table. You can run the following SQL statement to query error details:

  ```
  openGauss=# SELECT * FROM error_table_name;
  ```

  **Table 8-5** lists the columns of the *error_table_name* table.

  **Table 8-5** Columns in the error information table

  | Column Name | Type | Description |
  | --- | --- | --- |
  | nodeid | integer | ID of the node where an error is reported |
  | begintime | timestamp with time zone | Time when a data format error was reported |
  | filename | character varying | Name of the source data file where a data format error occurs |
  | rownum | numeric | Number of the row where a data format error occurs in a source data file |
  | rawrecord | text | Raw record of a data format error in the source data file |
  | detail | text | Error details |

- Non-data format errors

  A non-data format error leads to the failure of an entire data import task. You can locate and troubleshoot a non-data format error based on the error message displayed during data import.

## Handling Data Import Errors

Troubleshoot data import errors based on obtained error information and descriptions in **Table 8-6**.

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**Table 8-6** Handling data import errors

| Error Message | Cause | Solution |
| --- | --- | --- |
| missing data for column "r_reason_desc" | 1. The number of columns in the source data file is less than that in the foreign table.<br>2. In a TEXT-format source data file, an escape character (for example, \) leads to delimiter or quote mislocation. Example: The target table contains three columns, and the following data is imported. The escape character (\) converts the delimiter (\|) into the value of the second column, causing the value of the third column to lose.<br>`BE\|Belgium\\|1` | 1. If an error is reported due to missing columns, perform the following operations:<br>• Add the value of the **r_reason_desc** column to the source data file.<br>• When creating a foreign table, set the parameter **fill_missing_fields** to **on**. In this way, if the last column of a row in the source data file is missing, it will be set to **NULL** and no error will be reported.<br>2. Check whether the row where an error is reported contains the escape character (\). If the row contains such a character, you are advised to set the parameter **noescaping** to **true** when creating a foreign table, indicating that the escape character (\) and the characters following it are not escaped. |
| extra data after last expected column | The number of columns in the source data file is greater than that in the foreign table. | • Delete extra columns from the source data file.<br>• When creating a foreign table, set the parameter **ignore_extra_data** to **on**. In this way, if the number of columns in the source data file is greater than that in the foreign table, the extra columns at the end of rows will not be imported. |

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| Error Message | Cause | Solution |
| --- | --- | --- |
| invalid input syntax for type numeric: "a" | The data type is incorrect. | In the source data file, change the data type of the columns to import. If this error information is displayed, change the data type to **numeric**. |
| null value in column "staff_id" violates not-null constraint | The not-null constraint is violated. | In the source data file, add values to the specified columns. If this error information is displayed, add values to the **staff_id** column. |
| duplicate key value violates unique constraint "reg_id_pk" | The unique constraint is violated. | • Delete duplicate rows from the source data file.<br>• Run the **SELECT** statement with the **DISTINCT** keyword to ensure that all imported rows are unique.<br>openGauss=# **INSERT INTO** reasons **SELECT DISTINCT * FROM** foreign_tpcds_reasons; |
| value too long for type character varying(16) | The column length exceeds the upper limit. | In the source data file, change the column length. If this error information is displayed, reduce the column length to no greater than 16 bytes (VARCHAR2). |

# 8.1.8 Stopping GDS

## Scenarios

Stop GDS after data is imported successfully.

## Procedure

**Step 1** Log in as user **gds_user** to the data server where GDS is installed.

**Step 2** Select the mode of stopping GDS based on the GDS start mode.

- If GDS is started using the **gds** command, perform the following operations to stop GDS:
  a. Query the GDS process ID.
  ```
  ps -ef|grep gds
  ```
  For example, the GDS process ID is 128954.
  ```
  ps -ef|grep gds
  gds_user 128954     1  0 15:03 ?        00:00:00 gds -d /input_data/ -p 192.168.0.90:5000 -l /log/gds_log.txt -D
  gds_user 129003 118723  0 15:04 pts/0    00:00:00 grep gds
  ```

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b. Run the **kill** command to stop GDS. **128954** in the command is the GDS process ID.
```
kill -9 128954
```

- If GDS is started using the **gds_ctl.py** command, run the following commands to stop GDS:
```
cd /opt/bin/gds
python3 gds_ctl.py stop
```

**----End**

# 8.1.9 Examples

## 8.1.9.1 Example 1: Importing Data in Normal Mode

## Example: Parallel Import from Multiple Data Servers

The data servers reside on the same intranet as the cluster. Their IP addresses are 192.168.0.90 and 192.168.0.91. Source data files are in CSV format.

1. Create the target table **tpcds.reasons**.
```
openGauss=# CREATE TABLE tpcds.reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
);
```
2. (Optional) Create a user and its user group. The user is used to start GDS. If the user and user group already exist, skip this step.
```
groupadd gdsgrp
useradd -g gdsgrp gds_user
```
3. Log in to each GDS data server as user **gds_user** and create the **/input_data** directory for storing data files on the servers. The following uses the data server whose IP address is 192.168.0.90 as an example. Operations on the other server are the same.
```
su - gds_user
mkdir -p /input_data
```
4. Evenly distribute source data files to the **/input_data** directories on the data servers.
5. Change the owners of source data files and the **/input_data** directory on each data server to **gds_user**. The data server with the IP address 192.168.0.90 is used as an example.
```
chown -R gds_user:gdsgrp /input_data
```
6. Log in to each data server as user **gds_user** and start GDS.

   The GDS installation path is **/opt/bin/gds**. Source data files are stored in **/input_data/**. The IP addresses of the data servers are 192.168.0.90 and 192.168.0.91. The GDS listening port is 5000. GDS runs in daemon mode.

   Start GDS on the data server whose IP address is 192.168.0.90.
```
/gds/gds -d /input_data -p 192.168.0.90:5000 -H 10.10.0.1/24 -D
```

   Start GDS on the data server whose IP address is 192.168.0.91.
```
/gds/gds -d /input_data -p 192.168.0.91:5000 -H 10.10.0.1/24  -D
```
7. Create the foreign table **tpcds.foreign_tpcds_reasons** for the source data.

   Set import mode parameters as follows:

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- Set the import mode to **Normal**.
- When GDS is started, the source data file directory is **/input_data** and the GDS listening port is 5000. Therefore, set **location** to **gsfs://192.168.0.90:5000/* | gsfs://192.168.0.91:5000/***.

Information about the data format is set based on data format parameters specified during data export. The parameter settings are as follows:

- **format** is set to **CSV**.
- **encoding** is set to **UTF-8**.
- **delimiter** is set to **E'\x08'**.
- **quote** is set to **0x1b**.
- **null** is set to an empty string without quotation marks.
- **escape** is set to a double quotation mark.
- **header** is set to **false**, indicating that the first row is regarded as a data row when a file is imported.

Set import error tolerance parameters as follows:

- Set **PER NODE REJECT LIMIT** (number of allowed data format errors) to **unlimited**. In this case, all the data format errors detected during data import will be tolerated.
- Set **LOG INTO** to **err_tpcds_reasons**. The data format errors detected during data import will be recorded in the **err_tpcds_reasons** table.

Based on the above settings, the foreign table is created using the following statement:

```
openGauss=# CREATE FOREIGN TABLE tpcds.foreign_tpcds_reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
)
SERVER gsmpp_server OPTIONS (location 'gsfs://192.168.0.90:5000/* | gsfs://192.168.0.91:5000/*',
format 'CSV',mode 'Normal', encoding 'utf8', delimiter E'\x08', quote E'\x1b', null '', fill_missing_fields
'false') LOG INTO err_tpcds_reasons PER NODE REJECT LIMIT 'unlimited';
```

8. Import data through the foreign table **tpcds.foreign_tpcds_reasons** to the target table **tpcds.reasons**.

   ```
   openGauss=# INSERT INTO tpcds.reasons SELECT * FROM tpcds.foreign_tpcds_reasons;
   ```

9. Query data import errors in the **err_tpcds_reasons** table and rectify the errors (if any). For details, see **8.1.7 Handling Import Errors**.

   ```
   openGauss=# SELECT * FROM err_tpcds_reasons;
   ```

10. After data import is complete, log in to each data server as user **gds_user** and stop GDS.

    The data server with the IP address 192.168.0.90 is used as an example. The GDS process ID is 128954.

    ```
    ps -ef|grep gds
    gds_user 128954      1  0 15:03 ?        00:00:00 gds -d /input_data -p 192.168.0.90:5000 -D
    gds_user 129003 118723  0 15:04 pts/0    00:00:00 grep gds
    kill -9 128954
    ```

## Example: Data Import Using Multiple Threads

The data server resides on the same intranet as the cluster. The server IP address is 192.168.0.90. Source data files are in CSV format. Data will be imported to two tables using multiple threads in **Normal** mode.

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1. In the database, create the target tables **tpcds.reasons1** and **tpcds.reasons2**.
```
openGauss=# CREATE TABLE tpcds.reasons1
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
) ;
openGauss=# CREATE TABLE tpcds.reasons2
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
) ;
```
2. (Optional) Create a user and its user group. The user is used to start GDS. If the user and user group already exist, skip this step.
```
groupadd gdsgrp
useradd -g gdsgrp gds_user
```
3. Log in to the GDS data server as user **gds_user**, and then create the data file directory **/input_data** and its sub-directories **/input_data/import1/** and **/input_data/import2/**.
```
su - gds_user
mkdir -p /input_data
```
4. Store the source data files of the target table **tpcds.reasons1** in **/input_data/import1/** and the source data files of the target table **tpcds.reasons2** in **/input_data/import2/**.
5. Change the owners of source data files and the **/input_data** directory on the data server to **gds_user**.
```
chown -R gds_user:gdsgrp /input_data
```
6. Log in to the data server as user **gds_user** and start GDS.

   The GDS installation path is **/gds**. Source data files are stored in **/input_data/**. The IP address of the data server is 192.168.0.90. The GDS listening port is 5000. GDS runs in daemon mode. The degree of parallelism is 2. A recursive directory is specified.
```
/gds/gds -d /input_data -p 192.168.0.90:5000 -H 10.10.0.1/24  -D -t 2 -r
```
7. In the database, create the foreign tables **tpcds.foreign_tpcds_reasons1** and **tpcds.foreign_tpcds_reasons2** for the source data.

   The foreign table **tpcds.foreign_tpcds_reasons1** is used as an example to describe how to set parameters in a foreign table.

   Set import mode parameters as follows:

   - Set the import mode to **Normal**.
   - When GDS is started, the source data file directory is **/input_data** and the GDS listening port is 5000. However, source data files are actually stored in **/input_data/import1/**. Therefore, set **location** to **gsfs://192.168.0.90:5000/import1/***.

   Information about the data format is set based on data format parameters specified during data export. The parameter settings are as follows:

   - **format** is set to **CSV**.
   - **encoding** is set to **UTF-8**.
   - **delimiter** is set to **E'\x08'**.
   - **quote** is set to **0x1b**.
   - **null** is set to an empty string without quotation marks.

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- **escape** is set to a double quotation mark.
- **header** is set to **false**, indicating that the first row is regarded as a data row when a file is imported.

Set import error tolerance parameters as follows:

- Set **PER NODE REJECT LIMIT** (number of allowed data format errors) to **unlimited**. In this case, all the data format errors detected during data import will be tolerated.
- Set **LOG INTO** to **err_tpcds_reasons1**. The data format errors detected during data import will be recorded in the **err_tpcds_reasons1** table.
- If the last column (**fill_missing_fields**) in a source data file is missing, the **NULL** column will be automatically added to the target file.

Based on the above settings, the foreign table **tpcds.foreign_tpcds_reasons1** is created using the following statement:

```
openGauss=# CREATE FOREIGN TABLE tpcds.foreign_tpcds_reasons1
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
) SERVER gsmpp_server OPTIONS (location 'gsfs://192.168.0.90:5000/import1/*', format 'CSV',mode
'Normal', encoding 'utf8', delimiter E'\x20', quote E'\x1b', null '',fill_missing_fields 'on')LOG INTO
err_tpcds_reasons1 PER NODE REJECT LIMIT 'unlimited';
```

Based on the above settings, the foreign table **tpcds.foreign_tpcds_reasons2** is created using the following statement:

```
openGauss=# CREATE FOREIGN TABLE tpcds.foreign_tpcds_reasons2
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
) SERVER gsmpp_server OPTIONS (location 'gsfs://192.168.0.90:5000/import2/*', format 'CSV',mode
'Normal', encoding 'utf8', delimiter E'\x20', quote E'\x1b', null '',fill_missing_fields 'on')LOG INTO
err_tpcds_reasons2 PER NODE REJECT LIMIT 'unlimited';
```

8. Import data through the foreign tables **tpcds. foreign_tpcds_reasons1** and **tpcds. foreign_tpcds_reasons2** to **tpcds.reasons1** and **tpcds.reasons2**, respectively.

   ```
   openGauss=# INSERT INTO tpcds.reasons1 SELECT * FROM tpcds.foreign_tpcds_reasons1;
   openGauss=# INSERT INTO tpcds.reasons2 SELECT * FROM tpcds.foreign_tpcds_reasons2;
   ```

9. Query data import errors in the **err_tpcds_reasons1** and **err_tpcds_reasons2** tables and rectify the errors (if any). For details, see **8.1.7 Handling Import Errors**.

   ```
   openGauss=# SELECT * FROM err_tpcds_reasons1;
   openGauss=# SELECT * FROM err_tpcds_reasons2;
   ```

10. After data import is complete, log in to the data server as user **gds_user** and stop GDS.

    The GDS process ID is 128954.

    ```
    ps -ef|grep gds
    gds_user 128954      1  0 15:03 ?        00:00:00 gds -d /input_data -p 192.168.0.90:5000 -D -t 2 -r
    gds_user 129003 118723  0 15:04 pts/0    00:00:00 grep gds
    kill -9 128954
    ```

## 8.1.9.2 Example 2: Importing Data in Shared Mode

1. Prepare for data import.

   This section assumes that a source data file **foreign_tpcds_reasons.dat.0** in text format is stored in the **/input_data** directory on the 192.168.0.90 server.

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a. Configure the NFS service on the data server. For details, see **SUSE DOC: Administration Guide – Configuring NFS Server**.

> **CAUTION**
>
> The security of the NFS service and data transmission is ensured by users. You are advised to use the NFS service in a trusted domain.

b. Start the NFS service on the data server.
```
service nfs start
```

c. Log in as a common user to each server where GaussDB DNs reside, create the **/input_data** directory on each server, and mount each data server storing source data files to this directory.
```
cd /input_data
mount -t nfs 192.168.0.90:/input_data /input_data
```

2. Log in as the OS user **omm** to the host where the CN is located.
3. Run the following command to connect to the database:
```
gsql -d postgres -p 8000
```
**postgres** is the name of the database, and **8000** is the port number of the CN.

If information similar to the following is displayed, the connection succeeds:
```
gsql((GaussDB Kernel VxxxRxxxCxx build f521c606) compiled at 2021-09-16 14:55:22 commit 2935 last mr 6385 release)
Non-SSL connection (SSL connection is recommended when requiring high-security)
Type "help" for help.


openGauss=#
```
4. Create the target table **reasons**.
```
openGauss=# CREATE TABLE reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
);
```
5. Create the foreign table **foreign_tpcds_reasons** for the source data.
```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
) SERVER gsmpp_server OPTIONS (location 'file:///input_data/foreign_tpcds_reasons.dat.0', format 'TEXT', mode 'shared', delimiter E'\x20',  NULL '');
```
6. Import data to the **reasons** table.
```
openGauss=# INSERT INTO reasons SELECT * FROM foreign_tpcds_reasons;
```

### 8.1.9.3 Example 3: Importing Data in Private Mode

A cluster has four hosts and eight primary DNs and every two primary DNs reside on the same host. There are eight data files to import and the size of each file is 50 MB. The files are in CSV format.

1. Log in as the OS user **omm** to the host where the CN is located.
2. Run the following command to connect to the database:
```
gsql -d postgres -p 8000
```
**postgres** is the name of the database, and **8000** is the port number of the CN.

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If information similar to the following is displayed, the connection succeeds:

```
gsql((GaussDB Kernel VxxxRxxxCxx build f521c606) compiled at 2021-09-16 14:55:22 commit 2935
last mr 6385 release)
Non-SSL connection (SSL connection is recommended when requiring high-security)
Type "help" for help.

openGauss=#
```

3. Query DN names on each node.

```
openGauss=# SELECT node_name,node_host FROM pgxc_node WHERE node_type='D';
```

Example:

```
openGauss=# SELECT node_name,node_host FROM pgxc_node WHERE node_type='D';
  node_name   |   node_host
--------------+----------------
 dn_6001_6002 | 192.168.0.11
 dn_6003_6004 | 192.168.0.11
 dn_6005_6006 | 192.168.0.12
 dn_6007_6008 | 192.168.0.12
 dn_6009_6010 | 192.168.0.13
 dn_6011_6012 | 192.168.0.13
 dn_6013_6014 | 192.168.0.14
 dn_6015_6016 | 192.168.0.14
(8 rows)
```

4. Upload the source data files to the nodes where DNs are located.

   a. Log in to each cluster node as a common user. Create the **/input_data** directory to store data files and create sub-directories named after DNs on each node.

      The following uses the node with the IP address 192.168.0.11 which is queried in **3** as an example. Two DNs, dn_6001_6002 and dn_6003_6004, are on the node.

      ```
      mkdir -p /input_data
      mkdir -p /input_data/dn_6001_6002
      mkdir -p /input_data/dn_6003_6004
      ```

   b. Evenly distribute source data files to the sub-directories created on each node.

   c. Change the owner of data source files to be imported and the **/input_data** directory on each cluster node to **omm**.

      ```
      chown -R omm:dbgrp /input_data
      ```

5. Create the target table **reasons**.

```
openGauss=# CREATE TABLE reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
);
```

6. Create the foreign table **foreign_tpcds_reasons** for the source data.

   Set import mode parameters as follows:

   - Set the import mode to **Private**.
   - The source data files are stored in sub-directories named after DNs on the nodes, and can be locally accessed. Therefore, set **location** to **file:///input_data/***.

   Information about the data format is set based on data format parameters specified during data export. The parameter settings are as follows:

   - **format** is set to **CSV**.
   - **delimiter** is set to a comma (,).

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  - **quote** is set to **0x1b**.
  - **null** is set to an empty string without quotation marks.

  Set import error tolerance parameters as follows:

  - Set **PER NODE REJECT LIMIT** (number of allowed data format errors) to **unlimited**. In this case, all the data format errors detected during data import will be tolerated.
  - Set **LOG INTO** to **err_tpcds_reasons**. The data format errors detected during data import will be recorded in the **err_tpcds_reasons** table.

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
(
  r_reason_sk integer not null,
  r_reason_id char(16) not null,
  r_reason_desc char(100)
)
 SERVER gsmpp_server OPTIONS (location 'file:///input_data/*', format 'CSV', mode 'private', delimiter
',', quote E'\x1b', null '')LOG INTO err_tpcds_reasonS PER NODE REJECT LIMIT 'unlimited';
```

7. Import data to the **reasons** table.

```
openGauss=# INSERT INTO reasons SELECT * FROM foreign_tpcds_reasons;
```

8. Query data import errors in the **err_tpcds_reasons** table and rectify the errors (if any). For details, see **8.1.7 Handling Import Errors**.

```
openGauss=# SELECT * FROM err_tpcds_reasons;
```

# 8.2 Running the INSERT Statement to Insert Data

Run the **INSERT** statement to write data into GaussDB in either of the following ways:

- Use the client tool provided by GaussDB to write data into it.

  For details, see **2.6.2 Inserting Data to a Table**.
- Connect to the database using the JDBC or ODBC driver and run the **INSERT** statement to write data into GaussDB.

  For details, see **6.3.4 Connecting to a Database**.

You can add, modify, and delete database transactions for GaussDB. **INSERT** is the simplest way to write data and applies to scenarios with small data volume and low concurrency.

# 8.3 Running the COPY FROM STDIN Statement to Import Data

## 8.3.1 Data Import Using COPY FROM STDIN

This method is applicable to low-concurrency scenarios where a small volume of data is to import.

Run the **COPY FROM STDIN** statement to import data to GaussDB in either of the following ways:

- Write data into GaussDB by typing. For details, see **12.14.50 COPY**.
- Import data from a file or database to GaussDB through the CopyManager interface driven by JDBC. You can use any parameters in the **COPY** syntax.

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# 8.3.2 Introduction to the CopyManager Class

CopyManager is an API class provided by the JDBC driver in GaussDB. It is used to import data to GaussDB clusters in batches.

## Inheritance Relationship of CopyManager

The CopyManager class is in the **org.postgresql.copy** package and inherits the java.lang.Object class. The declaration of the class is as follows:

```
public class CopyManager
extends Object
```

## Constructor Method

public CopyManager(BaseConnection connection)

throws SQLException

## Common Methods

**Table 8-7** Common methods of CopyManager

| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| CopyIn | copyIn(String sql) | - | SQLException |
| long | copyIn(String sql, InputStream from) | Uses **COPY FROM STDIN** to quickly import data to tables in a database from InputStream. | SQLException,IOException |
| long | copyIn(String sql, InputStream from, int bufferSize) | Uses **COPY FROM STDIN** to quickly import data to tables in a database from InputStream. | SQLException,IOException |
| long | copyIn(String sql, Reader from) | Uses **COPY FROM STDIN** to quickly import data to tables in a database from Reader. | SQLException,IOException |
| long | copyIn(String sql, Reader from, int bufferSize) | Uses **COPY FROM STDIN** to quickly import data to tables in a database from Reader. | SQLException,IOException |

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| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| CopyOut | copyOut(String sql) | - | SQLException |
| long | copyOut(String sql, OutputStream to) | Sends the result set of **COPY TO STDOUT** from the database to the OutputStream class. | SQLException,IOException |
| long | copyOut(String sql, Writer to) | Sends the result set of **COPY TO STDOUT** from the database to the Writer class. | SQLException,IOException |

## 8.3.3 Example 1: Importing and Exporting Data Through Local Files

When the JAVA language is used for secondary development based on GaussDB, you can use the CopyManager interface to export data from the database to a local file or import a local file to the database by streaming. The file can be in CSV or TEXT format.

The sample program is as follows. Load the GaussDB JDBC driver before executing it.

```
import java.sql.Connection;
import java.sql.DriverManager;
import java.io.IOException;
import java.io.FileInputStream;
import java.io.FileOutputStream;
import java.sql.SQLException;
import org.postgresql.copy.CopyManager;
import org.postgresql.core.BaseConnection;

public class Copy{

    public static void main(String[] args)
    {
     String urls = new String("jdbc:postgresql://localhost:8000/postgres"); //URL of the database
     String username = new String("username");            //Username
     String password = new String("passwd");             //Password
     String tablename = new String("migration_table"); // Table information
     String tablename1 = new String("migration_table_1"); // Table information
     String driver = "org.postgresql.Driver";
     Connection conn = null;

     try {
         Class.forName(driver);
         conn = DriverManager.getConnection(urls, username, password);
     } catch (ClassNotFoundException e) {
          e.printStackTrace(System.out);
     } catch (SQLException e) {
          e.printStackTrace(System.out);
     }
```

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```
    // Export data from the migration_table table to the d:/data.txt file.
    try {
        copyToFile(conn, "d:/data.txt", "(SELECT * FROM migration_table)");
    } catch (SQLException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    } catch (IOException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    }
    // Import data from the d:/data.txt file to the migration_table_1 table.
    try {
        copyFromFile(conn, "d:/data.txt", tablename1);
    } catch (SQLException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    } catch (IOException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    }

    // Export data from the migration_table_1 table to the d:/data1.txt file.
    try {
        copyToFile(conn, "d:/data1.txt", tablename1);
    } catch (SQLException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    } catch (IOException e) {
        // TODO Auto-generated catch block
        e.printStackTrace();
    }
}

public static void copyFromFile(Connection connection, String filePath, String tableName)
        throws SQLException, IOException {

    FileInputStream fileInputStream = null;

    try {
        CopyManager copyManager = new CopyManager((BaseConnection)connection);
        fileInputStream = new FileInputStream(filePath);
        copyManager.copyIn("COPY " + tableName + " FROM STDIN ", fileInputStream);
    } finally {
        if (fileInputStream != null) {
            try {
                fileInputStream.close();
            } catch (IOException e) {
                e.printStackTrace();
            }
        }
    }
}
    public static void copyToFile(Connection connection, String filePath, String tableOrQuery)
            throws SQLException, IOException {

     FileOutputStream fileOutputStream = null;

     try {
        CopyManager copyManager = new CopyManager((BaseConnection)connection);
        fileOutputStream = new FileOutputStream(filePath);
        copyManager.copyOut("COPY " + tableOrQuery + " TO STDOUT", fileOutputStream);
    } finally {
        if (fileOutputStream != null) {
            try {
                fileOutputStream.close();
            } catch (IOException e) {
                e.printStackTrace();
            }
```

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```
        }
    }
  }
}
```

## 8.3.4 Example 2: Migrating Data from a MySQL Database

The following example shows how to use CopyManager to migrate data from MySQL.

```
import java.io.StringReader;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;

import org.postgresql.copy.CopyManager;
import org.postgresql.core.BaseConnection;

public class Migration{

    public static void main(String[] args) {
        String url = new String("jdbc:postgresql://localhost:8000/postgres"); //URL of the database
        String user = new String("username");            // GaussDB user name
        String pass = new String("passwd");              // GaussDB password
        String tablename = new String("migration_table_1"); // Table information
        String delimiter = new String("|");              // Delimiter
        String encoding = new String("UTF8");            // Character set
        String driver = "org.postgresql.Driver";
        StringBuffer buffer = new StringBuffer();       // Buffer to store formatted data

        try {
            // Obtain the query result set of the source database.
            ResultSet rs = getDataSet();

            // Traverse the result set and obtain records row by row.
            // The values of columns in each record are separated by the specified delimiter and end with a
linefeed, forming strings.
            // Add the strings to the buffer.
            while (rs.next()) {
                buffer.append(rs.getString(1) + delimiter
                        + rs.getString(2) + delimiter
                        + rs.getString(3) + delimiter
                        + rs.getString(4)
                        + "\n");
            }
            rs.close();

            try {
                // Connect to the target database.
                Class.forName(driver);
                Connection conn = DriverManager.getConnection(url, user, pass);
                BaseConnection baseConn = (BaseConnection) conn;
                baseConn.setAutoCommit(false);

                // Initialize the table.
                String sql = "Copy " + tablename + " from STDIN with (DELIMITER " + "'" + delimiter + "'" +","+ "
ENCODING " + "'" + encoding + "')";

                // Commit data in the buffer.
                CopyManager cp = new CopyManager(baseConn);
                StringReader reader = new StringReader(buffer.toString());
                cp.copyIn(sql, reader);
                baseConn.commit();
                reader.close();
                baseConn.close();
            } catch (ClassNotFoundException e) {
                e.printStackTrace(System.out);
```

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```
            } catch (SQLException e) {
                e.printStackTrace(System.out);
            }

        } catch (Exception e) {
            e.printStackTrace();
        }
    }

    //**********************************
    // Return the query result set from the source database.
    //**********************************
    private static ResultSet getDataSet() {
        ResultSet rs = null;
        try {
            Class.forName("com.mysql.jdbc.Driver").newInstance();
            Connection conn = DriverManager.getConnection("jdbc:mysql://10.119.179.227:3306/jack?
useSSL=false&allowPublicKeyRetrieval=true", "jack", "xxxxxxxxx");
            Statement stmt = conn.createStatement();
            rs = stmt.executeQuery("select * from migration_table");
        } catch (SQLException e) {
            e.printStackTrace();
        } catch (Exception e) {
            e.printStackTrace();
        }
        return rs;
    }
}
```

# 8.4 Using a gsql Meta-Command to Import Data

The **gsql** tool provides the **\copy** to import data.

## \copy Command

For the format and description of the **\copy** command, see **Table 8-8**.

**Table 8-8** \copy meta-command

| Syntax | Description |
| --- | --- |
| \copy { table [ ( column_list ) ] \| ( query ) } { from \| to } { filename \| stdin \| stdout \| pstdin \| pstdout } [ with ] [ binary ] [ oids ] [ delimiter [ as ] 'character' ] [ useeof ] [ null [ as ] 'string' ] [ csv [ header ] [ quote [ as ] 'character' ] [ escape [ as ] 'character' ] [ force quote column_list \| * ] [ force not null column_list ] ] | You can run this command to import or export data after logging in to a database on any gsql client. Different from the **COPY** statement in SQL, this command performs read/write operations on local files rather than files on database servers. The accessibility and permissions of the local files are restricted to local users.<br>**NOTE**<br>**\copy** applies only to small-scale data import in good format. It does not preprocess invalid characters or provides error tolerance. Therefore, **\copy** cannot be used in scenarios where abnormal data exists. **GDS** or **COPY** is preferred for data import. |

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## Parameter Description

- table

  Specifies the name (possibly schema-qualified) of an existing table.

  Value range: an existing table name

- column_list

  Indicates an optional list of columns to be copied.

  Value range: any field in the table. If no column list is specified, all columns of the table will be copied.

- query

  Specifies that the results will be copied.

  Value range: a **SELECT** or **VALUES** command in parentheses.

- filename

  Specifies the absolute path of a file. To run the **\copy to** command, you must have the write permission on the path. To run the **\copy from** command, you must have the read permission on the path.

- stdin

  Specifies that input comes from the client application.

- stdout

  Specifies that output goes to the client application.

- pstdin

  Specifies that input comes from the gsql client.

- pstout
- Specifies that output goes to the gsql client.
- binary

  Specifies that data is stored and read in binary mode instead of text mode. In binary mode, you cannot declare **DELIMITER**, **NULL**, or **CSV**. After **binary** is specified, CSV, FIXED, and TEXT cannot be specified through **option** or **copy_option**.

- oid

  Specifies the internal OID to be copied for each row.

  > NOTE
  >
  > An error is raised if OIDs are specified for a table that does not have OIDs, or in the case of copying a query.

  Value range: **true/on** and **false/off**

  Default value: false

- delimiter [ as ] 'character'

  Specifies the character that separates columns within each row (line) of the file.

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NOTE

- The value of **delimiter** cannot be **\r** or **\n**.
- A delimiter cannot be the same as the **null** value. The delimiter for the CSV format cannot be same as the **quote** value.
- The delimiter for the TEXT format data cannot contain backslashes (\), dots (.), lowercase letters, or digits, for example, **\.abcdefghijklmnopqrstuvwxyz0123456789**.
- The data length of a single row should be less than 1 GB. A row that has many columns using long delimiters cannot contain much valid data.
- You are advised to use multi-character delimiters or invisible delimiters. For example, you can use multi-characters (such as $^&) and invisible characters (such as 0x07, 0x08, and 0x1b).

Value range: a multi-character delimiter within 10 bytes

Default value:

- A tab character in text format
- A comma (,) in CSV format
- No delimiter in FIXED format

- null [ as ] 'string'

  Specifies that a string represents a null value in a data file.

  Value range:

  - A null value cannot be **\r** or **\n**. The maximum length is 100 characters.
  - A null value cannot be the same as the **delimiter** or **quote** value.

  Default value:

  - an empty string without quotation marks in CSV format
  - **\N** in text format

- useeof

  Does not report an error for **\.** in the imported data.

  Value range: **true** or **false**

  Default value: false

- header

  Specifies whether a file contains a header with the names of each column in the file. **header** is available only for CSV and FIXED files.

  When data is imported, if **header** is **on**, the first row of the data file will be identified as the header and ignored. If **header** is **off**, the first row will be identified as a data row.

  When data is exported, if header is **on**, **fileheader** must be specified. **fileheader** specifies the content in the header. If **header** is **off**, an exported file does not contain a header.

  Value range: **true/on** and **false/off**

  Default value: false

- quote [ as ] 'character'

  Specifies a quote character for a CSV file.

  Default value: ""

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NOTE

- The **quote** value cannot be the same as the **delimiter** or **null** value.
- The **quote** value must be a single-byte character.
- Invisible characters are recommended, such as 0x07, 0x08, and 0x1b.

- escape [ as ] 'character'

  Specifies an escape character for a CSV file. The value must be a single-byte character.

  Default value: "" If the value is the same as the **quote** value, it will be replaced with **\0**.

- force quote column_list | *

  In CSV COPY TO mode, forces quoting to be used for all not-null values in each specified column. **NULL** values are not quoted.

  Value range: an existing column

- force not null column_list

  Assigns a value to a specified column in CSV COPY FROM mode.

  Value range: an existing column

## Examples

1. Create a target table **a**.

```
openGauss=# CREATE TABLE a(a int);
```

2. Import data.

   a. Copy data from **stdin** to table **a**.

```
openGauss=# \copy a from stdin;
```

   When the **>>** characters are displayed, enter data. To end your input, enter a backslash and a period (\.).

```
Enter data to be copied followed by a newline.
End with a backslash and a period on a line by itself.
>> 1
>> 2
>> \.
```

   Query data imported to table **a**.

```
openGauss=# SELECT * FROM a;
 a
---
 1
 2
(2 rows)
```

   b. Copy data from a local file to table **a**. For example, the local file /home/omm/2.csv exists.

      - Commas (,) are used as delimiters.
      - If the number of columns defined in a source data file is greater than that in a foreign table, extra columns will be ignored during import.

```
openGauss=# \copy a FROM '/home/omm/2.csv' WITH (delimiter',',IGNORE_EXTRA_DATA 'on');
```

# 8.5 Updating Data in a Table

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# 8.5.1 Updating a Table by Using DML Statements

In GaussDB, you can update a table by running DML statements.

## Procedure

There is a table named **customer_t** and the table structure is as follows:

```
openGauss=# CREATE TABLE customer_t
( c_customer_sk             integer,
  c_customer_id             char(5),
  c_first_name              char(6),
  c_last_name               char(8)
) ;
```

You can run the following DML statements to update data in the table.

- Run the **INSERT** statement to insert data into the table.
  - Insert a row to the **customer_t** table.
    ```
    openGauss=# INSERT INTO customer_t (c_customer_sk, c_customer_id,
    c_first_name,c_last_name) VALUES (3769, 5, 'Grace','White');
    ```
  - Insert multiple rows to the **customer_t** table.
    ```
    openGauss=# INSERT INTO customer_t (c_customer_sk, c_customer_id,
    c_first_name,c_last_name) VALUES
    (6885, 1, 'Joes', 'Hunter'),
    (4321, 2, 'Lily','Carter'),
    (9527, 3, 'James', 'Cook'),
    (9500, 4, 'Lucy', 'Baker');
    ```

    For details on how to use **INSERT**, see **2.6.2 Inserting Data to a Table**.
- Run the **UPDATE** statement to update data in the table. Change the value of the **c_customer_id** column to **0**.
  ```
  openGauss=# UPDATE customer_t SET c_customer_id = 0;
  ```

  For details on how to use **UPDATE**, see **12.14.170 UPDATE**.
- Run the **DELETE** statement to delete rows from the table.

  You can use the **WHERE** clause to specify the rows whose data is to delete. If you do not specify it, all rows in the table are deleted and only the data structure is retained.
  ```
  openGauss=# DELETE FROM customer_t WHERE c_last_name = 'Baker';
  ```

  For details on how to use **DELETE**, see **12.14.95 DELETE**.
- Run the **TRUNCATE** statement to delete all rows from the table.
  ```
  openGauss=# TRUNCATE TABLE customer_t;
  ```

  For details on how to use **TRUNCATE**, see **12.14.169 TRUNCATE**.

  The **DELETE** statement deletes a row of data each time whereas the **TRUNCATE** statement deletes data by releasing the data page stored in the table. Therefore, data can be deleted more quickly by using **TRUNCATE** than using **DELETE**.

  **DELETE** deletes table data but does not release table storage space. **TRUNCATE** deletes table data and releases table storage space.

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# 8.5.2 Updating and Inserting Data by Using the MERGE INTO Statement

To add all or a large amount of data in a table to an existing table, you can run the **MERGE INTO** statement in GaussDB to merge the two tables so that data can be quickly added to the existing table.

The **MERGE INTO** statement matches data in a source table with that in a target table based on a join condition. If data matches, **UPDATE** will be executed on the target table. Otherwise, **INSERT** will be executed. This statement is a convenient way to combine multiple operations and avoids multiple **INSERT** or **UPDATE** statements.

## Prerequisites

You have the **INSERT** and **UPDATE** permissions for the target table and the **SELECT** permission for the source table.

## Procedure

**Step 1** Create a source table named **products** and insert data.

```
openGauss=# CREATE TABLE products
( product_id INTEGER,
  product_name VARCHAR2(60),
  category VARCHAR2(60)
);

openGauss=# INSERT INTO products VALUES
(1502, 'olympus camera', 'electrncs'),
(1601, 'lamaze', 'toys'),
(1666, 'harry potter', 'toys'),
(1700, 'wait interface', 'books');
```

**Step 2** Create a target table named **newproducts** and insert data.

```
openGauss=# CREATE TABLE newproducts
( product_id INTEGER,
  product_name VARCHAR2(60),
  category VARCHAR2(60)
);

openGauss=# INSERT INTO newproducts VALUES
(1501, 'vivitar 35mm', 'electrncs'),
(1502, 'olympus ', 'electrncs'),
(1600, 'play gym', 'toys'),
(1601, 'lamaze', 'toys'),
(1666, 'harry potter', 'dvd');
```

**Step 3** Run the **MERGE INTO** statement to merge data in the source table **products** into the target table **newproducts**.

```
openGauss=# MERGE INTO newproducts np
USING products p
ON (np.product_id = p.product_id )
WHEN MATCHED THEN
  UPDATE SET np.product_name = p.product_name, np.category = p.category
WHEN NOT MATCHED THEN
  INSERT VALUES (p.product_id, p.product_name, p.category) ;
```

For details on parameters in the statement, see **Table 8-9**. For more information, see **12.14.144 MERGE INTO**.

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**Table 8-9** Parameters in the MERGE INTO statement

| Parameter | Description | Example Value |
| --- | --- | --- |
| **INTO** clause | Specifies a target table that is to be updated or has data to be inserted.<br>• A table alias is supported.<br>• The target table can be copied, but the copied table cannot contain columns (such as auto-increment columns) that contain volatile functions. If **enable_stream_operator** is set to **off**, the target replication table must contain a primary key or a column must meet the **unique not null** constraint. | Value: newproducts np<br>The table name is **newproducts** and the alias is **np**. |
| **USING** clause | Specifies a source table. A table alias is supported.<br>If the target table is a replication table, the source table must also be a replication table. | Value: products p<br>The table name is **products** and the alias is **p**. |
| **ON** clause | Specifies a join condition between a target table and a source table.<br>Columns in the join condition cannot be updated. | Value: np.product_id = p.product_id<br>The join condition is that the **product_id** column in the target table **newproducts** has equivalent values as the **product_id** column in the source table **products**. |

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| Parameter | Description | Example Value |
| --- | --- | --- |
| **WHEN MATCHED** clause | Performs **UPDATE** if data in the source table matches that in the target table based on the condition.<br>• Only one **WHEN MATCHED** clause can be specified.<br>• The **WHEN MATCHED** clause can be omitted. If it is omitted, no operation will be performed on the rows that meet the condition in the **ON** clause.<br>• Columns involved in the distribution key of the target table cannot be updated. | Value: WHEN MATCHED THEN UPDATE SET np.product_name = p.product_name, np.category = p.category<br>When the condition in the **ON** clause is met, the values of the **product_name** and **category** columns in the target table **newproducts** are replaced with the values in the corresponding columns in the source table **products**. |
| **WHEN NOT MATCHED** clause | Performs **INSERT** if data in the source table does not match that in the target table based on the condition.<br>• Only one **WHEN NOT MATCHED** clause can be specified.<br>• The **WHEN NOT MATCHED** clause can be omitted.<br>• An **INSERT** clause can contain only one **VALUES**.<br>• The **WHEN MATCHED** and **WHEN NOT MATCHED** clauses can be exchanged in sequence. One of them can be omitted, but they cannot be omitted at the same time. | Value: WHEN NOT MATCHED THEN<br>INSERT VALUES (p.product_id, p.product_name, p.category)<br>Insert rows in the source table **products** that do not meet the condition in the **ON** clause into the target table **products**. |

**Step 4** Query the target table **newproducts** after the merge.

```
openGauss=# SELECT * FROM newproducts;
```

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The command output is as follows:

```
 product_id |  product_name  | category
------------+----------------+-----------
       1501 | vivitar 35mm   | electrncs
       1502 | olympus camera | electrncs
       1666 | harry potter   | toys
       1600 | play gym       | toys
       1601 | lamaze         | toys
       1700 | wait interface | books
(6 rows)
```

**----End**

# 8.6 Deep Copy

After data is imported, you can perform a deep copy to modify a distribution key or partition key, change a row-store table to a column-store table, or add a partial cluster key. A deep copy re-creates a table and batch inserts data into the table.

GaussDB provides three deep copy methods.

## 8.6.1 Performing a Deep Copy by Using the CREATE TABLE Statement

Run the **CREATE TABLE** statement to create a copy of the original table, batch insert data of the original table into the copy, and rename the copy to the name of the original table.

When creating the copy, you can specify table and column attributes, including the primary key and foreign key.

### Procedure

Perform the following operations to carry out a deep copy for the **customer_t** table:

**Step 1** Run the **CREATE TABLE** statement to create the copy **customer_t_copy** of the **customer_t** table.

```
openGauss=# CREATE TABLE customer_t_copy
( c_customer_sk             integer,
  c_customer_id             char(5),
  c_first_name              char(6),
  c_last_name               char(8)
) ;
```

**Step 2** Run the **INSERT INTO...SELECT** statement to batch insert data of the original table into the copy.

```
openGauss=# INSERT INTO customer_t_copy (SELECT * FROM customer_t);
```

**Step 3** Delete the original table.

```
openGauss=# DROP TABLE customer_t;
```

**Step 4** Run the **ALTER TABLE** statement to rename the copy to the name of the original table.

```
openGauss=# ALTER TABLE customer_t_copy RENAME TO customer_t;
```

**----End**

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## 8.6.2 Performing a Deep Copy by Using the CREATE TABLE LIKE Statement

Run the **CREATE TABLE LIKE** statement to create a copy of the original table, batch insert data of the original table into the copy, and rename the copy to the name of the original table. This method does not inherit the primary key and foreign key of the original table. You can use the **ALTER TABLE** statement to add them.

### Procedure

**Step 1** Run the **CREATE TABLE LIKE** statement to create the copy **customer_t_copy** of the **customer_t** table.

```
openGauss=# CREATE TABLE customer_t_copy (LIKE customer_t);
```

**Step 2** Run the **INSERT INTO...SELECT** statement to batch insert data of the original table into the copy.

```
openGauss=# INSERT INTO customer_t_copy (SELECT * FROM customer_t);
```

**Step 3** Delete the original table.

```
openGauss=# DROP TABLE customer_t;
```

**Step 4** Run the **ALTER TABLE** statement to rename the copy to the name of the original table.

```
openGauss=# ALTER TABLE customer_t_copy RENAME TO customer_t;
```

**----End**

## 8.6.3 Performing a Deep Copy by Creating a Temporary Table and Truncating the Original Table

Run the **CREATE TABLE .... AS** statement to create a temporary table for the original table, truncate the original table, and batch insert data of the temporary data into the original table.

When creating the temporary table, retain the primary key and foreign key of the original table. This method is recommended if the original table has dependency items.

### Procedure

**Step 1** Run the **CREATE TABLE AS** statement to create a temporary table **customer_t_temp** for the **customer_t** table.

```
openGauss=# CREATE TEMP TABLE customer_t_temp AS SELECT * FROM customer_t;
```

NOTE

- Compared with the use of permanent tables, the use of temporary tables can improve performance but may incur data loss. A temporary table is automatically deleted at the end of the session where it is located. If data loss is unacceptable, use a permanent table.
- Temporary tables and common tables are stored in the same location. You can also specify a tablespace to store temporary tables. If too many local temporary tables are used, the system catalog may bloat, but the overall impact is acceptable.

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**Step 2** Truncate the original table **customer_t**.

```
openGauss=# TRUNCATE customer_t;
```

**Step 3** Run the **INSERT INTO...SELECT** statement to batch insert data of the temporary table into the original table.

```
openGauss=# INSERT INTO customer_t (SELECT * FROM customer_t_temp);
```

**Step 4** Delete the temporary table **customer_t_temp**.

```
openGauss=# DROP TABLE customer_t_temp;
```

**----End**

# 8.7 Checking for Data Skew

## Scenarios

Data skew causes query performance to deteriorate. Before importing all data from a table containing over 10 million records, you are advised to import some of the data and check whether there is data skew and whether the distribution keys need to be changed. Troubleshoot the data skew if any. It is costly to address data skew and change the distribution keys after a large volume of data has been imported.

## Background

GaussDB uses a massively parallel processing (MPP) system of the shared-nothing architecture. MPP performs horizontal partitioning to store tuples in the service data table on all DNs using proper distribution policies.

The current product supports multiple user table distribution policies, such as replication, hash, range, and list.

- Replication: Full table data is stored on each DN. You are advised to use the replication distribution policy for tables with a small volume of data.
- Hash: A distribution key must be specified for a user table. When a record is inserted, the system hashes it based on the distribution key and then stores it on the corresponding DN. You are advised to use the hash distribution policy for tables with a large volume of data.
- Range and List: These modes are used in the scenario where users specify the data distribution rule. The target node of the tuple is determined based on the specified column value and the preset range or specific value.

If an inappropriate distribution key is used, there may be data skew when you use the hash policy. Therefore, after this policy is used, data skew check will be performed on user tables to ensure that data is evenly distributed on each DN. You are advised to use the column with few replicated values as the distribution key.

## Procedure

**Step 1** Analyze source data and select candidate distribution keys.

**Step 2** Select a column from the candidates in **Step 1** as the distribution key to create a target table.

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```
CREATE [ [ GLOBAL | LOCAL ] [ TEMPORARY | TEMP ] | UNLOGGED ] TABLE [ IF NOT EXISTS ] table_name
   ({ column_name data_type [ compress_mode ] [ COLLATE collation ] [ column_constraint [ ... ] ]
   | table_constraint    | LIKE source_table [ like_option [...] ] }
   [, ... ])    [ WITH ( {storage_parameter = value} [, ... ] ) ]
   [ ON COMMIT { PRESERVE ROWS | DELETE ROWS } ]
   [ COMPRESS | NOCOMPRESS ]    [ TABLESPACE tablespace_name ]
   [ DISTRIBUTE BY { REPLICATION
                   | { HASH ( column_name [,...] )
                   | { RANGE ( column_name [, ...] ) SLICE REFERENCES tablename
                      | ( slice_less_than_item [, ...]
                      | slice_start_end_item [, ...] )
                   | { LIST ( column_name [, ...] ) SLICE REFERENCES tablename
                      | ( slice_values_item [, ...] )  }}} } ]
```

**Step 3** Import a small batch of data to the target table.

When importing a single data file, you can evenly split this file and import a part of it to check for the data skew in the target table.

**Step 4** Check for data skew. (Replace *table_name* with the actual table name.)

```
openGauss=# SELECT a.count,b.node_name FROM (SELECT count(*) AS count,xc_node_id FROM
table_name GROUP BY xc_node_id) a, pgxc_node b WHERE a.xc_node_id=b.node_id ORDER BY a.count
desc;
```

**Step 5** If data distribution deviation is less than 10% across DNs, data has been evenly distributed and an appropriate distribution key has been selected. Delete the small batch of imported data and import full data to complete data migration.

If data distribution deviation across DNs is greater than or equal to 10%, data skew occurs. Remove this distribution key from the candidates in step 1, delete the target table, and repeat steps 2 to 5.

**Step 6** (Optional) If you fail to select an appropriate distribution key after performing the above steps, select multiple columns from the candidates as distribution keys.

**----End**

## Examples

To select an appropriate distribution key for the **staffs** table, perform the following operations:

1. Analyze source data for the **staffs** table and select the **staff_ID**, **FIRST_NAME**, and **LAST_NAME** columns as candidate distribution keys.
2. Select the **staff_ID** column as the distribution key and create the target table **staffs**.

```
openGauss=# CREATE TABLE staffs
(
  staff_ID       NUMBER(6) not null,
  FIRST_NAME     VARCHAR2(20),
  LAST_NAME      VARCHAR2(25),
  EMAIL          VARCHAR2(25),
  PHONE_NUMBER   VARCHAR2(20),
  HIRE_DATE      DATE,
  employment_ID  VARCHAR2(10),
  SALARY         NUMBER(8,2),
  COMMISSION_PCT NUMBER(2,2),
  MANAGER_ID     NUMBER(6),
  section_ID     NUMBER(4)
)
DISTRIBUTE BY hash(staff_ID);
```

3. Import a small batch of data to the target table **staffs**.

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As queried by the following statement, there are eight DNs in the cluster. You are advised to import 80,000 records.

```
openGauss=# SELECT count(*) FROM pgxc_node where node_type='D';
 count
-------
     8
(1 row)
```

4. Verify the data skew of the target table **staffs** whose distribution key is **staff_ID**.

```
openGauss=# SELECT a.count,b.node_name FROM (select count(*) as count,xc_node_id FROM staffs
GROUP BY xc_node_id) a, pgxc_node b WHERE a.xc_node_id=b.node_id ORDER BY a.count desc;
count | node_name
------+-----------
11010 | datanode4
10000 | datanode3
12001 | datanode2
 8995 | datanode1
10000 | datanode5
 7999 | datanode6
 9995 | datanode7
10000 | datanode8
(8 rows)
```

5. As shown in the above query result, the data distribution deviation across DNs is greater than 10%, indicating data skew. Therefore, delete **staff_ID** from the distribution key candidates and delete the **staffs** table.

```
openGauss=# DROP TABLE staffs;
```

6. Use **staff_ID**, **FIRST_NAME**, and **LAST_NAME** as distribution keys and create the target table **staffs**.

```
openGauss=# CREATE TABLE staffs
(
  staff_ID       NUMBER(6) not null,
  FIRST_NAME     VARCHAR2(20),
  LAST_NAME      VARCHAR2(25),
  EMAIL          VARCHAR2(25),
  PHONE_NUMBER   VARCHAR2(20),
  HIRE_DATE      DATE,
  employment_ID  VARCHAR2(10),
  SALARY         NUMBER(8,2),
  COMMISSION_PCT NUMBER(2,2),
  MANAGER_ID     NUMBER(6),
  section_ID     NUMBER(4)
)
DISTRIBUTE BY hash(staff_ID,FIRST_NAME,LAST_NAME);
```

7. Verify the data skew of the target table **staffs** whose distribution keys are **staff_ID**, **FIRST_NAME**, and **LAST_NAME**.

```
openGauss=# SELECT a.count,b.node_name FROM (select count(*) as count,xc_node_id FROM staffs
GROUP BY xc_node_id) a, pgxc_node b WHERE a.xc_node_id=b.node_id ORDER BY a.count desc;
count | node_name
------+-----------
10010 | datanode4
10000 | datanode3
10001 | datanode2
 9995 | datanode1
10000 | datanode5
 9999 | datanode6
 9995 | datanode7
10000 | datanode8
(8 rows)
```

8. As shown in the above query result, the data distribution deviation across DNs is less than 10%, indicating even data distribution and a proper distribution key.

9. Delete the imported small-batch data.

```
openGauss=# TRUNCATE TABLE staffs;
```

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10. Import the full data to complete data migration.

# 8.8 Analyzing Tables

The execution plan generator needs to use table statistics to generate the most effective query execution plan to improve query performance. After data is imported, you are advised to run the **ANALYZE** statement to update table statistics. The statistics are stored in the system catalog **PG_STATISTIC**.

## Analyzing Tables

**ANALYZE** supports row-store and column-store tables. **ANALYZE** can also collect statistics on specified columns of a local table. For details on **ANALYZE**, see **12.14.40 ANALYZE | ANALYSE**.

**Step 1** Update table statistics.

Do **ANALYZE** to the **product_info** table.

```
openGauss=# ANALYZE product_info;
ANALYZE
```

**----End**

## Automatically Analyzing a Table

GaussDB provides the GUC parameter **autovacuum** to specify whether to enable the autovacuum function of the database.

If **autovacuum** is set to **on**, the system will start the autovacuum thread to automatically analyze tables when the data volume in the table reaches the threshold. This is the autoanalyze function.

- For an empty table, when the number of rows inserted to it is greater than 50, **ANALYZE** is automatically triggered.
- For a table containing data, the threshold is 50 + 10% x **reltuples**, where **reltuples** indicates the total number of rows in the table.

The autovacuum function also depends on the following two GUC parameters in addition to **autovacuum**:

- **track_counts**: This parameter must be set to **on** to enable statistics collection about the database.
- **autovacuum_max_workers**: This parameter must be set to a value greater than **0** to specify the maximum number of concurrent autovacuum threads.

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**NOTICE**

- The autoanalyze function supports the default sampling mode but not percentage sampling.
- The autoanalyze function does not collect multi-column statistics, which only supports percentage sampling. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)
- The autoanalyze function supports row-store and column-store tables but does not support the following: foreign tables, OBS tables (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.), temporary tables, unlogged tables, and TOAST tables.

# 8.9 Doing VACUUM to a Table

If a large number of rows were updated or deleted during import, run **VACUUM FULL** before **ANALYZE**. A large number of UPDATE and DELETE operations generate huge disk page fragments, which reduces query efficiency. **VACUUM FULL** can restore disk page fragments and return them to the OS.

**Step 1** Run the **VACUUM FULL** statement.

Do **VACUUM FULL** to the **product_info** table.

```
openGauss=# VACUUM FULL product_info
VACUUM
```

**----End**

# 8.10 Managing Concurrent Write Operations

## 8.10.1 Transaction Isolation

GaussDB manages transactions based on MVCC and two-phase locks, avoiding conflicts between read and write operations. SELECT is a read-only operation, whereas UPDATE and DELETE are read/write operations.

- There is no conflict between read/write and read-only operations, or between read/write operations. Each concurrent transaction creates a snapshot when it starts. Concurrent transactions cannot detect updates made by each other.
  - At the **READ COMMITTED** level, if transaction T1 is committed, transaction T2 can see changes made by T1.
  - At the **REPEATABLE READ** level, if T2 starts before T1 is committed, T2 will not see changes made by T1 even after T1 is committed. The query results in a transaction are consistent and unaffected by other transactions.
- Read/Write operations use row-level locks. Different transactions can concurrently update the same table but not the same row. A row update transaction will start only after the previous one is committed.
  - **READ COMMITTED**: At this level, a transaction can access only committed data. This is the default level.

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  - **REPEATABLE READ**: Only data committed before transaction start is read. Uncommitted data or data committed in other concurrent transactions cannot be read.

## 8.10.2 Write and Read/Write Operations

Statements for write-only and read/write operations are as follows:

- **INSERT**, used to insert one or more rows of data into a table
- **UPDATE**, used to modify existing data in a table
- **DELETE**, used to delete existing data from a table
- **COPY**, used to import data

INSERT and COPY are write-only operations. Only one of them can be performed at a time. If INSERT or COPY of transaction T1 locks a table, INSERT or COPY of transaction T2 needs to wait until T1 unlocks the table.

UPDATE and DELETE operations are read/write operations. They need to query for the target rows before modifying data. Concurrent transactions cannot see changes made by each other, and UPDATE and DELETE operations read snapshots of data committed before their transactions start. Write operations use row-level locks. If T2 starts after T1 and is to update the same row as T1 does, T2 waits for T1 to finish update. If T1 is not complete within the specified timeout duration, T2 will time out. If T1 and T2 update different rows in a table, they can be concurrently executed.

## 8.10.3 Potential Deadlocks During Concurrent Write

Whenever transactions involve updates of more than one table, there is always the possibility that concurrently running transactions become deadlocked when they both try to write to the same set of tables. A transaction releases all of its locks at once when it either commits or rolls back; it does not relinquish locks one at a time. For example, transactions T1 and T2 start at roughly the same time.

- If T1 starts writing to table A and T2 starts writing to table B, both transactions can proceed without conflict. However, if T1 finishes writing to table A and needs to start writing to the same rows as T2 does in table B, it will not be able to proceed because T2 still holds the lock on B. Conversely, if T2 finishes writing to table B and needs to start writing to the same rows as T1 does in table A, it will not be able to proceed either because T1 still holds the lock on A. In this case, a deadlock occurs. If T1 is committed and releases the lock within the lock timeout duration, subsequent update can proceed. If a lock times out, an error is reported and the corresponding transaction exits.
- If T1 updates rows 1 to 5 and T2 updates rows 6 to 10 in the same table, the two transactions do not conflict. However, if T1 finishes the update and proceeds to update rows 6 to 10, and T2 proceeds to update rows 1 to 5, neither of them can continue. If either of the transactions is committed and releases the lock within the lock timeout duration, subsequent update can proceed. If a lock times out, an error is reported and the corresponding transaction exits.

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# 8.10.4 Concurrent Write Examples

This section uses the **test** table as an example to describe how to perform concurrent **INSERT** and **DELETE** in the same table, concurrent **INSERT** in the same table, concurrent **UPDATE** in the same table, and concurrent import and queries.

```
CREATE TABLE test(id int, name char(50), address varchar(255));
```

## 8.10.4.1 Concurrent INSERT and DELETE in the Same Table

Transaction T1:

```
START TRANSACTION;
INSERT INTO test VALUES(1,'test1','test123');
COMMIT;
```

Transaction T2:

```
START TRANSACTION;
DELETE test WHERE NAME='test1';
COMMIT;
```

Scenario 1:

T1 is started but not committed. At this time, T2 is started. After **INSERT** of T1 is complete, **DELETE** of T2 is performed. In this case, **DELETE 0** is displayed, because T1 is not committed and T2 cannot see the data inserted by T1.

Scenario 2:

- **READ COMMITTED** level

  T1 is started but not committed. At this time, T2 is started. After **INSERT** of T1 is complete, T1 is committed and **DELETE** of T2 is executed. In this case, **DELETE 1** is displayed, because T2 can see the data inserted by T1.

- **REPEATABLE READ** level

  T1 is started but not committed. At this time, T2 is started. After **INSERT** of T1 is complete, T1 is committed and **DELETE** of T2 is executed. In this case, **DELETE 0** is displayed, because the data obtained in queries is consistent in a transaction.

## 8.10.4.2 Concurrent INSERT in the Same table

Transaction T1:

```
START TRANSACTION;
INSERT INTO test VALUES(2,'test2','test123');
COMMIT;
```

Transaction T2:

```
START TRANSACTION;
INSERT INTO test VALUES(3,'test3','test123');
COMMIT;
```

Scenario 1:

T1 is started but not committed. At this time, T2 is started. After **INSERT** of T1 is complete, **INSERT** of T2 is executed and succeeds. At the **READ COMMITTED** and **REPEATABLE READ** levels, the **SELECT** statement of T1 cannot see data inserted by T2, and a query in T2 cannot see data inserted by T1.

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Scenario 2:

- **READ COMMITTED** level

  T1 is started but not committed. At this time, T2 is started. After **INSERT** of T1 is complete, T1 is committed. In T2, a query executed after **INSERT** can see the data inserted by T1.

- **REPEATABLE READ** level

  T1 is started but not committed. At this time, T2 is started. After **INSERT** of T1 is complete, T1 is committed. In T2, a query executed after **INSERT** cannot see the data inserted by T1.

### 8.10.4.3 Concurrent UPDATE in the Same Table

Transaction T1:

```
START TRANSACTION;
UPDATE test SET address='test1234' WHERE name='test1';
COMMIT;
```

Transaction T2:

```
START TRANSACTION;
UPDATE test SET address='test1234' WHERE name='test2';
COMMIT;
```

Transaction T3:

```
START TRANSACTION;
UPDATE test SET address='test1234' WHERE name='test1';
COMMIT;
```

Scenario 1:

T1 is started but not committed. At this time, T2 is started. **UPDATE** of T1 and then T2 starts, and both of them succeed. This is because the **UPDATE** operations use row-level locks and do not conflict when they update different rows.

Scenario 2:

T1 is started but not committed. At this time, T3 is started. **UPDATE** of T1 and then T3 starts, and **UPDATE** of T1 succeeds. **UPDATE** of T3 times out. This is because T1 and T3 update the same row and the lock is held by T1 at the time of the update.

### 8.10.4.4 Concurrent Data Import and Queries

Transaction T1:

```
START TRANSACTION;
COPY test FROM '...';
COMMIT;
```

Transaction T2:

```
START TRANSACTION;
SELECT * FROM test;
COMMIT;
```

Scenario 1:

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T1 is started but not committed. At this time, T2 is started. **COPY** of T1 and then **SELECT** of T2 starts, and both of them succeed. In this case, T2 cannot see the data added by **COPY** of T1.

Scenario 2:

- **READ COMMITTED** level

  T1 is started but not committed. At this time, T2 is started. **COPY** of T1 is complete and T1 is committed. In this case, T2 can see the data added by **COPY** of T1.

- **REPEATABLE READ** level

  T1 is started but not committed. At this time, T2 is started. **COPY** of T1 is complete and T1 is committed. In this case, T2 cannot see the data added by **COPY** of T1.

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# 9 Exporting Data

## 9.1 Exporting Data in Parallel Using a Foreign Table

### 9.1.1 Exporting Data In Parallel

In high-concurrency scenarios, you can use GDS to export a large volume of data from a database to a common file system. To export data in parallel using a foreign table, you must enable the stream operator first.

#### Overview

**Using foreign tables**: Data files to export are specified based on the export mode and data formats specified in a foreign table. Data is exported in parallel through multiple DNs from the database to data files, which improves overall data export performance.

- The CN plans data export tasks and delivers the tasks to DNs. Then the CN is released to process other tasks.
- The computing capabilities and bandwidths of all the DNs are fully leveraged to export data.

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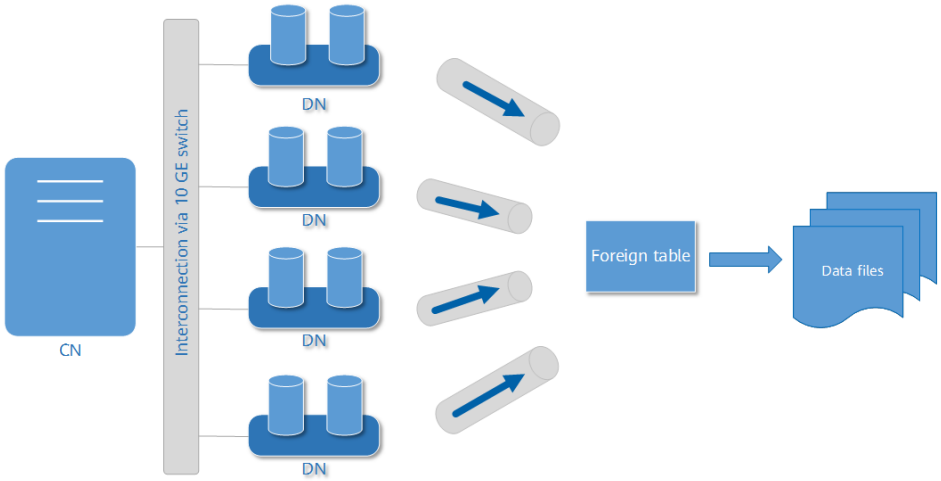
**Figure 9-1** Exporting data using foreign tables




## Concepts

- **Data file**: A TEXT, CSV, or FIXED file that stores data exported from GaussDB.
- **Foreign table**: a table that stores information, such as the format, location, and encoding format of a data file.
- **GDS**: a data service tool. To export data, deploy GDS on the server where data files are stored.
- **Table**: a table in the database, including row-store tables and column-store tables. Data in data files is exported from these tables.
- **Local mode**: Service data in a cluster is exported to hosts in the cluster.
- **Remote mode**: Service data in a cluster is exported to hosts outside the cluster.

## Exporting a Schema

In GaussDB, data can be exported in local or remote mode.

- **Remote mode**: Service data in a cluster is exported to hosts outside the cluster.
  - In this mode, multiple GDSs are used to concurrently export data. One GDS can export data for only one cluster at a time.
  - The data export rate of a GDS that resides on the same intranet as cluster nodes is limited by the network bandwidth. A 10 GE configuration is recommended.
  - Data files in TEXT, CSV, or FIXED format are supported. The size of data in a single row must be less than 1 GB.
- **Local mode**: Service data in a cluster is exported to hosts in the cluster. The local mode is dedicated to exporting data from a large number of small files.
  - In this mode, data is evenly divided and stored in specified directories on cluster nodes, occupying the disk space of these cluster nodes.
  - Data files in TEXT, CSV, or FIXED format are supported. The size of data in a single row must be less than 1 GB.

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## Export Process

**Figure 9-2** Process of parallel data export

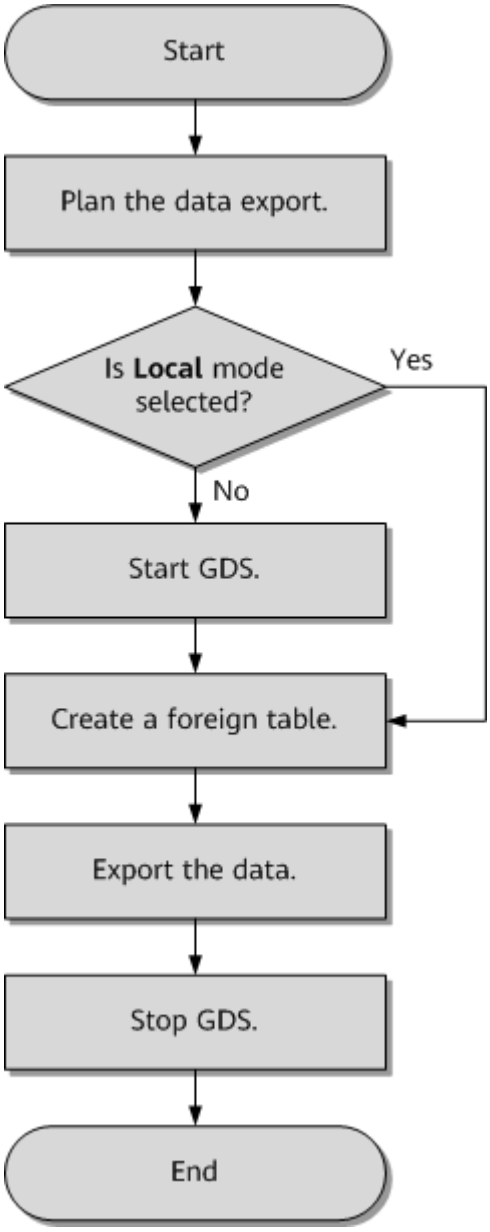


**Table 9-1** Process description

| Process | Description | Sub-task |
| --- | --- | --- |
| Plan data export | Prepare data to export and plan the export path.<br>For details, see **9.1.2 Planning Data Export**. | N/A |

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| Process | Description | Sub-task |
| --- | --- | --- |
| Check whether the **Local** mode is selected | Check the export mode specified during foreign table creation to determine whether the **Local** mode is selected. | N/A |
| Start GDS | If the **Remote** mode is selected, install, configure, and start GDS on data servers.<br>For details, see **9.1.3 Installing, Configuring, and Starting GDS**. | N/A |
| Create a foreign table | Create a foreign table to help GDS specify information about a data file. The foreign table stores information, such as the location, format, encoding, and inter-data delimiter of a data file.<br>For details, see **9.1.4 Creating a GDS Foreign Table**. | N/A |
| Export data | After the foreign table is created, run the **INSERT** statement to efficiently export data to data files.<br>For details, see **9.1.5 Exporting Data**. | N/A |
| Stop GDS | Stop GDS after data is exported.<br>For details, see **9.1.6 Stopping GDS**. | N/A |

## 9.1.2 Planning Data Export

### Scenarios

Before you use GDS to export data from a cluster, prepare data to export and plan the export path.

### Planning an Export Path

- **Remote** mode

**Step 1** (Optional) Create a user and a user group. The user is used to start GDS and must have the write permission on the directory for storing data files.

```
groupadd gdsgrp
useradd -g gdsgrp gdsuser
```

If the following information is displayed, the user and user group already exist. Skip this step.

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```
useradd: Account 'gdsuser' already exists.
groupadd: Group 'gdsgrp' already exists.
```

**Step 2** Create the **/output_data** directory for storing exported data files.

```
mkdir -p /output_data
```

**Step 3** Change the directory owner to **gdsuser**.

```
chown -R gdsuser:gdsgrp /output_data
```

**----End**

- **Local** mode

**Step 1** Create the **/output_data** directory for storing data files on each DN in the cluster.

```
mkdir -p /output_data
```

**Step 2** Change the directory owner to **omm**.

```
chown -R omm:dbgrp /output_data
```

**Step 3** Set **location** to a local path. You do not need to specify the file name.

For example, to store data files to the **/output_data/** directory, set the **location** parameter to **file:///output_data/** when you create a foreign table.

**----End**

## 9.1.3 Installing, Configuring, and Starting GDS

GDS is a data service tool provided by GaussDB. Using the foreign table mechanism, this tool helps export data at a high speed. Based on the load of the export job, check whether the server where GDS is located is properly connected to each physical cluster of the GaussDB Kernel clusters and whether there are robust system resources such as memory, handles, and disk space. For details, see **8.1.4 Installing, Configuring, and Starting GDS**.

## 9.1.4 Creating a GDS Foreign Table

### Procedure

**Step 1** Set the **location** parameter for the foreign table based on the path planned in **9.1.2 Planning Data Export**.

- **Remote** mode

  Set the **location** parameter to the URL of the directory that stores the data files.

  - You do not need to specify a file name in the URL.
  - If multiple URLs are configured, only the first URL is effective.

  **Example**:

  The IP address of the GDS data server is 192.168.0.90. The listening port number set during GDS startup is 5000. The directory for storing data files is **/output_data**.

  In this case, set the **location** parameter to **gsfs://192.168.0.90:5000/**.

- **Local** mode

  Set the **location** parameter to the directory for storing the data files. You do not need to specify the file name.

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**Example**:

To store data files in the **/output_data/** directory, set the **location** parameter to **file:///output_data/** when you create a foreign table.

**Step 2** Set data format parameters in the foreign table based on the planned data file formats. For details on format parameters, see **data format parameters**.

**Step 3** Create a GDS foreign table based on the parameter settings in the preceding steps. For details, see **12.14.60 CREATE FOREIGN TABLE (for Import and Export)**.

**----End**

## Examples

- **Example 1**: Create the GDS foreign table **foreign_tpcds_reasons** to receive data from a data server. Data will be exported in CSV format.

  Data export settings are as follows:

  The data server resides on the same intranet as the cluster. The IP address of the data server is 192.168.0.90. Data is to be exported as CSV files. The **Remote** mode is selected for parallel data export.

  If the directory for storing data files is **/output_data/** and the GDS listening port is 5000 when GDS is started, set the **location** parameter to **gsfs://192.168.0.90:5000/**.

  Data format parameter settings are as follows:

  - **format** is set to **CSV**.
  - **encoding** is set to **UTF-8**.
  - **delimiter** is set to **E'\x20'**.
  - **quote** is set to **0x1b**.
  - **null** is set to an empty string without quotation marks.
  - **escape** is set to a double quotation mark.
  - **header** is set to **false**, indicating that the first row is identified as a data row in an exported file.
  - **EOL** is set to **0X0A**.

  The statement for creating the foreign table is as follows:

  ```
  openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
  (
    r_reason_sk    integer        not null,
    r_reason_id    char(16)       not null,
    r_reason_desc  char(100)
  )
  SERVER gsmpp_server
  OPTIONS (LOCATION 'gsfs://192.168.0.90:5000/',
  FORMAT 'CSV',
  DELIMITER E'\x20',
  QUOTE E'\x1b',
  NULL '',
  EOL '0x0a'
  )
  WRITE ONLY;
  ```

- **Example 2**: The GDS foreign table **foreign_tpcds_reasons** is created for receiving data from a data server. Data will be exported as FIXED files.

  Data export settings are as follows:

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The data server resides on the same intranet as the cluster. The IP address of the data server is 192.168.0.90. Data is to be exported as CSV files. The **Remote** mode is selected for parallel data export.

If the directory for storing data files is **/output_data/** and the GDS listening port is 5000 when GDS is started, set the **location** parameter to **gsfs://192.168.0.90:5000/**.

Data format parameter settings are as follows:

- **format** is set to **FIXED**.
- **encoding** is set to **UTF-8**.
- **header** is set to false, indicating that when the file is exported, the first row is regarded as a data row.
- **POSITION(***offset***,***length***)** is set to specify the position of a column in a source data file. **offset** indicates the starting point of a column in the data file. **length** indicates the length (in bytes) of the column.

  In the **r_reason_sk** column, the data type is **integer** and the maximum number of bytes is 2 (as shown in the following statement output). Therefore, *offset* is set to **1** and *length* is set to **2**.

  In the **r_reason_id** column, the data type is **character varying(16)** and the maximum number of bytes is 16 (as shown in the following statement output). Therefore, *offset* is set to **3** (sum of *offset* and *length* of **r_reason_sk**) and *length* is set to **16**.

  In the **r_reason_desc** column, the data type is **character varying(100)** and the maximum number of bytes is 100 (as shown in the following statement output). Therefore, *offset* is set to **19** (sum of *offset* and *length* of **r_reason_id**) and *length* is set to **100**.

  ```
  openGauss=# SELECT
  max(lengthb(r_reason_sk)),max(lengthb(r_reason_id)),max(lengthb(r_reason_desc)) FROM
  reasons;
   max | max | max
  -----+-----+-----
     2 |  16 | 100
  (1 row)
  ```

- **EOL** is set to **0X0A**.

The statement for creating the foreign table is as follows:

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
( r_reason_sk    integer        position(1,2),
  r_reason_id    char(16)       position(3,16),
  r_reason_desc  char(100)      position(19,100)
)
SERVER gsmpp_server
OPTIONS (LOCATION 'gsfs://192.168.0.90:5000/',
FORMAT 'FIXED',
ENCODING 'utf8',
EOL '0x0a'
)
WRITE ONLY;
```

# 9.1.5 Exporting Data

## Prerequisites

The IP addresses and ports of servers where CNs and DNs reside can connect to those of a GDS server.

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## Procedure

**Step 1** Export data.

```
INSERT INTO [Foreign table name] SELECT * FROM [Source table name];
```

NOTE

- Create batch processing scripts to export data in parallel. The degree of parallelism depends on server resource usage. You can test several tables and monitor resource usage to determine whether to increase or reduce the amount. Common resource monitoring commands include **top** for monitoring memory and CPU usage, **iostat** for monitoring I/O usage, and **sar** for monitoring networks.
- Only a single internal table can be exported at a time. Multi-table join is not supported during export. Results of the aggregation, sort, subquery, and limit operations on a single table also cannot be exported.
- In this version, GDS export supports CN RETRY. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) CN RETRY is triggered when a network error occurs due to a DN or GTM fault. Ensure that the GDS version is the same as or later than the kernel version.

**----End**

## Examples

- **Example 1**: Export data from the **reasons** table to data files through the foreign table **foreign_tpcds_reasons**.
  ```
  openGauss=# INSERT INTO foreign_tpcds_reasons SELECT * FROM reasons;
  ```
- **Example 2**: Export part of the data to data files by specifying the filter condition **r_reason_sk =1**.
  ```
  openGauss=# INSERT INTO foreign_tpcds_reasons SELECT * FROM reasons WHERE r_reason_sk=1;
  ```
- **Example 3**: Data of a special type, such as RAW, is exported as a binary file, which cannot be recognized by the import tool. You need to use the RAWTOHEX() function to convert it to hexadecimal the format before export.
  ```
  openGauss=# INSERT INTO foreign_blob_type_tab SELECT RAWTOHEX(c) FROM blob_type_tab;
  ```

# 9.1.6 Stopping GDS

GDS is a data service tool provided by GaussDB. Using the foreign table mechanism, this tool helps export data at a high speed.

For details, see **8.1.8 Stopping GDS**.

# 9.1.7 Examples

## Example: Exporting Data in Remote Mode

A data server resides on the same intranet as the cluster, the IP address of the data server is 192.168.0.90, and data files are in CSV format. In this scenario, data is concurrently exported in **Remote** mode.

To concurrently export data in **Remote** mode, perform the following operations:

1. (Optional) Create a user and its user group. The user is used to start GDS. If the user and user group already exist, skip this step.
   ```
   groupadd gdsgrp
   useradd -g gdsgrp gds_user
   ```

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2. Switch to user **gds_user**, create the **/output_data** directory for storing data files, and start user **gds_user** and its user group.
   ```
   su - gds_user
   mkdir -p /output_data
   ```
3. Change the owner of the **/output_data** directory on the data server to **gds_user**.
   ```
   chown -R gds_user:gdsgrp /output_data
   ```
4. Log in to the data server as user **gds_user** and start GDS.

   The GDS installation path is **/opt/bin/gds**. Exported data files are stored in **/output_data/**. The IP address of the data server is 192.168.0.90. The GDS monitoring port number is 5000. The GDS runs in the background.
   ```
   /opt/bin/gds/gds -d /output_data -p 192.168.0.90:5000 -H 10.10.0.1/24 -D
   ```
5. In the database, create the foreign table **foreign_tpcds_reasons** for receiving data from the data server.

   Data export mode settings are as follows:

   - The directory for storing exported files is set to **/output_data/** and the GDS listening port number is 5000 while GDS is started. The created directory for storing exported files is **/output_data/**. Therefore, set the **location** parameter to **gsfs://192.168.0.90:5000/**.

   Data format parameter settings are as follows:

   - **format** is set to **CSV**.
   - **encoding** is set to **UTF-8**.
   - **delimiter** is set to **E'\x20'**.
   - **quote** is set to **0x1b**.
   - **null** is set to an empty string without quotation marks.
   - **escape** is set to a double quotation mark.
   - **header** is set to **false**, indicating that the first row is identified as a data row in an exported file.

   Based on the above settings, the foreign table is created using the following statement:
   ```
   openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
   (
     r_reason_sk    integer        not null,
     r_reason_id    char(16)       not null,
     r_reason_desc  char(100)
   ) SERVER gsmpp_server OPTIONS (LOCATION 'gsfs://192.168.0.90:5000/', FORMAT 'CSV',ENCODING
   'utf8',DELIMITER E'\x20', QUOTE E'\x1b', NULL '') WRITE ONLY;
   ```
6. In the database, export data to data files through the foreign table **foreign_tpcds_reasons**.
   ```
   openGauss=# INSERT INTO foreign_tpcds_reasons SELECT * FROM reasons;
   ```
7. After data export is complete, log in to the data server as user **gds_user** and stop GDS.

   The GDS process ID is 128954.
   ```
   ps -ef|grep gds
   gds_user 128954      1  0 15:03 ?        00:00:00 gds -d /output_data -p 192.168.0.90:5000 -D
   gds_user 129003 118723  0 15:04 pts/0    00:00:00 grep gds
   kill -9 128954
   ```

## Example: Exporting Data Using Multiple Threads

A data server resides on the same intranet as the cluster, the IP address of the data server is 192.168.0.90, and source data files are in CSV format. In this

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scenario, data is concurrently exported from two tables using multiple threads in **Remote** mode.

To concurrently export data using multiple threads in **Remote** mode, perform the following operations:

1. Log in to the GDS data server and create a database user and its user group.
   ```
   groupadd gdsgrp
   useradd -g gdsgrp gds_user
   ```
2. Switch to user **gds_user** and create the **/output_data** directory for storing exported files.
   ```
   su - gds_user
   mkdir -p /output_data
   ```
3. Change the owner of the **/output_data** directory on the data server to **gds_user**.
   ```
   chown -R gds_user:gdsgrp /output_data
   ```
4. Log in to the data server as user **gds_user** and start GDS.

   The GDS installation path is **/opt/bin/gds**. Exported data files are stored in **/output_data/**. The IP address of the data server is 192.168.0.90. The GDS listening port number is 5000. The GDS runs in the background. The concurrency level is 2.
   ```
   /opt/bin/gds/gds -d /output_data -p 192.168.0.90:5000 -H 10.10.0.1/24 -D -t 2
   ```
5. In GaussDB, create the foreign tables **foreign_tpcds_reasons1** and **foreign_tpcds_reasons2** for receiving data from the data server.
   - Data export mode settings are as follows:
     - The directory for storing exported files is set to **/output_data/** and the GDS listening port number is 5000 while GDS is started. The created directory for storing exported files is **/output_data/**. Therefore, the **location** parameter is set to **gsfs://192.168.0.90:5000/**.
   - Data format parameter settings are as follows:
     - **format** is set to **CSV**.
     - **encoding** is set to **UTF-8**.
     - **delimiter** is set to **E'\x20'**.
     - **quote** is set to **0x1b**.
     - **null** is set to an empty string without quotation marks.
     - **escape** is set to a double quotation mark.
     - **header** is set to **false**, indicating that the first row is identified as a data row in an exported file.

   Based on the above settings, the foreign table **foreign_tpcds_reasons1** is created using the following statement:
   ```
   openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons1
   (
     r_reason_sk    integer      not null,
     r_reason_id    char(16)     not null,
     r_reason_desc  char(100)
   ) SERVER gsmpp_server OPTIONS (LOCATION 'gsfs://192.168.0.90:5000/', FORMAT 'CSV',ENCODING
   'utf8', DELIMITER E'\x20', QUOTE E'\x1b', NULL '') WRITE ONLY;
   ```

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Based on the above settings, the foreign table **foreign_tpcds_reasons2** is created using the following statement:

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons2
(
  r_reason_sk    integer     not null,
  r_reason_id    char(16)    not null,
  r_reason_desc  char(100)
) SERVER gsmpp_server OPTIONS (LOCATION 'gsfs://192.168.0.90:5000/', FORMAT 'CSV', DELIMITER
E'\x20', QUOTE E'\x1b', NULL '') WRITE ONLY;
```

6. In the database, export data from table **reasons1** through the foreign table **foreign_tpcds_reasons1** and from table **reasons2** through the foreign table **foreign_tpcds_reasons2** to **/output_data**.

   ```
   openGauss=# INSERT INTO foreign_tpcds_reasons1 SELECT * FROM reasons1;
   openGauss=# INSERT INTO foreign_tpcds_reasons2 SELECT * FROM reasons2;
   ```

7. After data export is complete, log in to the data server as user **gds_user** and stop GDS.

   The GDS process ID is 128954.

   ```
   ps -ef|grep gds
   gds_user 128954      1  0 15:03 ?        00:00:00 gds -d /output_data -p 192.168.0.90:5000 -D -t 2
   gds_user 129003 118723  0 15:04 pts/0    00:00:00 grep gds
   kill -9 128954
   ```

## Example: Exporting Data in Local Mode

A cluster contains eight DNs and four physical nodes. Every two DNs reside on the same physical node. The cluster has sufficient disk space and the cluster node I/O performance is satisfactory. In this scenario, data is concurrently exported in **Local** mode.

To concurrently export data in **Local** mode, perform the following operations:

1. Log in to a physical node, create the **/output_data** directory for storing data files, and change the owner of the directory to **omm**.

   All the following operations use a node with the IP address 192.168.0.11 as an example.

   ```
   mkdir -p /output_data
   chown -R omm:dbgrp /output_data
   ```

2. In the database, create the foreign table **foreign_tpcds_reasons**.
   - Data export mode settings are as follows:
     - The directory created in the previous step for storing data files is **/output_data/**. Therefore, the **location** parameter is set to **file:///output_data/**.
   - Data format parameter settings are as follows:
     - **format** is set to **CSV**.
     - **encoding** is set to **UTF-8**.
     - **delimiter** is set to **E'\x20'**.
     - **quote** is set to **0x1b**.
     - **null** is set to an empty string without quotation marks.
     - **escape** is set to a double quotation mark.

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- **header** is set to **false**, indicating that the first row is identified as a data row in an exported file.

Based on the above settings, the foreign table **foreign_tpcds_reasons** is created using the following statement:

```
openGauss=# CREATE FOREIGN TABLE foreign_tpcds_reasons
(
  r_reason_sk    integer      not null,
  r_reason_id    char(16)     not null,
  r_reason_desc  char(100)
) SERVER gsmpp_server OPTIONS (LOCATION 'file:///output_data/', FORMAT 'CSV',ENCODING 'utf8',
DELIMITER E'\x20', QUOTE E'\x1b', NULL '') WRITE ONLY;
```

3. Export data in the database.

```
openGauss=# INSERT INTO foreign_tpcds_reasons SELECT * FROM reasons;
```

4. View data files.

   The data files are generated in **/output_data/***YYYYMMDD/DN name* on each cluster node. *YYYYMMDD* indicates the current system date. *DN name* can be found by running the following statement:

```
openGauss=# SELECT node_name,node_host FROM pgxc_node WHERE node_type='D';
  node_name   |   node_host
--------------+---------------
 dn_6001_6002 | 192.168.0.11
 dn_6003_6004 | 192.168.0.11
 dn_6005_6006 | 192.168.0.12
 dn_6007_6008 | 192.168.0.12
 dn_6009_6010 | 192.168.0.13
 dn_6011_6012 | 192.168.0.13
 dn_6013_6014 | 192.168.0.14
 dn_6015_6016 | 192.168.0.14
(8 rows)
```

   On the node whose IP address is 192.168.0.11, the names of DNs are **dn_6001_6002** and **dn_6003_6004**. In this case, data files are generated in **/output_data/20160101/dn_6001_6002** and **/output_data/20160101/dn_6003_6004** on the node.

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# 10 Performance Tuning

## 10.1 Overview

To fine-tune GaussDB performance, you need to identify performance bottlenecks, adjust key parameters, and optimize SQL statements. During performance tuning, locate and analyze performance issues based on performance elements, such as system resources, throughput, and loads to achieve required system performance.

Various factors must be considered during GaussDB performance tuning. Therefore, optimization personnel must know well about knowledge, such as system software architecture, hardware and software configuration, database parameter configuration, concurrency control (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.), query processing, and database applications.

**NOTICE**

Performance tuning sometimes require cluster restart, which may interrupt current services. Therefore, after the service goes live and when the cluster needs to be restarted, you must send the request to related management department about the operation time window for approval.

### Tuning Process

**Figure 10-1** shows the procedure of performance tuning.

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**Figure 10-1** GaussDB performance tuning

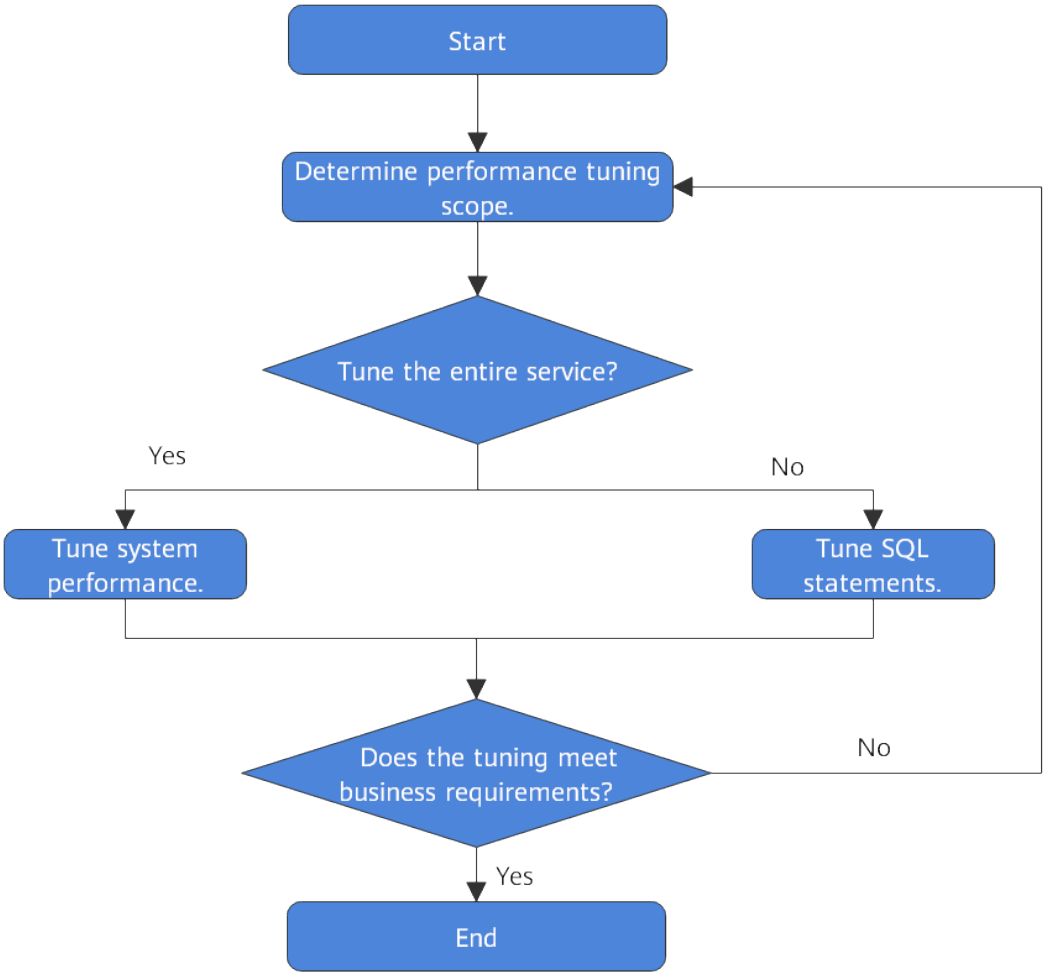


**Table 10-1** lists the details about each phase.

**Table 10-1** GaussDB performance tuning

| Phase | Description |
| --- | --- |
| **10.2 Determining the Scope of Performance Tuning** | The phase where the CPU, memory, I/O, and network resource usage of each cluster node are obtained to check whether these resources are fully used and whether any bottleneck exists |

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| Phase | Description |
| --- | --- |
| 10.3 SQL Optimization | The phase where the SQL statements used are analyzed to determine whether any optimization can be performed. Analysis of SQL statements comprises:<br>• Generating table statistics using **ANALYZE**: The **ANALYZE** statement collects statistics about the database table content. Statistical results are stored in the system catalog **PG_STATISTIC**. The execution plan generator uses these statistics to determine which one is the most effective execution plan.<br>• Analyzing the execution plan: The **EXPLAIN** statement displays the execution plan of SQL statements, and the **EXPLAIN PERFORMANCE** statement displays the execution time of each operator in SQL statements.<br>• Identifying the root causes of issues: Identifies possible causes by analyzing the execution plan and perform specific optimization by modifying database-level SQL optimization parameters.<br>• Compiling better SQL statements: Compiles better SQL statements in the scenarios, such as cache of intermediate and temporary data for complex queries, result set cache, and result set combination. |

# 10.2 Determining the Scope of Performance Tuning

Database performance tuning often happens when users are not satisfied with the service execution efficiency and want to improve the efficiency. The database performance is affected by many factors as described in section **Performance Elements**. Therefore, performance tuning is a complex process and sometimes cannot be systematically described or explained. It depends more on the database administrator's experience. However, this section still attempts to illustrate the performance tuning methods that can be referred to by application development personnel and new GaussDB database administrators.

## Performance Elements

There are multiple performance factors that affect the database performance. Knowing these factors can help you identify and analyze performance-associated issues.

- System resources

  Database performance greatly relies on disk I/O and memory usage. To accurately set performance counters, you need to have a knowledge of the basic performance of the hardware deployed in the cluster. Performance of hardware, such as the CPU, hard disk, disk controller, memory, and network interfaces, greatly affects database running speed.

- Load

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The load indicates the total database system demands and it changes over time. The overall load contains user queries, applications, concurrent jobs, transactions, and system commands transferred at any time. For example, the system load increases if multiple users are executing multiple queries. The load greatly affects database performance. Identifying load peak hours helps improve resource utilization so that tasks are executed effectively.

- Throughput

  The data processing capability of a database is defined by its throughput. Database throughput is measured by the number of queries or processed transactions per second or by the average response time. The database processing capacity is closely related to the underlying system performance (disk I/O, CPU speed, and storage bandwidth). You need to know about the hardware performance before setting a target throughput.

- Competition

  Competition indicates that two or more load components try to use system resources in a conflicting way. For example, competition occurs when multiple queries attempt to update the same data at the same time, or when a large number of loads compete for system resources. When competition increases, the throughput decreases.

- Optimization

  The database optimization can affect the performance of the whole system. Before executing the SQL statements, configuring database parameters, designing tables, and performing data distribution, enable the database query optimizer can help you obtain the most efficient execution plan.

### Determining the Tuning Scope

Performance tuning depends on the usage of hardware resources, such as the CPU, memory, I/O, and network of each node in the cluster. Check whether these resources are fully utilized, and whether any bottlenecks exist, and then perform performance tuning as required.

- If a resource reaches the bottleneck:
  a. Check whether the key OS parameters and database parameters are properly set.
  b. Find the resource consuming SQL statements by querying the most time-consuming SQL statements and unresponsive SQL statements, and then perform **10.3 SQL Optimization**.
- If no resource reaches the bottleneck, the system performance can be improved. In this case, query the most time-consuming SQL statements and the unresponsive SQL statements, and then perform **10.3 SQL Optimization** as required.

## 10.2.1 Querying SQL Statements That Affect Performance Most

This section describes how to query SQL statements whose execution takes a long time, leading to poor system performance.

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## Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** Query the statements that are run for a long time in the database.

```
SELECT current_timestamp - query_start AS runtime, datname, usename, query FROM pg_stat_activity
where state != 'idle' ORDER BY 1 desc;
```

The command output lists the query statements in descending order by their execution duration length. The first record is the query statement that takes the longest time for execution. The returned result contains SQL statements invoked by the system and SQL statements run by users. Find the statements that were run by users and took a long time.

Alternatively, you can set **current_timestamp - query_start** to be greater than a threshold to identify query statements that are executed for a duration longer than this threshold.

```
SELECT query FROM pg_stat_activity WHERE current_timestamp - query_start > interval '1 days';
```

**Step 3** Set the parameter **track_activities** to **on**.

```
SET track_activities = on;
```

The database collects the running information about active queries only if the parameter is set to **on**.

**Step 4** View the running query statements.

The **pg_stat_activity** view is used as an example here.

```
SELECT datname, usename, state FROM pg_stat_activity;
 datname  | usename | state  |
----------+---------+--------+
 postgres |   omm   | idle   |
 postgres |   omm   | active |
(2 rows)
```

If the **state** column is **idle**, the connection is idle and requires a user to enter a command.

To identify only active query statements, run the following command:

```
SELECT datname, usename, state FROM pg_stat_activity WHERE state != 'idle';
```

**Step 5** Analyze the status of the query statements that were run for a long time.

- If the query statement is normal, wait until the execution of the query statement is complete.
- If a query statement is blocked, run the following command to view this query statement:

  ```
  SELECT datname, usename, state, query FROM pg_stat_activity WHERE waiting = true;
  ```

  The query statement is displayed. It is requesting a lock resource that may be held by another session, and is waiting for the lock resource to be released by the session.

  **NOTE**

  Only when the query is blocked by internal lock resources, the **waiting** column is **true**. In most cases, blocks happen when query statements are waiting for lock resources to be released. However, query statements may be blocked due to write and timers operations. Such blocked queries are not displayed in the **pg_stat_activity** view.

**----End**

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# 10.2.2 Checking Blocked Statements

During database running, query statements are blocked in some service scenarios and run for an excessively long time. In this case, you can forcibly terminate the faulty session.

## Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** Check the blocked query statements, the SQL statement that blockes the query, query status, and session ID (applicable when the SQL thread pool is enabled).

```
SELECT w.query AS waiting_query,
w.state as w_state,
w.datname as w_datname,
w.usename as w_user,
w.client_addr as w_client_addr,
l.query AS locking_query,
l.state as l_state,
l.pid AS l_pid,
l.sessionid as l_sessionid
FROM pgxc_stat_activity AS w
JOIN (
    SELECT query_id,block_sessionid,global_sessionid,node_name
    FROM pgxc_thread_wait_status
) AS a ON a.query_id = w.query_id
 JOIN (
    SELECT sessionid,node_name,global_sessionid  FROM pgxc_thread_wait_status
) AS b ON b.sessionid = a.block_sessionid and b.node_name=a.node_name
JOIN (select query,pid,sessionid,global_sessionid,state from pgxc_stat_activity ) l
on substring(l.global_sessionid,0,instr(l.global_sessionid,'#')) ilike
substring(b.global_sessionid,0,instr(b.global_sessionid,'#'))
WHERE a.block_sessionid !=0;
```

This query returns the session ID, user information, query status, and the statement that causes the blocking and its query status and session ID.

**Step 3** Run the following command to terminate the required session, where **139834762094352** is the thread ID:

```
SELECT PG_TERMINATE_BACKEND(139834762094352);
```

If information similar to the following is displayed, the session is successfully terminated:

```
 PG_TERMINATE_BACKEND
----------------------
 t
(1 row)
```

If information similar to the following is displayed, the user is attempting to end the current session:

```
FATAL:  terminating connection due to administrator command
FATAL:  terminating connection due to administrator command
```

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NOTE

1. If the **PG_TERMINATE_BACKEND** function is used to terminate the backend threads of the current session and the user is an initial user, the **gsql** client is reconnected automatically rather than be logged out. The message "The connection to the server was lost. Attempting reset: Succeeded." is returned. Otherwise, the client fails to be reconnected and the error message "The connection to the server was lost. Attempting reset: Failed." is returned because only the initial user can use password-free login.
2. If the **PG_TERMINATE_BACKEND** function is used to terminate inactive backend threads and the thread pool is opened, idle sessions do not have thread IDs and cannot be ended. In non-thread pool mode, ended sessions are not automatically reconnected.

**----End**

# 10.3 SQL Optimization

The aim of SQL optimization is to maximize the utilization of resources, including CPU, memory, disk I/O, and network I/O. All optimization methods are intended for resource utilization. To maximize resource utilization is to run SQL statements as efficiently as possible to achieve the highest performance at a lower cost. For example, when performing a typical point query, you can use a Seq Scan and a filter (that is, read every tuple and point query conditions for match). You can also use an Index Scan, which can be implemented at a lower cost but achieve the same effect.

You can determine a proper cluster deployment solution and table definition based on hardware resources and service characteristics. This is the basis of meeting performance requirements. The following performance tuning sections assume that you have finished installation based on a proper cluster solution in the software installation guide and performed database design based on the guide for database design and development.

## 10.3.1 Query Execution Process

The process from receiving SQL statements to the statement execution by the SQL engine is shown in **Figure 10-2** and described in **Table 10-2**. The texts in red are steps where database administrators can optimize queries.

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**Figure 10-2** Execution process of query-related SQL statements by the SQL engine

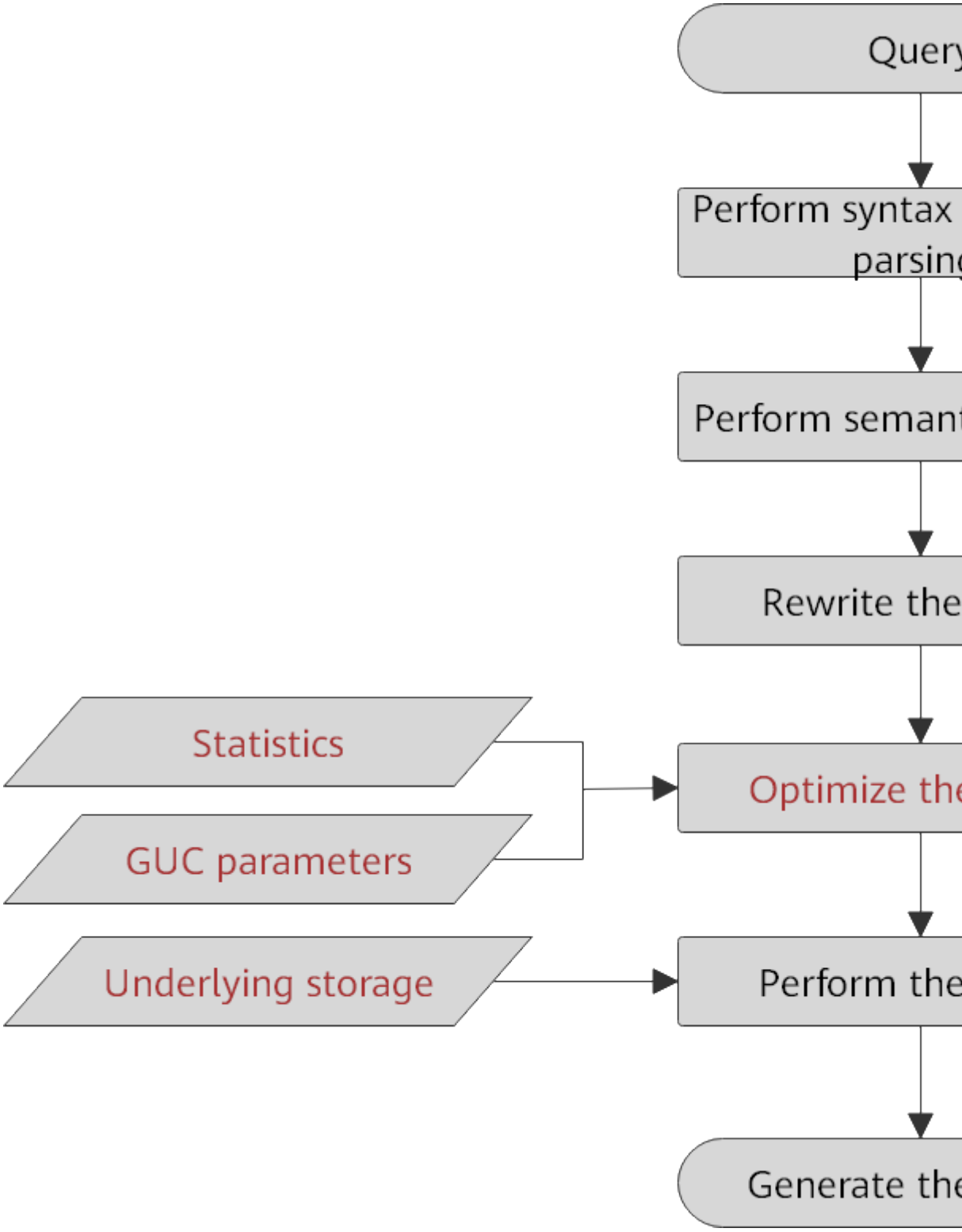


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**Table 10-2** Execution process of query-related SQL statements by the SQL engine

| Step | Description |
| --- | --- |
| 1. Perform syntax and lexical parsing. | Converts the input SQL statements from the string data type to the formatted structure stmt based on the specified SQL statement rules. |
| 2. Perform semantic parsing. | Converts the formatted structure obtained from the previous step into objects that can be recognized by the database. |
| 3. Rewrite the query statements. | Converts the output of the previous step into the structure that optimizes the query execution. |
| 4. Optimize the query. | Determines the execution mode of SQL statements (the execution plan) based on the result obtained from the previous step and the internal database statistics. For details about how the internal database statistics and GUC parameters affect the query optimization (execution plan), see **Optimizing Queries Using Statistics** and **Optimizing Queries Using GUC Parameters**. |
| 5. Perform the query. | Executes the SQL statements based on the execution path specified in the previous step. Selecting a proper underlying storage mode improves the query execution efficiency. For details, see **Optimizing Queries Using the Underlying Storage**. |

## Optimizing Queries Using Statistics

The GaussDB optimizer is a typical Cost-based Optimization (CBO). By using CBO, the database calculates the number of tuples and the execution cost for each execution step under each execution plan based on the number of table tuples, column width, NULL record ratio, and characteristic values, such as distinct, MCV, and HB values, and certain cost calculation methods. The database then selects the execution plan that takes the lowest cost for the overall execution or for the return of the first tuple. These characteristic values are the statistics, which is the core for optimizing a query. Accurate statistics helps the planner select the most appropriate query plan. Generally, you can collect statistics of a table or that of some columns in a table using **ANALYZE**. You are advised to periodically execute **ANALYZE** or execute it immediately after you modified most contents in a table.

## Optimizing Queries Using GUC Parameters

Optimizing queries aims to select an efficient execution mode.

Take the following SQL statement as an example:

```
select count(1)
from customer inner join store_sales on (ss_customer_sk = c_customer_sk);
```

During execution of **customer inner join store_sales**, GaussDB supports nested loop, merge join, and hash join. The optimizer estimates the result set sizes and the execution cost for each join mode based on the statistics on the **customer** and

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**store_sales** tables. It then compares the costs and selects the one costing the least.

As described in the preceding content, the execution cost is calculated based on certain methods and statistics. If the actual execution cost cannot be accurately estimated, you need to optimize the execution plan by setting the GUC parameters.

### Optimizing Queries Using the Underlying Storage

GaussDB supports row- and column-store tables. The selection of an underlying storage mode strongly depends on specific customer service scenarios. You are advised to use column-store tables for computing service scenarios (mainly involving association and aggregation operations) and row-store tables for service scenarios, such as point queries and massive **UPDATE** or **DELETE** executions.

Optimization methods of each storage mode will be described in detail below.

### Optimizing Queries by Rewriting SQL Statements

Besides the preceding methods that improve the performance of the execution plan generated by the SQL engine, database administrators can also enhance SQL statement performance by rewriting SQL statements while retaining the original service logic based on the execution mechanism of the database and abundant practices.

This requires that database administrators know the customer services well and have professional knowledge of SQL statements. Below chapters will describe some common SQL rewriting scenarios.

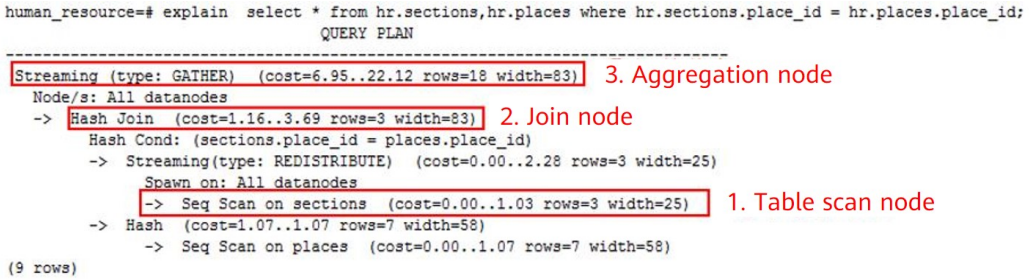
## 10.3.2 Introduction to the SQL Execution Plan

### 10.3.2.1 Overview

The SQL execution plan is a node tree, which displays detailed procedure when GaussDB runs an SQL statement. A database operator indicates one step.

You can run the **EXPLAIN** command to view the execution plan generated for each query by an optimizer. The output of **EXPLAIN** has one row for each execution node, showing the basic node type and the cost estimation that the optimizer made for the execution of this node, as shown in **Figure 10-3**.

**Figure 10-3** SQL execution plan example

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- Nodes at the bottom level are scan nodes. They scan tables and return raw rows. The types of scan nodes (sequential scans and index scans) vary depending on the table access methods. Objects scanned by the bottom layer nodes may not be row-store data (not directly read from a table), such as **VALUES** clauses and functions that return rows, which have their own types of scan nodes.
- If the query requires join, aggregation, sorting, or other operations on the raw rows, there will be other nodes above the scan nodes to perform these operations. In addition, there is more than one way to perform these operations, so different types of execution nodes may be displayed here.
- The first row (the upper-layer node) estimates the total execution cost of the execution plan. Such an estimate indicates the value that the optimizer tries to minimize.

## Execution Plan Display Format

GaussDB provides four display formats: **normal**, **pretty**, **summary**, and **run**.

- **normal** indicates that the default printing format is used, as shown in **Figure 10-3**.
- **pretty** indicates that the optimized display mode of GaussDB is used. A new format contains a plan node ID, directly and effectively analyzing performance, as shown in **Figure 10-4**.
- **summary** indicates that the analysis result on this information is printed in addition to the printed information in the format specified by **pretty**.
- **run** indicates that in addition to the printed information specified by **summary**, the database exports the information as a CSV file.

**Figure 10-4** Example of an execution plan using the pretty format

```
openGauss=# explain select cjxh, count(1) from dwcjk group by cjxh;
 id |               operation                | E-rows | E-memory | E-width | E-costs
----+----------------------------------------+--------+----------+---------+---------
  1 | ->  Row Adapter                        |      1 |          |      52 | 58.42
  2 |    ->  Vector Streaming (type: GATHER) |      1 |          |      52 | 58.42
  3 |       ->  Vector Hash Aggregate        |      1 | 16MB     |      52 | 58.02
  4 |          ->  CStore Scan on dwcjk      |      1 | 1MB      |      44 | 58.00
(4 rows)
```

You can change the display format of execution plans by setting **explain_perf_mode**. Later examples use the pretty format by default.

## Execution Plan Information

In addition to setting different display formats for an execution plan, you can use different **EXPLAIN** syntax to display execution plan information in detail. The following lists the common **EXPLAIN** syntax. For details about more **EXPLAIN** syntax, see **12.14.137 EXPLAIN**.

- EXPLAIN *statement*: only generates an execution plan and does not execute. The *statement* indicates SQL statements.
- EXPLAIN ANALYZE *statement*: generates and executes an execution plan, and displays the execution summary. Then actual execution time statistics are

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added to the display, including the total elapsed time expended within each plan node (in milliseconds) and the total number of rows it actually returned.

- EXPLAIN PERFORMANCE *statement*: generates and executes the execution plan, and displays all execution information.

To measure the run time cost of each node in the execution plan, the current execution of **EXPLAIN ANALYZE** or **EXPLAIN PERFORMANCE** adds profiling overhead to query execution. Running **EXPLAIN ANALYZE** or **EXPLAIN PERFORMANCE** on a query sometimes takes longer time than executing the query normally. The amount of overhead depends on the nature of the query, as well as the platform being used.

Therefore, if an SQL statement is not finished after being running for a long time, run the **EXPLAIN** statement to view the execution plan and then locate the fault. If the SQL statement has been properly executed, run the **EXPLAIN ANALYZE** or **EXPLAIN PERFORMANCE** statement to check the execution plan and information to locate the fault.

## 10.3.2.2 Description

As described in **10.3.2.1 Overview**, **EXPLAIN** displays the execution plan, but will not actually run SQL statements. **EXPLAIN ANALYZE** and **EXPLAIN PERFORMANCE** both will actually run SQL statements and return the execution information. This section describes the execution plan and execution information in detail.

## Execution Plans

The following SQL statement is used as an example:

```
select
   cjxh,
   count(1)
from dwcjk
group by cjxh;
```

Run the **EXPLAIN** command and the output is as follows:

```
openGauss=# explain select cjxh, count(1) from dwcjk group by cjxh;
 id |               operation                | E-rows | E-memory | E-width | E-costs
----+----------------------------------------+--------+----------+---------+---------
  1 | ->  Row Adapter                        |      1 |          |      52 | 58.42
  2 |    ->  Vector Streaming (type: GATHER) |      1 |          |      52 | 58.42
  3 |       ->  Vector Hash Aggregate        |      1 | 16MB     |      52 | 58.02
  4 |          ->  CStore Scan on dwcjk      |      1 | 1MB      |      44 | 58.00
(4 rows)
```

**Interpretation of the execution plan column (horizontal)**:

- **id**: ID of a node corresponding to each execution operator
- **operation**: name of an execution operator

  An operator prefixed with **Vector** is a vectorized executor operator, usually used in a query containing a column-store table.

  Streaming is a special operator. It implements the core data shuffle function of the distributed architecture. Streaming has three types, which correspond to different data shuffle functions in the distributed architecture:

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  - Streaming (type: GATHER): The CN collects data from DNs.
  - Streaming (type: REDISTRIBUTE): Data is redistributed to all the DNs based on selected columns.
  - Streaming (type: BROADCAST): Data on the current DN is broadcast to other DNs.
- **E-rows**: number of output rows estimated by each operator
- **E-memory**: estimated memory used by each operator on a DN. Only operators executed on DNs are displayed. In certain scenarios, the memory upper limit enclosed in parentheses will be displayed following the estimated memory usage.
- **E-width**: estimated width of an output tuple of each operator
- **E-costs**: execution cost estimated by each operator
  - **E-costs** is measured by the optimizer based on an overhead unit. Usually, fetching a disk page is defined as a unit. Other overhead parameters are set based on the unit.
  - The overhead of each node (specified by **E-costs**) includes the overheads of all its child nodes.
  - Such an overhead reflects only what the optimizer is concerned about, but does not consider the time for transferring result rows to the client. Although the time may play a very important role in the actual total time, it is ignored by the optimizer, because it cannot be changed by modifying the plan.

**Interpretation of the execution plan level (vertical)**:

1. Layer 1: **CStore Scan on dwcjk**

   The table scan operator scans the table **dwcjk** using **CStore Scan**. At this layer, data in the table **dwcjk** is read from a buffer or disk, and then transferred to the upper-layer node for calculation.

2. Layer 2: **Vector Hash Aggregate**

   Aggregation operator. It is used to perform aggregation (**GROUP BY**) on the data transferred from the lower layer.

3. Layer 3: **Vector Streaming (type: GATHER)**

   GATHER-type Shuffle operator. It is used to aggregate data from DNs to the CN.

4. Layer 4: **Row Adapter**

   Storage format conversion operator. It is used to convert memory data from column storage to row storage for client display.

If the operator in the top layer is **Data Node Scan**, set **enable_fast_query_shipping** to **off** to view the detailed execution plan. The following is an example plan.

```
openGauss=# explain select cjxh, count(1) from dwcjk group by cjxh;
                QUERY PLAN
--------------------------------------------------
 Data Node Scan  (cost=0.00..0.00 rows=0 width=0)
   Node/s: All datanodes
(2 rows)
```

After **enable_fast_query_shipping** is set, the execution plan will be displayed as follows:

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```
openGauss=# set enable_fast_query_shipping=off;
SET
openGauss=# explain select cjxh, count(1) from dwcjk group by cjxh;
 id |               operation                | E-rows | E-memory | E-width | E-costs
----+----------------------------------------+--------+----------+---------+---------
  1 | ->  Row Adapter                        |      1 |          |      52 | 58.42
  2 |    ->  Vector Streaming (type: GATHER) |      1 |          |      52 | 58.42
  3 |       ->  Vector Hash Aggregate        |      1 | 16MB     |      52 | 58.02
  4 |          ->  CStore Scan on dwcjk      |      1 | 1MB      |      44 | 58.00
(4 rows)
```

**Keywords in the execution plan**:

1. Table access modes
   - Seq Scan

     Scans all rows of the table in sequence.
   - Index Scan

     The optimizer uses a two-step plan: the child plan node visits an index to find the locations of rows matching the index condition, and then the upper plan node actually fetches those rows from the table itself. Fetching rows separately is much more expensive than reading them sequentially, but because not all pages of the table have to be visited, this is still cheaper than a sequential scan. The upper-layer planning node sorts index-identified rows based on their physical locations before reading them. This minimizes the independent capturing overhead.

     If there are separate indexes on multiple columns referenced in **WHERE**, the optimizer might choose to use an **AND** or **OR** combination of the indexes. However, this requires the visiting of both indexes, so it is not necessarily a win compared to using just one index and treating the other condition as a filter.

     The following index scans featured with different sorting mechanisms are involved:

     - Bitmap index scan

       Fetches data pages using a bitmap.
     - Index scan using index_name

       Fetches table rows in index order, which makes them even more expensive to read. However, there are so few rows that the extra cost of sorting the row locations is unnecessary. This plan type is used mainly for queries fetching just a single row and queries having an **ORDER BY** condition that matches the index order, because no extra sorting step is needed to satisfy **ORDER BY**.
2. Table connection modes
   - Nested Loop

     A nested loop is used for queries that have a smaller data set connected. In a nested loop join, the foreign table drives the internal table and each row returned from the foreign table should have a matching row in the internal table. The returned result set of all queries should be less than 10,000. The table that returns a smaller subset will work as a foreign

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table, and indexes are recommended for connection columns of the internal table.

- (Sonic) Hash Join

  A hash join is used for large tables. The optimizer uses a hash join, in which rows of one table are entered into an in-memory hash table, after which the other table is scanned and the hash table is probed for matches to each row. Sonic and non-Sonic hash joins differ in their hash table structures, which do not affect the execution result set.

- Merge Join

  In most cases, the execution performance of a merge join is lower than that of a hash join. However, if the source data has been pre-sorted and no more sorting is needed during the merge join, its performance excels.

3. Operators
   - sort

     Sorts the result set.

   - filter

     The **EXPLAIN** output shows the **WHERE** clause being applied as a **Filter** condition attached to the **Seq Scan** plan node. This means that the plan node checks the condition for each row it scans, and returns only the ones that meet the condition. The estimated number of output rows has been reduced because of the **WHERE** clause. However, the scan will still have to visit all 10,000 rows, as a result, the cost is not decreased. It increases a bit (by 10,000 x **cpu_operator_cost**) to reflect the extra CPU time spent on checking the **WHERE** condition.

   - LIMIT

     Limits the number of output execution results. If a **LIMIT** condition is added, not all rows are retrieved.

## Execution Information

In SQL optimization process, you can use **EXPLAIN ANALYZE** or **EXPLAIN PERFORMANCE** to check the SQL statement execution information. By comparing estimation differences between actual implementation and the optimizer, basis for service optimization is provided. **EXPLAIN PERFORMANCE** provides the execution information on each DN, whereas **EXPLAIN ANALYZE** does not.

The following SQL statement is used as an example:

```
select count(1) from tb1;
```

The output of running **EXPLAIN PERFORMANCE** is as follows:

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```
openGauss=#  explain performance select count(1) from tbl;
 id |               operation                |    A-time      | A
----+----------------------------------------+----------------+--
  1 | ->  Aggregate                          | 19.269         |
  2 |    ->  Streaming (type: GATHER)        | 19.191         |
  3 |       ->  Aggregate                    | [0.004,0.069] |
  4 |          ->  Seq Scan on public.tbl | [0.001,0.060] |
(4 rows)

            Memory Information (identified by plan id)
-----------------------------------------------------------------
 Coordinator Query Peak Memory:
        Query Peak Memory: 0MB
 DataNode Query Peak Memory
        datanode1 Query Peak Memory: 0MB
        datanode2 Query Peak Memory: 0MB
        datanode3 Query Peak Memory: 0MB
        datanode4 Query Peak Memory: 0MB
   1 --Aggregate
        Peak Memory: 10KB, Estimate Memory: 64MB
   2 --Streaming (type: GATHER)
        Peak Memory: 144KB, Estimate Memory: 64MB
   3 --Aggregate
        datanode1 Peak Memory: 10KB, Estimate Memory: 1024KB
        datanode2 Peak Memory: 10KB, Estimate Memory: 1024KB
        datanode3 Peak Memory: 10KB, Estimate Memory: 1024KB
        datanode4 Peak Memory: 10KB, Estimate Memory: 1024KB
        datanode1 Stream Send time: 0.000; Data Serialize ti
        datanode2 Stream Send time: 0.000; Data Serialize ti
        datanode3 Stream Send time: 0.000; Data Serialize ti
        datanode4 Stream Send time: 0.000; Data Serialize ti
   4 --Seq Scan on public.tbl
        datanode1 Peak Memory: 12KB, Estimate Memory: 1024KB
        datanode2 Peak Memory: 12KB, Estimate Memory: 1024KB
        datanode3 Peak Memory: 12KB, Estimate Memory: 1024KB
        datanode4 Peak Memory: 12KB, Estimate Memory: 1024KB
(25 rows)
```

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```
 Targetlist Information (identified by plan id)
------------------------------------------------
   1 --Aggregate
         Output: count((count(1)))
   2 --Streaming (type: GATHER)
         Output: (count(1))
         Node/s: All datanodes
   3 --Aggregate
         Output: count(1)
   4 --Seq Scan on public.tb1
         Output: a, b
         Distribute Key: a
(10 rows)
```

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```
                    Datanode Information (identified by plan id
-------------------------------------------------------------------
   1 --Aggregate
         (actual time=19.269..19.269 rows=1 loops=1)
         (Buffers: 0)
         (CPU: ex c/r=50593, ex row=4, ex cyc=202372, inc cyc
   2 --Streaming (type: GATHER)
         (actual time=12.371..19.191 rows=4 loops=1)
         (Buffers: 0)
         (CPU: ex c/r=12473027, ex row=4, ex cyc=49892108, in
   3 --Aggregate
         datanode1 (actual time=0.041..0.041 rows=1 loops=1)
         datanode2 (actual time=0.063..0.063 rows=1 loops=1)
         datanode3 (actual time=0.069..0.069 rows=1 loops=1)
         datanode4 (actual time=0.004..0.004 rows=1 loops=1)
         datanode1 (Buffers: shared hit=1)
         datanode2 (Buffers: shared hit=1)
         datanode3 (Buffers: shared hit=1)
         datanode4 (Buffers: 0)
         datanode1 (CPU: ex c/r=32888, ex row=1, ex cyc=32888
         datanode2 (CPU: ex c/r=9992, ex row=2, ex cyc=19984,
         datanode3 (CPU: ex c/r=12272, ex row=2, ex cyc=24544
         datanode4 (CPU: ex c/r=0, ex row=0, ex cyc=8100, inc
   4 --Seq Scan on public.tb1
         datanode1 (actual time=0.027..0.029 rows=1 loops=1)
         datanode2 (actual time=0.054..0.055 rows=2 loops=1)
         datanode3 (actual time=0.059..0.060 rows=2 loops=1)
         datanode4 (actual time=0.001..0.001 rows=0 loops=1)
         datanode1 (Buffers: shared hit=1)
         datanode2 (Buffers: shared hit=1)
         datanode3 (Buffers: shared hit=1)
         datanode4 (Buffers: 0)
         datanode1 (CPU: ex c/r=74852, ex row=1, ex cyc=74852
         datanode2 (CPU: ex c/r=71640, ex row=2, ex cyc=14328
         datanode3 (CPU: ex c/r=77732, ex row=2, ex cyc=15546
         datanode4 (CPU: ex c/r=0, ex row=0, ex cyc=2668, inc
(34 rows)
```

```
                    User Define Profiling
------------------------------------------------------------
 Plan Node id: 2  Track name: coordinator get datanode connec
       coordinator1: (time=0.054 total_calls=1 loops=1)
(2 rows)

                      ====== Query Summary =====
------------------------------------------------------------
 Datanode executor start time [datanode1, datanode2]: [1.352
 Datanode executor end time [datanode4, datanode3]: [0.121 ms
 Remote query poll time: 10.992 ms, Deserialze time: 0.000 ms
 System available mem: 9188966KB
 Query Max mem: 9473228KB
 Query estimated mem: 2048KB
 Coordinator executor start time: 0.505 ms
 Coordinator executor run time: 19.277 ms
 Coordinator executor end time: 0.380 ms
 Planner runtime: 2.260 ms
 Query Id: 79375943434081342
 Total runtime: 20.803 ms
(12 rows)
```

This figure shows that the execution information can be classified into the following seven aspects.

1. The plan is displayed as a table, which contains 11 columns: **id**, **operation**, **A-time**, **A-rows**, **E-rows**, **E-distinct**, **Peak Memory**, **E-memory**, **A-width**, **E-width**, and **E-costs**. The definition of the plan-type columns (columns started with id, operation, or E) is the same as that of running **EXPLAIN**. For details, see **Execution Plans**. The definition of **A-time**, **A-rows**, **E-distinct**, **Peak Memory**, and **A-width** are described as follows:
   - **A-time**: execution completion time of the operator. Generally, **A-time** of the operator is two values enclosed with square brackets ([]), indicating the shortest time and longest time for completing the operator on all DNs, respectively.
   - **A-rows**: number of actual output tuples of the operator
   - **E-distinct**: estimated distinct value of the Hash Join operator
   - **Peak Memory**: peak memory of the operator on each DN
   - **A-width**: actual tuple width in each row of the current operator. This parameter is valid only for heavy memory operators, including (Vec)HashJoin, (Vec)HashAgg, (Vec)HashSetOp, (Vec)Sort, and (Vec)Materialize. The (Vec)HashJoin calculation width is the width of its right subtree operator and will be displayed on the right subtree.
2. **Predicate Information (identified by plan id)**:

   This part displays the static information that does not change in the plan execution process, such as some join conditions and filter information.
3. **Memory Information (identified by plan id)**:

   This part displays the memory usage information printed by certain operators (mainly Hash and Sort), including **peak memory**, **control memory**, **operator**

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**memory**, **width**, **auto spread num**, and **early spilled**; and spill details, including **spill Time(s)**, **inner/outer partition spill num**, **temp file num**, spilled data volume, and **written disk IO [***min, max***]**.

4. **Targetlist Information (identified by plan id)**:

   This part displays the target columns provided by each operator.

5. **DataNode Information (identified by plan id)**:

   The execution time, CPU, and buffer usage of each operator are printed in this part.

6. **User Define Profiling**:

   This part displays CNs and DNs, DN and DN connection time, and some execution information at the storage layer.

7. **====== Query Summary =====**:

   The total execution time and network traffic, including the maximum and minimum execution time in the initialization and end phases on each DN, the time in the initialization, execution, and end phases on each CN, the system available memory and statement estimation memory information during the current statement execution, are printed in this part.

**NOTICE**

- The difference between **A-rows** and **E-rows** shows the deviation between the optimizer estimation and actual execution. Generally, if the deviation is larger, the plan generated by the optimizer is more improper, and more manual intervention and optimization are required.
- If the difference of the **A-time** values is larger, the operator computing skew (difference between execution time on different DNs) is larger, and more manual intervention and optimization are required.
- **Max Query Peak Memory** is often used to estimate the consumed memory of SQL statements, and is also used as an important basis for setting a running memory parameter during SQL statement optimization. Generally, the output from **EXPLAIN ANALYZE** or **EXPLAIN PERFORMANCE** is provided for the input for further optimization.

## 10.3.3 Optimization Process

You can analyze slow SQL statements to optimize them.

### Procedure

**Step 1** Collect all table statistics associated with the SQL statements. In a database, statistics indicate the source data of a plan generated by a planner. If no collection statistics are available or out of date, the execution plan may seriously deteriorate, leading to low performance. According to past experience, about 10% performance problems occurred because no statistics are collected. For details, see **10.3.4 Updating Statistics**.

**Step 2** View the execution plan to find out the cause. If the SQL statements have been running for a long period of time and not ended, run the **EXPLAIN** statement to view the execution plan and then locate the fault. If the SQL statement has been

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properly executed, run the **EXPLAIN ANALYZE** or **EXPLAIN PERFORMANCE** statement to check the execution plan and information to locate the fault. For details about the execution plan, see **10.3.2 Introduction to the SQL Execution Plan**.

**Step 3** **Review and modify a table definition**.

**Step 4** For details about **EXPLAIN** or **EXPLAIN PERFORMANCE**, the reason why SQL statements are slowly located, and how to solve this problem, see **10.3.6 Typical SQL Optimization Methods**.

**Step 5** Generally, some SQL statements can be converted to its equivalent statements in all or certain scenarios by rewriting queries. SQL statements are simpler after they are rewritten. Some execution steps can be simplified to improve the performance. Query rewriting methods are universal in all databases. **10.3.7 Experience in Rewriting SQL Statements** describes several tuning methods by rewriting SQL statements.

**----End**

# 10.3.4 Updating Statistics

In a database, statistics indicate the source data of a plan generated by a planner. If no statistics are available or out of date, the execution plan may seriously deteriorate, leading to low performance.

## Background

The **ANALYZE** statement collects statistic about table contents in databases, which will be stored in the **PG_STATISTIC** system catalog. Then, the query optimizer uses the statistics to work out the most efficient execution plan.

After executing batch insertions and deletions, you are advised to run the **ANALYZE** statement on the table or the entire library to update statistics. By default, 30,000 rows of statistics are sampled. That is, the default value of the GUC parameter **default_statistics_target** is **100**. If the total number of rows in the table exceeds 1,600,000, you are advised to set **default_statistics_target** to **-2**, indicating that 2% of the statistics are collected.

For an intermediate table generated during the execution of a batch script or stored procedure, you also need to run the **ANALYZE** statement.

If there are multiple inter-related columns in a table and the conditions or grouping operations based on these columns are involved in the query, collect statistics about these columns so that the query optimizer can accurately estimate the number of rows and generate an effective execution plan. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

## Procedure

Run the following commands to update the statistics about a table or the entire database:

```
ANALYZE tablename;                --Update statistics about a table.
ANALYZE;                        ---Update statistics about the entire database.
```

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Run the following statements to perform statistics-related operations on multiple columns:

```
ANALYZE tablename ((column_1, column_2));                    --Collect statistics about column_1 and column_2 of tablename.

ALTER TABLE tablename ADD STATISTICS ((column_1, column_2));    --Declare statistics about column_1 and column_2 of tablename.
ANALYZE tablename;                                           --Collect statistics about one or more columns.

ALTER TABLE tablename DELETE STATISTICS ((column_1, column_2)); --Delete statistics about column_1 and column_2 of tablename or their statistics declaration.
```

**NOTICE**

After the statistics are declared for multiple columns by running the **ALTER TABLE** *tablename* **ADD STATISTICS** statement, the system collects the statistics about these columns next time **ANALYZE** is performed on the table or the entire database.

To collect the statistics, run the **ANALYZE** statement.

**NOTE**

Use **EXPLAIN** to show the execution plan of each SQL statement. If **rows=10** (the default value, probably indicating that the table has not been analyzed) is displayed in the **SEQ SCAN** output of a table, run the **ANALYZE** statement for this table.

## 10.3.5 Reviewing and Modifying a Table Definition

### 10.3.5.1 Overview

In a distributed framework, data is distributed on DNs. Data on one or more DNs is stored on a physical storage device. To properly define a table, you must:

1. **Evenly distribute data on each DN** to avoid the available capacity decrease of a cluster caused by insufficient storage space of the storage device associated with a DN. Specifically, select a proper distribution key to avoid data skew.
2. **Evenly assign table scanning tasks on each DN** to avoid that a single DN is overloaded by the table scanning tasks. Specifically, do not select columns in the equivalent filter of a base table as the distribution key.
3. **Reduce the data volume scanned** by using the partition pruning mechanism.
4. **Minimize random I/Os** by using clustering or partial clustering.
5. **Avoid data shuffle** to reduce the network pressure by selecting the **join-condition** or **group by** column as the distribution key.

The distribution key is the core for defining a table. **Figure 10-5** shows the procedure of defining a table. The table definition is created during the database design and is reviewed and modified during the SQL statement optimization.

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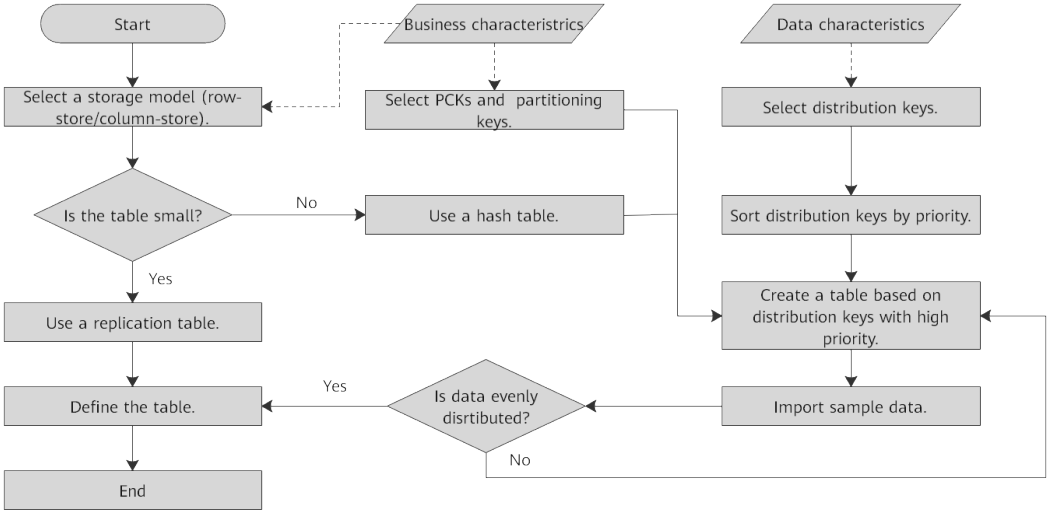
**Figure 10-5** Procedure of defining a table




## 10.3.5.2 Selecting a Storage Model

During database design, some key factors about table design will greatly affect the subsequent query performance of the database. Table design affects data storage as well. Scientific table design reduces I/O operations and minimizes memory usage, improving the query performance.

Selecting a model for table storage is the first step of table definition. Select a proper storage model for your service based on the following table.

| Storage Model | Application Scenario |
| --- | --- |
| Row storage | Point queries (simple index-based queries that only return a few records)<br>Scenarios requiring frequent addition, deletion, and modification operations |
| Column storage | Statistics analysis query, in which operations, such as group and join, are performed many times |

## 10.3.5.3 Selecting a Distribution Mode

In replication mode, full data in a table is copied to each DN in the cluster. This mode is used for tables containing a small volume of data. Full data in a table stored on each DN avoids data redistribution during the join operation. This reduces network costs and plan segment (each having a thread), but generates much redundant data. Generally, this mode is only used for small dimension tables.

In hash mode, hash values are generated for one or more columns. You can obtain the storage location of a tuple based on the mapping between DNs and the hash values. In a hash table, I/O resources on each node can be used during data read/write, which improves the read/write speed of a table. Generally, a table containing a large amount data is defined as a hash table.

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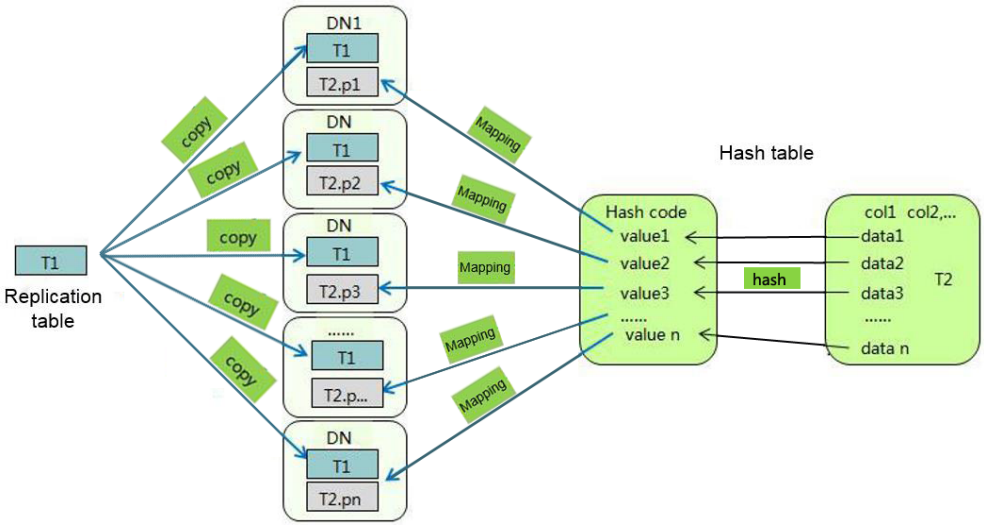
Range distribution and list distribution are user-defined distribution policies. Values in a distribution column are within a certain range or fall into a specific value range of the corresponding target DN. The two distribution modes facilitate flexible data management which, however, requires users equipped with certain data abstraction capability.

| Policy | Description | Application Scenario |
| --- | --- | --- |
| Hash | Table data is distributed on all DNs in the cluster. | Fact tables containing a large amount of data |
| Replication | Full data in a table is stored on every DN in the cluster. | Small tables and dimension tables |
| Range | Table data is mapped to specified columns based on the range and distributed to the corresponding DNs. | Users need to customize distribution rules. |
| List | Table data is mapped to specified columns based on specific values and distributed to corresponding DNs. | Users need to customize distribution rules. |

As shown in **Figure 10-6**, **T1** is a replication table and **T2** is a hash table.

**Figure 10-6** Replication tables and hash tables




## 10.3.5.4 Selecting Distribution Keys

Selecting a distribution key for a hash table is essential. Details are as follows:

1. **Ensure that the column values are discrete so that data can be evenly distributed to each DN.** You can select the primary key of the table as the distribution key. For example, for a person information table, choose the ID card number column as the distribution key.
2. **Do not select the column that has a constant filter.** For example, if a constant constraint (for example, zqdh= '000001') exists on the **zqdh** column

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in some queries on the **dwcjk** table, you are not advised to use **zqdh** as the distribution key.

3. **Select the join condition as the distribution key**, so that join tasks can be pushed down to DNs to execute, reducing the amount of data transferred between the DNs.

For a hash table, an improper distribution key may cause data skew or poor I/O performance on certain DNs. Therefore, you need to check the table to ensure that data is evenly distributed on each DN. You can run the following SQL statement to check for data skew:

```
select
xc_node_id, count(1)
from tablename
group by xc_node_id
order by xc_node_id desc;
```

**xc_node_id** corresponds to a DN. Generally, **over 5% difference between the amount of data on different DNs is regarded as data skew. If the difference is over 10%, choose another distribution key.**

Multiple distribution keys can be selected in GaussDB to evenly distribute data.

You can select the distribution key of the range or list distribution table as required. In addition to selecting a proper distribution key, pay attention to the impact of distribution rules on data distribution.

## 10.3.5.5 Using PCKs

The PCK is the column-store-based technology. It can minimize or maximize sparse indexes to quickly filter base tables. You are advised to select a maximum of two columns as PCKs. Use the following principles to specify PCKs:

1. The selected PCKs must be restricted by simple expressions in base tables. Such constraints are usually represented by *col op const*, in which *col* indicates the column name, *op* indicates operators, (including =, >, >=, <=, and <), and *const* indicates constants.
2. Select columns that are frequently selected (to filter much more undesired data) in simple expressions.
3. List the less frequently selected columns on the top.
4. List the columns of the enumerated type at the top.

## 10.3.5.6 Using Partitioned Tables

Partitioning refers to splitting what is logically one large table into smaller physical pieces based on specific schemes. The table based on the logic is called a partitioned table, and a physical piece is called a partition. Data is stored on these physical partitions, instead of the logical partitioned table. A partitioned table has the following advantages over an ordinary table:

1. High query performance: You can specify partitions when querying partitioned tables, improving query efficiency.
2. High availability: If a certain partition in a partitioned table is faulty, data in the other partitions is still available.
3. Easy maintenance: To fix a partitioned table having a faulty partition, you only need to fix the partition.

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GaussDB supports range partitioned tables.

Range partitioned table: Data in different ranges is mapped to different partitions. The range is determined by the partition key specified during the partitioned table creation. The partition key is usually a date. For example, sales data is partitioned by month.

### 10.3.5.7 Selecting a Data Type

Use the following principles to select efficient data types:

1. **Select data types that facilitate data calculation.**

   Generally, the calculation of integers (including common comparison calculations, such as =, >, <, ≥, ≤, and ≠ and group by) is more efficient than that of strings and floating point numbers. For example, if you need to perform a point query on a column-store table whose numeric column is used as a filter condition, the query will take over 10s. If you change the data type from **NUMERIC** to **INT**, the query duration will be reduced to 1.8s.

2. **Select data types with a short length.**

   Data types with short length reduce both the data file size and the memory used for computing, improving the I/O and computing performance. For example, use **SMALLINT** instead of **INT**, and **INT** instead of **BIGINT**.

3. **Use the same data type for a join.**

   You are advised to use the same data type for a join. To join columns with different data types, the database needs to convert them to the same type, which leads to additional performance overheads.

## 10.3.6 Typical SQL Optimization Methods

SQL optimization involves continuous analysis and trying. Queries are run before they are used for services to determine whether the performance meets requirements. If it does not, queries will be optimized by **checking the execution plan** and identifying the causes. Then, the queries will be run and optimized again until they meet the requirements.

### 10.3.6.1 Optimizing SQL Self-Diagnosis

Performance issues may occur when you query data or run the **INSERT**, **DELETE**, **UPDATE**, or **CREATE TABLE AS** statement. In this case, you can query the **warning** column in the **15.3.88 GS_WLM_SESSION_STATISTICS**, **15.3.83 GS_WLM_SESSION_HISTORY**, and **15.2.33 GS_WLM_SESSION_QUERY_INFO_ALL** views to obtain reference for performance optimization.

Alarms that can trigger SQL self diagnosis depend on the settings of **resource_track_level**. If **resource_track_level** is set to **query**, alarms about the failures in collecting column statistics and pushing down SQL statements will trigger the diagnosis. If **resource_track_level** is set to **operator**, all alarms will trigger the diagnosis.

Whether a SQL plan will be diagnosed depends on the settings of **resource_track_cost**. A SQL plan will be diagnosed only if its execution cost is greater than **resource_track_cost**. You can use the **EXPLAIN** keyword to check the plan execution cost.

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The SQL self-diagnosis function is affected by the **enable_analyze_check** parameter. Ensure that the function is enabled before using it.

If a large number of statements are executed, certain data may fail to be collected due to memory control. In this case, you can increase the value of **instr_unique_sql_count**.

## Alarms

Currently, the following performance alarms will be reported:

- Some column statistics are not collected.

An alarm will be reported if some column statistics are not collected. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) For details about the optimization, see **10.3.4 Updating Statistics** and **10.3.6.4 Optimizing Statistics**.

An alarm will also be reported if column statistics are not collected for queries on OBS foreign tables. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The performance of the **ANALYZE** statement executed for OBS foreign tables is poor and seems inefficient for a simple query. Run this statement as needed.

Example alarms:

No statistics about a table are not collected.

```
Statistic Not Collect:
    schema_test.t1
```

The statistics about a single column are not collected.

```
Statistic Not Collect:
    schema_test.t2(c1,c2)
```

The statistics about multiple columns are not collected.

```
Statistic Not Collect:
    schema_test.t3((c1,c2))
```

The statistics about a single column and multiple columns are not collected.

```
Statistic Not Collect:
    schema_test.t4(c1,c2)    schema_test.t4((c1,c2))
```

- SQL statements are not pushed down.

  The cause details are displayed in the alarms. For details about the optimization, see **10.3.6.2 Optimizing Statement Pushdown**.

  - If the pushdown failure is caused by functions, the function names are displayed in the alarm.
  - If the pushdown failure is caused by syntax, the alarm indicates that the syntax does not support pushdown. For example, the syntax containing the **With Recursive**, **Distinct On**, or **Row** expression, and syntax whose return value is of record type do not support pushdown.

Example alarms:

```
SQL is not plan-shipping, reason : "With Recursive" can not be shipped"
SQL is not plan-shipping, reason : "Function now() can not be shipped"
SQL is not plan-shipping, reason : "Function string_agg() can not be shipped"
```

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- In a hash join, the larger table is used as the inner table.

An alarm will be reported if the number of rows in the inner table reaches or exceeds 10 times of that in the outer table, more than 100 thousand of inner-table rows are processed on each DN in average, and the join statement has spilled to disks. You can view the **query_plan** column in **15.3.83 GS_WLM_SESSION_HISTORY** to check whether the hash join is used. For details about the optimization, see **10.3.9 Hint-based Tuning**.

Example alarms:

```
PlanNode[7] Large Table is INNER in HashJoin "Vector Hash Aggregate"
```

- **nestloop** is used in a large-table equivalent join.

An alarm will be reported if **nestloop** is used in an equivalent join where more than 100 thousand of the larger-table rows are processed on each DN in average. You can view the **query_plan** column of **15.3.83 GS_WLM_SESSION_HISTORY** to check whether **nestloop** is used. For details about the optimization, see **15.3.83 GS_WLM_SESSION_HISTORY**.

Example alarms:

```
PlanNode[5] Large Table with Equal-Condition use Nestloop"Nested Loop"
```

- A large table is broadcasted.

An alarm will be reported if more than 100 thousand of rows are broadcast on each DN in average. For details about the optimization, see **10.3.9 Hint-based Tuning**.

Example alarms:

```
PlanNode[5] Large Table in Broadcast "Streaming(type: BROADCAST dop: 1/2)"
```

- Data skew occurs.

An alarm will be reported if the number of rows processed on any DN exceeds 100 thousand, and the number of rows processed on a DN reaches or exceeds 10 times of that processed on another DN. For the optimization, see **10.4.1 Case: Selecting an Appropriate Distribution Key** and **10.3.6.6 Optimizing Data Skew**.

Example alarms:

```
PlanNode[6] DataSkew:"Seq Scan", min_dn_tuples:0, max_dn_tuples:524288
```

- Estimation is inaccurate.

An alarm will be reported if the maximum number or the estimated maximum number of rows processed on a DN is over 10 thousand, and the larger number reaches or exceeds 10 times of the smaller one. For details about the optimization, see **10.3.9 Hint-based Tuning**.

Example alarms:

```
PlanNode[5] Inaccurate Estimation-Rows: "Hash Join" A-Rows:0, E-Rows:52488
```

## Restrictions

1. An alarm contains a maximum of 2048 characters. If the length of an alarm exceeds this value (for example, a large number of long table names and column names are displayed in the alarm when their statistics are not collected), a warning instead of an alarm will be reported.

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```
WARNING, "Planner issue report is truncated, the rest of planner issues will be skipped"
```

2. If a query statement contains the **Limit** operator, alarms of operators lower than **Limit** will not be reported.
3. For alarms about data skew and inaccurate estimation, only alarms on the lower-layer nodes in a plan tree will be reported. This is because the same alarms on the upper-level nodes may be triggered by problems on the lower-layer nodes. For example, if data skew occurs on the **Scan** node, data skew may also occur in operators (for example, **Hashagg**) at the upper layer.

## 10.3.6.2 Optimizing Statement Pushdown

### Statement Pushdown

Currently, the GaussDB optimizer can use three methods to develop statement execution policies in the distributed framework: generating a statement pushdown plan, a distributed execution plan, or a distributed execution plan for sending statements.

- A statement pushdown plan pushes query statements from a CN down to DNs for execution and returns the execution results to the CN.
- In a distributed execution plan, a CN compiles and optimizes query statements, generates a plan tree, and then sends the plan tree to DNs for execution. After the statements have been executed, execution results will be returned to the CN.
- A distributed execution plan for sending statements pushes queries that can be pushed down (mostly base table scanning statements) to DNs for execution. Then, the plan obtains the intermediate results and sends them to the CN, on which the remaining queries are to be executed.

The third policy sends many intermediate results from DNs to the CN for further execution. In this case, the CN performance bottleneck (in bandwidth, storage, and computing) is caused by statements that cannot be pushed down to DNs. Therefore, you are not advised to use the query statements where only the third policy applies.

Statements cannot be pushed down to DNs if they have **functions that do not support pushdown** or **syntax that does not support pushdown**. Generally, you can rewrite the execution statements to solve the problem.

### Typical Scenarios of Statement Pushdown

In the GaussDB optimizer, if you want to support statement pushdown, set the GUC parameter **enable_fast_query_shipping** to **on**. Generally, no execution plan operator is displayed after the EXPLAIN statement. If the keyword similar to "Data Node Scan on" is displayed in the first line (excluding the plan format), the statement has been pushed down to DNs for execution. The following describes statement pushdown and its supported scope from three scenarios.

**1. Pushdown of single-table query statements**

In a distributed database, to query a single table, whether the current statement can be pushed down depends on whether the CN needs to participate in calculation instead of simply collecting data. If the CN needs to further calculate the DN result, the statement cannot be pushed down. Generally, statements with

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keywords such as **agg**, **windows function**, **limit/offset**, **sort**, **distinct** cannot be pushed down.

- Pushdown: Simple queries can be pushed down without further calculation on the CN.

```
openGauss=# explain select * from t where c1 > 1;
                            QUERY PLAN
------------------------------------------------------------------------------
 Data Node Scan on "__REMOTE_FQS_QUERY__"  (cost=0.00..0.00 rows=0 width=0)
   Node/s: All datanodes
(2 rows)
```

- Non-pushdown: A CN with the **limit** clause cannot simply send statements to DNs and collect data, which is inconsistent with the semantics of the **limit** clause.

```
openGauss=# explain select * from t limit 1;
                                QUERY PLAN
---------------------------------------------------------------------------------------
 Limit  (cost=0.00..0.00 rows=1 width=12)
   ->  Data Node Scan on "__REMOTE_LIMIT_QUERY__"  (cost=0.00..0.00 rows=1 width=12)
         Node/s: All datanodes
(3 rows)
```

- Non-pushdown: A CN with the **aggregate** function cannot simply push down statements. Instead, it needs to further aggregate the results collected from DNs.

```
openGauss=# explain select sum(c1), count(*) from t;
                                QUERY PLAN
---------------------------------------------------------------------------------------
 Aggregate  (cost=0.10..0.11 rows=1 width=20)
   ->  Data Node Scan on "__REMOTE_GROUP_QUERY__"  (cost=0.00..0.00 rows=20 width=4)
         Node/s: All datanodes
(3 rows)
```

**2. Pushdown of multi-table query statements**

In the multi-table query scenario, whether a statement can be pushed down depends on the **join** condition and distribution columns. That is, if the **join** condition matches the distribution columns of the table, the statement can be pushed down. Otherwise, the statement cannot be pushed down. Generally, a replication table can be pushed down.

- Create two hash distribution tables.

```
openGauss=# create table t(c1 int, c2 int, c3 int)distribute by hash(c1);
CREATE TABLE
openGauss=# create table t1(c1 int, c2 int, c3 int)distribute by hash(c1);
CREATE TABLE
```

- Pushdown: The **join** condition meets the hash distribution column attributes of two tables.

```
openGauss=# explain select * from t1 join t on t.c1 = t1.c1;
                            QUERY PLAN
------------------------------------------------------------------------------
 Data Node Scan on "__REMOTE_FQS_QUERY__"  (cost=0.00..0.00 rows=0 width=0)
   Node/s: All datanodes
(2 rows)
```

- Non-pushdown: The **join** condition does not meet the hash distribution column attribute. That is, **t1.c2** is not the distribution column of **t1**.

```
openGauss=# explain select * from t1 join t on t.c1 = t1.c2;
                                  QUERY PLAN
-------------------------------------------------------------------------------------------
 Hash Join  (cost=0.25..0.53 rows=20 width=24)
   Hash Cond: (t1.c2 = t.c1)
   ->  Data Node Scan on t1 "_REMOTE_TABLE_QUERY_"  (cost=0.00..0.00 rows=20 width=12)
         Node/s: All datanodes
```

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```
  ->  Hash  (cost=0.00..0.00 rows=20 width=12)
        ->  Data Node Scan on t "_REMOTE_TABLE_QUERY_"  (cost=0.00..0.00 rows=20 width=12)
              Node/s: All datanodes
(7 rows)
```

**3. Special scenarios**

In some special scenarios, for example, a statement containing the **with recursive** clause or a column-store table cannot be pushed down.

## Checking Whether the Execution Plan Has Been Pushed Down to DNs

Perform the following procedure to quickly determine whether the execution plan can be pushed down to DNs:

**Step 1** Set the GUC parameter **enable_fast_query_shipping** to **off** to use the distributed framework policy for the query optimizer.

```
SET enable_fast_query_shipping = off;
```

**Step 2** View the execution plan.

If the execution plan contains Data Node Scan nodes, the execution plan is a distributed execution plan for sending statements and cannot be pushed down. If the execution plan contains Streaming nodes, the SQL statements can be pushed down to DNs.

For example:

```
select
count(ss.ss_sold_date_sk order by ss.ss_sold_date_sk)c1
from store_sales ss, store_returns sr
where
sr.sr_customer_sk = ss.ss_customer_sk;
```

The execution plan is as follows, which indicates that the SQL statement cannot be pushed down.

```
                            QUERY PLAN
------------------------------------------------------------------------------
Aggregate
->  Hash Join
Hash Cond: (ss.ss_customer_sk = sr.sr_customer_sk)
->  Data Node Scan on store_sales "_REMOTE_TABLE_QUERY_"
Node/s: All datanodes
->  Hash
->  Data Node Scan on store_returns "_REMOTE_TABLE_QUERY_"
Node/s: All datanodes
(8 rows)
```

**----End**

## Syntax That Does Not Support Pushdown

SQL syntax that does not support pushdown is described using the following table definition examples:

```
openGauss=# CREATE TABLE CUSTOMER1
(
    C_CUSTKEY     BIGINT NOT NULL
  , C_NAME        VARCHAR(25) NOT NULL
  , C_ADDRESS     VARCHAR(40) NOT NULL
  , C_NATIONKEY   INT NOT NULL
```

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```
  , C_PHONE       CHAR(15) NOT NULL
  , C_ACCTBAL     DECIMAL(15,2)   NOT NULL
  , C_MKTSEGMENT  CHAR(10) NOT NULL
  , C_COMMENT     VARCHAR(117) NOT NULL
)
DISTRIBUTE BY hash(C_CUSTKEY);
openGauss=# CREATE TABLE test_stream(a int, b float);--float does not support redistribution.
openGauss=# CREATE TABLE sal_emp ( c1 integer[] ) DISTRIBUTE BY replication;
```

- The **returning** statement cannot be pushed down.

```
openGauss=# explain update customer1 set C_NAME = 'a' returning c_name;
                            QUERY PLAN
------------------------------------------------------------------
 Update on customer1  (cost=0.00..0.00 rows=30 width=187)
   Node/s: All datanodes
   Node expr: c_custkey
   ->  Data Node Scan on customer1 "_REMOTE_TABLE_QUERY_"  (cost=0.00..0.00 rows=30 width=187)
         Node/s: All datanodes
(5 rows)
```

- If a SQL statement contains the aggregate functions using **ORDER BY**, this statement cannot be pushed down.

```
openGauss=# explain verbose select count ( c_custkey order by c_custkey) from customer1;

                        QUERY PLAN
------------------------------------------------------------------- Aggregate  (cost=2.50..2.51 rows=1 width=8)
   Output: count(customer1.c_custkey ORDER BY customer1.c_custkey)
   ->  Data Node Scan on customer1 "_REMOTE_TABLE_QUERY_"  (cost=0.00..0.00 rows=30 width=8)
         Output: customer1.c_custkey
         Node/s: All datanodes
         Remote query: SELECT c_custkey FROM ONLY public.customer1 WHERE true
(6 rows)
```

- If a SQL statement contains **COUNT(DISTINCT *expr*)** and columns in **COUNT(DISTINCT *expr*)** do not support redistribution, this statement cannot be pushed down.

```
openGauss=# explain verbose select count(distinct b) from test_stream;
                                    QUERY PLAN
------------------------------------------------------------------------- Aggregate  (cost=2.50..2.51 rows=1 width=8)
   Output: count(DISTINCT test_stream.b)
   ->  Data Node Scan on test_stream "_REMOTE_TABLE_QUERY_"  (cost=0.00..0.00 rows=30 width=8)
         Output: test_stream.b
         Node/s: All datanodes
         Remote query: SELECT b FROM ONLY public.test_stream WHERE true
(6 rows)
```

- A statement containing **DISTINCT ON** cannot be pushed down.

```
openGauss=# explain verbose select distinct on (c_custkey) c_custkey from customer1 order by
c_custkey;
                                    QUERY PLAN
------------------------------------------------------------------------- Unique  (cost=49.83..54.83 rows=30 width=8)
   Output: customer1.c_custkey
   ->  Sort  (cost=49.83..52.33 rows=30 width=8)
         Output: customer1.c_custkey
         Sort Key: customer1.c_custkey
         ->  Data Node Scan on customer1 "_REMOTE_TABLE_QUERY_"  (cost=0.00..0.00 rows=30
width=8)
               Output: customer1.c_custkey
               Node/s: All datanodes
               Remote query: SELECT c_custkey FROM ONLY public.customer1 WHERE true
(9 rows)
```

- A statement containing array expressions cannot be pushed down.

```
openGauss=# explain verbose select array[c_custkey,1] from customer1 order by c_custkey;

                        QUERY PLAN
------------------------------------------------------------------- Sort  (cost=49.83..52.33 rows=30 width=8)
   Output: (ARRAY[customer1.c_custkey, 1::bigint]), customer1.c_custkey
   Sort Key: customer1.c_custkey
   ->  Data Node Scan on "__REMOTE_SORT_QUERY__"  (cost=0.00..0.00 rows=30 width=8)
```

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```
        Output: (ARRAY[customer1.c_custkey, 1::bigint]), customer1.c_custkey
        Node/s: All datanodes
        Remote query: SELECT ARRAY[c_custkey, 1::bigint], c_custkey FROM ONLY public.customer1
WHERE true ORDER BY 2
(7 rows)
```

- The following table describes the scenarios where a statement containing **WITH RECURSIVE** cannot be pushed down in the current version, as well as the causes.

| No. | Scenario | Cause of Not Supporting Pushdown |
| --- | --- | --- |
| 1 | The query contains foreign tables. | LOG: SQL can't be shipped, reason: RecursiveUnion contains ForeignScan is not shippable (In this table, **LOG** describes the cause of not supporting pushdown.)<br>In the current version, queries containing foreign tables do not support pushdown. |
| 2 | Multiple node groups | LOG: SQL can't be shipped, reason: With-Recursive under multi-nodegroup scenario is not shippable<br>In the current version, pushdown is supported only when all base tables are stored and computed in the same node group. |
| 3 | **ALL** is not used for **UNION**. In this case, the return result is deduplicated. | LOG: SQL can't be shipped, reason: With-Recursive does not contain "ALL" to bind recursive & none-recursive branches<br>For example:<br>`WITH recursive t_result AS (`<br>`SELECT dm,sj_dm,name,1 as level`<br>`FROM test_rec_part`<br>`WHERE sj_dm > 10`<br>`UNION`<br>`SELECT t2.dm,t2.sj_dm,t2.name\|\|' > '\|\|`<br>`t1.name,t1.level+1`<br>`FROM t_result t1`<br>`JOIN test_rec_part t2 ON t2.sj_dm = t1.dm`<br>`)`<br>`SELECT * FROM t_result t;` |

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| No. | Scenario | Cause of Not Supporting Pushdown |
| --- | --- | --- |
| 4 | A base table contains the system catalog. | LOG: SQL can't be shipped, reason: With-Recursive contains system table is not shippable<br>For example:<br>WITH RECURSIVE x(id) AS<br>(<br>select count(1) from pg_class where oid=1247<br>UNION ALL<br>SELECT id+1 FROM x WHERE id < 5<br>), y(id) AS<br>(<br>select count(1) from pg_class where oid=1247<br>UNION ALL<br>SELECT id+1 FROM x WHERE id < 10<br>)<br>SELECT y.*, x.* FROM y LEFT JOIN x USING (id) ORDER BY 1; |
| 5 | Only **VALUES** is used for scanning base tables. In this case, the statement can be executed on the CN, and DNs are unnecessary. | LOG: SQL can't be shipped, reason: With-Recursive contains only values rte is not shippable<br>For example:<br>WITH RECURSIVE t(n) AS (<br>VALUES (1)<br>UNION ALL<br>SELECT n+1 FROM t WHERE n < 100<br>)<br>SELECT sum(n) FROM t; |
| 6 | Only the recursion part has correlation conditions of correlated subqueries, and the non-recursion part has no correlation condition. | LOG: SQL can't be shipped, reason: With-Recursive recursive term correlated only is not shippable<br>For example:<br>select  a.ID,a.Name,<br>(<br>with recursive cte as (<br>select ID, PID, NAME from b where b.ID = 1<br>union all<br>select parent.ID,parent.PID,parent.NAME from cte as child join b as parent on child.pid=parent.id<br>where child.ID = a.ID<br>)<br>select NAME from cte limit 1<br>) cName<br>from<br>(<br>select id, name, count(*) as cnt<br>from a group by id,name<br>) a order by 1,2; |

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| No. | Scenario | Cause of Not Supporting Pushdown |
| --- | --- | --- |
| 7 | The **replicate** plan is used for **limit** in the non-recursion part but the **hash** plan is used in the recursion part, resulting in conflicts. | LOG: SQL can't be shipped, reason: With-Recursive contains conflict distribution in none-recursive(Replicate) recursive(Hash)<br>For example:<br>`WITH recursive t_result AS (`<br>`select * from(`<br>`SELECT dm,sj_dm,name,1 as level`<br>`FROM test_rec_part`<br>`WHERE sj_dm < 10 order by dm limit 6 offset 2)`<br>`UNION all`<br>`SELECT t2.dm,t2.sj_dm,t2.name||' > '|| t1.name,t1.level+1`<br>`FROM t_result t1`<br>`JOIN test_rec_part t2 ON t2.sj_dm = t1.dm`<br>`)`<br>`SELECT * FROM t_result t;` |
| 8 | **recursive** of multiple-layers are nested. That is, a **recursive** is nested in the recursion part of another **recursive**. | LOG: SQL can't be shipped, reason: Recursive CTE references recursive CTE "cte"<br>For example:<br>`with recursive cte as`<br>`(`<br>`select * from rec_tb4 where id<4`<br>`union all`<br>`select h.id,h.parentID,h.name from`<br>`(`<br>`with recursive cte as`<br>`(`<br>`select * from rec_tb4 where id<4`<br>`union all`<br>`select h.id,h.parentID,h.name from rec_tb4 h inner join cte c on h.id=c.parentID`<br>`)`<br>`SELECT id ,parentID,name from cte order by parentID`<br>`) h`<br>`inner join cte  c on h.id=c.parentID`<br>`)`<br>`SELECT id ,parentID,name from cte order by parentID,1,2,3;` |

## Functions That Do Not Support Pushdown

The following describes the volatility of functions. In GaussDB, every function has a volatility classification, with the possibilities being:

- **IMMUTABLE**

  Indicates that the function always returns the same result if the parameter values are the same.

- **STABLE**

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Indicates that the function cannot modify the database, and that within a single table scan it will consistently return the same result for the same parameter value, but its result varies by SQL statements.

- **VOLATILE**

  Indicates that the function value can change in a single table scan and no optimization is performed.

The volatility of a function can be obtained by querying for its **provolatile** column in **pg_proc**. The value **i** indicates immutable, **s** indicates stable, and **v** indicates volatile. The valid values of the **proshippable** column in **pg_proc** are **t**, **f**, and **NULL**. This column and the **provolatile** column together describe whether a function is pushed down.

- If the **provolatile** of a function is **i**, the function can be pushed down regardless of the value of **proshippable**.
- If the **provolatile** of a function is **s** or **v**, the function can be pushed only if the value of **proshippable** is **t**.
- CTEs containing **random**, **exec_hadoop_sql**, or **exec_on_extension** are not pushed down, because pushdown may lead to incorrect results.

When creating a customized function, you can specify the values of **provolatile** and **proshippable**. For details, see **12.14.61 CREATE FUNCTION**.

In scenarios where a function does not support pushdown, perform one of the following as required:

- If it is a system function, replace it with a functionally equivalent one.
- If it is a customized function, check whether its **provolatile** and **proshippable** are correctly defined.

## Example: Customized Functions

Define a customized function that generates fixed output for a certain input as the **immutable** type.

Take the sales information of TPC Benchmark DS (TPC-DS) as an example. If you want to write a function to calculate the discount data of a product, you can define the function as follows:

```
CREATE FUNCTION func_percent_2 (NUMERIC, NUMERIC) RETURNS NUMERIC
AS 'SELECT $1 / $2 WHERE $2 > 0.01'
LANGUAGE SQL
VOLATILE;
```

Run the following statement:

```
SELECT func_percent_2(ss_sales_price, ss_list_price)
FROM store_sales;
```

The execution plan is as follows:

```
 Data Node Scan on store_sales "_REMOTE_TABLE_QUERY_"
   Output: func_percent_2(store_sales.ss_sales_price, store_sales.ss_list_price)
   Remote query: SELECT ss_sales_price, ss_list_price FROM ONLY store_sales WHERE true
(3 rows)
```

**func_percent_2** is not pushed down, and **ss_sales_price** and **ss_list_price** are executed on a CN. In this case, a large amount of resources on the CN is consumed, and the performance deteriorates as a result.

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In this example, the function generates the same output when the same input is provided. Therefore, we can modify the function to the following one:

```
CREATE FUNCTION func_percent_1 (NUMERIC, NUMERIC) RETURNS NUMERIC
AS 'SELECT $1 / $2 WHERE $2 > 0.01'
LANGUAGE SQL
IMMUTABLE;
```

Run the following statement:

```
SELECT func_percent_1(ss_sales_price, ss_list_price)
FROM store_sales;
```

The execution plan is as follows:

```
 Data Node Scan
   Output: (func_percent_1(store_sales.ss_sales_price, store_sales.ss_list_price))
   Remote query: SELECT func_percent_1(ss_sales_price, ss_list_price) AS func_percent_1 FROM store_sales
(3 rows)
```

**func_percent_1** is pushed down to DNs for quicker execution. (In TPC-DS 1000X, where three CNs and 18 DNs are used, the query efficiency is improved by over 100 times).

## Example 2: Pushing Down the Sorting Operation

For details, see **10.4.4 Case: Pushing Down Sort Operations to DNs**.

## 10.3.6.3 Optimizing Subqueries

## Background

When an application runs a SQL statement to operate the database, a large number of subqueries are used because they are more clear than table join. Especially in complicated query statements, subqueries have more complete and independent semantics, which makes SQL statements clearer and easier to understand. Therefore, subqueries are widely used.

In GaussDB, subqueries can also be called sublinks based on the location of subqueries in SQL statements.

- Subquery: corresponds to a range table (RangeTblEntry) in the query parse tree. That is, a subquery is a **SELECT** statement following immediately after the **FROM** keyword.
- Sublink: corresponds to an expression in the query parsing tree. That is, a sublink is a statement in the **WHERE** or **ON** clause or in the target list.

  In conclusion, a subquery is a RangeTblEntry and a sublink is an expression in the query parsing tree. A sublink can be found in constraint conditions and expressions. In GaussDB, sublinks can be classified into the following types:

  - exist_sublink: corresponds to the **EXIST** and **NOT EXIST** statements.
  - any_sublink: corresponds to the *op* **ANY(SELECT...)** statement. *op* can be the <, >, or = operator. **IN/NOT IN (SELECT...)** also belongs to this type.
  - all_sublink: corresponds to the *op* **ALL(SELECT...)** statement. *op* can be the <, >, or = operator.
  - rowcompare_sublink: corresponds to the **RECORD** *op* **(SELECT...)** statement.

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- expr_sublink: corresponds to the **(SELECT** *with a single target list item...*) statement.
- array_sublink: corresponds to the **ARRAY(SELECT...)** statement.
- cte_sublink: corresponds to the **WITH(...)** query statement.

The exist_sublink and any_sublink are pulled up by the optimization engine of GaussDB. In addition, expr_sublink can also be pulled up. However, because of the flexible use of subqueries in SQL statements, complex subqueries may affect query performance. If you do not want to pull up expr_sublink, set the GUC parameter **rewrite_rule**. For details, see **19.8.4 Other Optimizer Options**. Subqueries are classified into non-correlated subqueries and correlated subqueries.

- **Non-correlated subqueries**

  The execution of a subquery is independent from attributes of the outer query. In this way, a subquery can be executed before outer queries.

  For example:

```
select t1.c1,t1.c2
from t1
where t1.c1 in (
   select c2
   from t2
   where t2.c2 IN (2,3,4)
);
                        QUERY PLAN
------------------------------------------------------------------
Streaming (type: GATHER)
  Node/s: All datanodes
  ->  Hash Right Semi Join
        Hash Cond: (t2.c2 = t1.c1)
        ->  Streaming(type: REDISTRIBUTE)
              Spawn on: All datanodes
              ->  Seq Scan on t2
                    Filter: (c2 = ANY ('{2,3,4}'::integer[]))
        ->  Hash
              ->  Seq Scan on t1
(10 rows)
```

- **Correlated subqueries**

  The execution of a subquery depends on some attributes (used as **AND** conditions of the subquery) of outer queries. In the following example, **t1.c1** in the **t2.c1 = t1.c1** condition is a correlated attribute. Such a subquery depends on outer queries and needs to be executed once for each outer query.

  For example:

```
select t1.c1,t1.c2
from t1
where t1.c1 in (
   select c2
   from t2
   where t2.c1 = t1.c1 AND t2.c2 in (2,3,4)
);
                              QUERY PLAN
-----------------------------------------------------------------------
Streaming (type: GATHER)
  Node/s: All datanodes
  ->  Seq Scan on t1
        Filter: (SubPlan 1)
        SubPlan 1
          ->  Result
                Filter: (t2.c1 = t1.c1)
                ->  Materialize
```

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```
                    ->  Streaming(type: BROADCAST)
                        Spawn on: All datanodes
                        ->  Seq Scan on t2
                            Filter: (c2 = ANY ('{2,3,4}'::integer[]))
(12 rows)
```

## Sublink Optimization on GaussDB

To optimize a sublink, a subquery is pulled up to join with tables in outer queries, preventing the subquery from being converted into a plan involving subplans and broadcast. You can run the **EXPLAIN** statement to check whether a subquery is converted into such a plan.

For example:

```
select t1.c1,t1.c2
from t1
where t1.c1 in (
    select c2
    from t2
    where t2.c1 = t1.c1
);
```

```
QUERY PLAN
-------------------------------------------------------------
Streaming (type: GATHER)
  Node/s: All datanodes
  ->  Seq Scan on t1
        Filter: (SubPlan 1)
        SubPlan 1
          ->  Result
                Filter: (t2.c1 = t1.c1)
                ->  Materialize
                      ->  Streaming(type: BROADCAST)
                            Spawn on: All datanodes
                            ->  Seq Scan on t2
(11 rows)
```

- **Sublink-release scenarios supported by GaussDB**
  - Pulling up the **IN** sublink
    - The subquery cannot contain columns in the outer query (columns in more outer queries are allowed).
    - The subquery cannot contain volatile functions.

```
select t1.c1,t1.c2
from t1
where t1.c1 in (
    select c2
    from t2
    where t2.c1 = 1
);
```

```
QUERY PLAN
-------------------------------------------------
Streaming (type: GATHER)
  Node/s: All datanodes
  ->  Nested Loop Semi Join
        Join Filter: (t1.c1 = t2.c2)
        ->  Seq Scan on t1
        ->  Materialize
              ->  Streaming(type: REDISTRIBUTE)
                    Spawn on: datanode1
                    ->  Seq Scan on t2
                          Filter: (c1 = 1)
(10 rows)
```

  - Pulling up the **EXISTS** sublink

    The **WHERE** clause must contain a column in the outer query. Other parts of the subquery cannot contain the column. Other restrictions are as follows:
    - The subquery must contain the **FROM** clause.
    - The subquery cannot contain the **WITH** clause.
    - The subquery cannot contain aggregate functions.
    - The subquery cannot contain a **SET**, **SORT**, **LIMIT**, **WindowAgg**, or **HAVING** operation.
    - The subquery cannot contain volatile functions.

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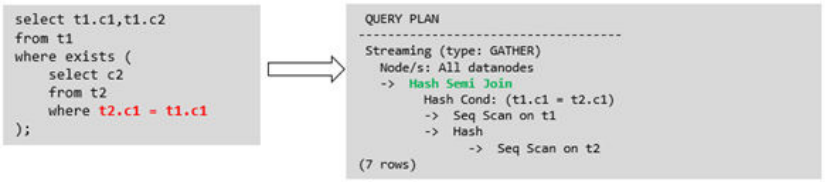


- Pulling up an equivalent correlated query containing aggregate functions

  The **WHERE** condition of the subquery must contain a column from the outer query. Equivalence comparison must be performed between this column and related columns in tables of the subquery. These conditions must be connected using **AND**. Other parts of the subquery cannot contain the column. Other restrictions are as follows:

  - The columns in the expression in the **WHERE** condition of the subquery must exist in tables.
  - After the **SELECT** keyword of the subquery, there must be only one output column. The output column must be an aggregate function (for example, **MAX**), and the parameter (for example, **t2.c2**) of the aggregate function cannot be columns of a table (for example, **t1**) in outer queries. The aggregate function cannot be **COUNT**.

    For example, the following subquery can be pulled up:

    ```
    select * from t1 where c1 >(
        select max(t2.c1) from t2 where t2.c1=t1.c1
    );
    ```

    The following subquery cannot be pulled up because the subquery has no aggregate function:

    ```
    select * from t1 where c1 >(
        select  t2.c1 from t2 where t2.c1=t1.c1
    );
    ```

    The following subquery cannot be pulled up because the subquery has two output columns:

    ```
    select * from t1 where (c1,c2) >(
        select  max(t2.c1),min(t2.c2) from t2 where t2.c1=t1.c1
    );
    ```

  - The subquery must be a **FROM** clause.
  - The subquery cannot contain a **GROUP BY**, **HAVING**, or **SET** operation.
  - The subquery can only be an inner join.

    For example, the following subquery cannot be pulled up:

    ```
    select * from t1 where c1 >(
        select max(t2.c1) from t2 full join t3 on (t2.c2=t3.c2) where t2.c1=t1.c1
    );
    ```

  - The target list of the subquery cannot contain the function that returns a set.
  - The **WHERE** condition of the subquery must contain a column from the outer query. Equivalence comparison must be performed between this column and related columns in tables of the subquery. These conditions must be connected using **AND**. Other parts of the

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subquery cannot contain the column. For example, the following subquery can be pulled up:

```
select * from t3 where t3.c1=(
      select t1.c1
      from t1 where c1 >(
            select max(t2.c1) from t2 where t2.c1=t1.c1
));
```

If another condition is added to the subquery in the previous example, the subquery cannot be pulled up because the subquery references to the column in the outer query. For example:

```
select * from t3 where t3.c1=(
      select t1.c1
      from t1 where c1 >(
            select max(t2.c1) from t2 where t2.c1=t1.c1 and t3.c1>t2.c2

));
```

- Pulling up a sublink in the **OR** clause

  If the **WHERE** condition contains an **EXIST** correlated sublink connected by **OR**:

  Example:

  ```
  select a, c from t1
  where t1.a = (select avg(a) from t3 where t1.b = t3.b) or
  exists (select * from t4 where t1.c = t4.c);
  ```

  The process of pulling up such a sublink is as follows:

  i. Extract **opExpr** from the **OR** clause in the **WHERE** condition. The value is **t1.a = (select avg(a) from t3 where t1.b = t3.b)**.

  ii. The **opExpr** contains a subquery. If the subquery can be pulled up, the subquery is rewritten as **select avg(a), t3.b from t3 group by t3.b**, generating the **NOT NULL** condition **t3.b is not null**. The **opExpr** is replaced with this **NOT NULL** condition. In this case, the SQL statement changes to:

  ```
  select a, c
  from t1 left join (select avg(a) avg, t3.b from t3 group by t3.b)  as t3 on (t1.a = avg and t1.b = t3.b)
  where t3.b is not null or exists (select * from t4 where t1.c = t4.c);
  ```

  iii. Extract the **EXISTS** sublink **exists (select * from t4 where t1.c = t4.c)** from the **OR** clause to check whether the sublink can be pulled up. If it can be pulled up, it is converted into **select t4.c from t4 group by t4.c**, generating the **NOT NULL** condition **t4.c is not null**. In this case, the SQL statement changes to:

  ```
  select t1.a, t1.c from t1 left join (select avg(a) avg, t3.b from t3 group by t3.b) as t3 on (t1.a = avg and t1.b = t3.b) left join (select t5.c from t5 group by t5.c) as t5 on (t1.c = t5.c) where t3.b is not null or t5.c is not null;
  ```

  ```
  select * from t1
  where exists (
      select t2.c1 from t2
      where t2.c1 = t1.c1
  ) OR
  exists (
      select t3.c1 from t3
      where t3.c1 = t1.c1
  );
  ```

  ⇒

  ```
  QUERY PLAN
  ------------------------------------------------------------
  Streaming (type: GATHER)
    Node/s: All datanodes
    ->  Hash Left Join
          Hash Cond: (t1.c1 = t3.c1)
          Filter: ((t2.c1 IS NOT NULL) OR (t3.c1 IS NOT NULL))
          ->  Hash Left Join
                Hash Cond: (t1.c1 = t2.c1)
                ->  Seq Scan on t1
                ->  Hash
                      ->  HashAggregate
                            Group By Key: t2.c1
                            ->  Seq Scan on t2
          ->  Hash
                ->  HashAggregate
                      Group By Key: t3.c1
                      ->  Seq Scan on t3
  (16 rows)
  ```

- **Sublink-release scenarios not supported by GaussDB**

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Except the sublinks described above, all the other sublinks cannot be pulled up. In this case, a join subquery is planned as the combination of subplans and broadcast. As a result, if tables in the subquery have a large amount of data, query performance may be poor.

If a correlated subquery joins with two tables in outer queries, the subquery cannot be pulled up. You need to change the outer query into a **WITH** clause and then perform the join.

For example:

```
select distinct t1.a, t2.a
from t1 left join t2 on t1.a=t2.a and not exists (select a,b from test1 where test1.a=t1.a and
test1.b=t2.a);
```

The outer query is changed into:

```
with temp as
(
      select * from (select t1.a as a, t2.a as b from t1 left join t2 on t1.a=t2.a)

)
select distinct a,b
from temp
where not exists (select a,b from test1 where temp.a=test1.a and temp.b=test1.b);
```

– The subquery (without **COUNT**) in the target list cannot be pulled up.

  For example:

  ```
  explain (costs off)
  select (select c2 from t2 where t1.c1 = t2.c1) ssq, t1.c2
  from t1
  where t1.c2 > 10;
  ```

  The execution plan is as follows:

  ```
  explain (costs off)
  select (select c2 from t2 where t1.c1 = t2.c1) ssq, t1.c2
  from t1
  where t1.c2 > 10;
                    QUERY PLAN
  ------------------------------------------------------------
   Streaming (type: GATHER)
     Node/s: All datanodes
     ->  Seq Scan on t1
           Filter: (c2 > 10)
           SubPlan 1
             ->  Result
                   Filter: (t1.c1 = t2.c1)
                   ->  Materialize
                         ->  Streaming(type: BROADCAST)
                               Spawn on: All datanodes
                               ->  Seq Scan on t2
  (11 rows)
  ```

  The correlated subquery is displayed in the target list (query return list). Values need to be returned even if the condition **t1.c1=t2.c1** is not met. Therefore, use left outer join to join **T1** and **T2** so that SSQ can return padding values when the condition **t1.c1=t2.c1** is not met.

  **NOTE**

  ScalarSubQuery (SSQ) and Correlated-ScalarSubQuery (CSSQ) are described as follows:

  - SSQ: a sublink that returns a scalar value of a single row with a single column
  - CSSQ: an SSQ containing correlation conditions

  The preceding SQL statement can be changed into:

  ```
  with ssq as
  (
  ```

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```
   select t2.c2 from t2
)
select ssq.c2, t1.c2
from t1 left join ssq on t1.c1 = ssq.c2
where t1.c2 > 10;
```

The execution plan after the change is as follows:

```
                QUERY PLAN
-------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Hash Right Join
         Hash Cond: (t2.c2 = t1.c1)
         ->  Streaming(type: REDISTRIBUTE)
               Spawn on: All datanodes
               ->  Seq Scan on t2
         ->  Hash
               ->  Seq Scan on t1
                     Filter: (c2 > 10)
(10 rows)
```

In the preceding example, the SSQ in the target list is pulled up to right join, preventing poor performance caused by the plan involving subplans and broadcast when the table (**T2**) in the subquery is too large.

- The subquery (with **COUNT**) in the target list cannot be pulled up.

  For example:

```
select (select count(*) from t2 where t2.c1=t1.c1) cnt, t1.c1, t3.c1
from t1,t3
where t1.c1=t3.c1 order by cnt, t1.c1;
```

  The execution plan is as follows:

```
                          QUERY PLAN
-----------------------------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Sort
         Sort Key: ((SubPlan 1)), t1.c1
         ->  Hash Join
               Hash Cond: (t1.c1 = t3.c1)
               ->  Seq Scan on t1
               ->  Hash
                     ->  Seq Scan on t3
               SubPlan 1
                 ->  Aggregate
                       ->  Result
                             Filter: (t2.c1 = t1.c1)
                             ->  Materialize
                                   ->  Streaming(type: BROADCAST)
                                         Spawn on: All datanodes
                                         ->  Seq Scan on t2
(17 rows)
```

  The correlated subquery is displayed in the target list (query return list). Values need to be returned even if the condition **t1.c1=t2.c1** is not met. Therefore, use left outer join to join **T1** and **T2** so that SSQ can return padding values when the condition **t1.c1=t2.c1** is not met. However, **COUNT** is used, which requires that **0** is returned when the condition is not met. Therefore, **case-when NULL then 0 else count(*)** can be used.

  The preceding SQL statement can be changed into:

```
with ssq as
(
   select count(*) cnt, c1 from t2 group by c1
)
select case when
          ssq.cnt is null then 0
```

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```
          else ssq.cnt
      end cnt, t1.c1, t3.c1
from t1 left join ssq on ssq.c1 = t1.c1,t3
where t1.c1 = t3.c1
order by ssq.cnt, t1.c1;
```

The execution plan after the change is as follows:

```
 QUERY PLAN
-----------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Sort
         Sort Key: (count(*)), t1.c1
         ->  Hash Join
               Hash Cond: (t1.c1 = t3.c1)
               ->  Hash Left Join
                     Hash Cond: (t1.c1 = t2.c1)
                     ->  Seq Scan on t1
                     ->  Hash
                           ->  HashAggregate
                                 Group By Key: t2.c1
                                 ->  Seq Scan on t2
               ->  Hash
                     ->  Seq Scan on t3
(15 rows)
```

– Non-equivalent correlated subqueries cannot be pulled up.

  For example:

```
select t1.c1, t1.c2
from t1
where t1.c1 = (select agg() from t2.c2 > t1.c2);
```

  Non-equivalent correlated subqueries cannot be pulled up. You can perform join twice (one CorrelationKey and one rownum self-join) to rewrite the statement.

  You can rewrite the statement in either of the following ways:

  - Subquery rewriting

```
select t1.c1, t1.c2
from t1, (
   select t1.rowid, agg() aggref
   from t1,t2
   where t1.c2 > t2.c2 group by t1.rowid
) dt /* derived table */
where t1.rowid = dt.rowid AND t1.c1 = dt.aggref;
```

  - CTE rewriting

```
WITH dt as
(
   select t1.rowid, agg() aggref
   from t1,t2
   where t1.c2 > t2.c2 group by t1.rowid
)
select t1.c1, t1.c2
from t1, derived_table
where t1.rowid = derived_table.rowid AND
t1.c1 = derived_table.aggref;
```

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**NOTICE**

- Currently, GaussDB does not have an effective way to provide globally unique row IDs for tables and intermediate result sets. Therefore, the rewriting is difficult. It is recommended that this issue is avoided at the service layer or by using **t1.xc_nodeid + t1.ctid** to associate row IDs. However, the high repetition rate of **xc_nodeid** leads to low association efficiency, and **xc_node_id+ctid** cannot be used as the join condition of a hash join.
- If the AGG type is **COUNT(*)**, **0** is used for data padding when **CASE-WHEN** is not matched. If the type is not **COUNT(*)**, **NULL** is used.
- CTE rewriting works better by using share scan.

## More Optimization Examples

1. Change the base table to a replication table and create an index on the filter column.

```
create table master_table (a int);
create table sub_table(a int, b int);
select a from master_table group by a having a in (select a from sub_table);
```

In this example, a correlated subquery is contained. To improve the query performance, you can change **sub_table** to a replication table and create an index on the **a** column.

2. Modify the **SELECT** statement to change the subquery to a **JOIN** relationship between the primary table and the parent query, or modify the subquery to improve the query performance. Ensure that the subquery to be used is semantically correct.

```
explain (costs off)select * from master_table as t1 where t1.a in (select t2.a from sub_table as t2 where t1.a
= t2.b);
                      QUERY PLAN
-------------------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Seq Scan on master_table t1
         Filter: (SubPlan 1)
         SubPlan 1
           ->  Result
                 Filter: (t1.a = t2.b)
                 ->  Materialize
                       ->  Streaming(type: BROADCAST)
                             Spawn on: All datanodes
                             ->  Seq Scan on sub_table t2
(11 rows)
```

In the preceding example, a subplan is used. To remove the subplan, you can modify the statement as follows:

```
explain(costs off) select * from master_table as t1 where exists (select t2.a from sub_table as t2 where t1.a
= t2.b and t1.a = t2.a);
                   QUERY PLAN
-------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Hash Semi Join
         Hash Cond: (t1.a = t2.b)
         ->  Seq Scan on master_table t1
```

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```
      ->  Hash
            ->  Streaming(type: REDISTRIBUTE)
                  Spawn on: All datanodes
                  ->  Seq Scan on sub_table t2
(9 rows)
```

In this way, the subplan is replaced by the semi-join between the two tables, greatly improving the execution efficiency.

## 10.3.6.4 Optimizing Statistics

## Background

GaussDB generates optimal execution plans based on the cost estimation. Optimizers need to estimate the number of data rows and the cost based on statistics collected using **ANALYZE**. Therefore, the statistics is vital for the estimation of the number of rows and cost. Global statistics are collected using **ANALYZE**: **relpages** and **reltuples** in the **pg_class** table; **stadistinct**, **stanullfrac**, **stanumbersN**, **stavaluesN**, and **histogram_bounds** in the **pg_statistic** table.

## Example 1: Poor Query Performance Due to the Lack of Statistics

In most cases, the lack of statistics about tables or columns involved in the query greatly affects the query performance.

The table structure is as follows:

```
CREATE TABLE LINEITEM
(
L_ORDERKEY        BIGINT        NOT NULL
, L_PARTKEY       BIGINT        NOT NULL
, L_SUPPKEY       BIGINT        NOT NULL
, L_LINENUMBER    BIGINT        NOT NULL
, L_QUANTITY      DECIMAL(15,2) NOT NULL
, L_EXTENDEDPRICE  DECIMAL(15,2) NOT NULL
, L_DISCOUNT      DECIMAL(15,2) NOT NULL
, L_TAX           DECIMAL(15,2) NOT NULL
, L_RETURNFLAG    CHAR(1)       NOT NULL
, L_LINESTATUS    CHAR(1)       NOT NULL
, L_SHIPDATE      DATE          NOT NULL
, L_COMMITDATE    DATE          NOT NULL
, L_RECEIPTDATE   DATE          NOT NULL
, L_SHIPINSTRUCT  CHAR(25)      NOT NULL
, L_SHIPMODE      CHAR(10)      NOT NULL
, L_COMMENT       VARCHAR(44)   NOT NULL
) with (orientation = column, COMPRESSION = MIDDLE) distribute by hash(L_ORDERKEY);

CREATE TABLE ORDERS
(
O_ORDERKEY       BIGINT        NOT NULL
, O_CUSTKEY      BIGINT        NOT NULL
, O_ORDERSTATUS  CHAR(1)       NOT NULL
, O_TOTALPRICE   DECIMAL(15,2) NOT NULL
, O_ORDERDATE    DATE NOT NULL
, O_ORDERPRIORITY CHAR(15)     NOT NULL
, O_CLERK        CHAR(15)      NOT NULL
, O_SHIPPRIORITY  BIGINT       NOT NULL
, O_COMMENT      VARCHAR(79)   NOT NULL
)with (orientation = column, COMPRESSION = MIDDLE) distribute by hash(O_ORDERKEY);
```

The query statements are as follows:

```
explain verbose select
count(*) as numwait
```

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```
from
lineitem l1,
orders
where
o_orderkey = l1.l_orderkey
and o_orderstatus = 'F'
and l1.l_receiptdate > l1.l_commitdate
and not exists (
select
*
from
lineitem l3
where
l3.l_orderkey = l1.l_orderkey
and l3.l_suppkey <> l1.l_suppkey
and l3.l_receiptdate > l3.l_commitdate
)
order by
numwait desc;
```

If such an issue occurs, you can use the following methods to check whether statistics in tables or columns has been collected using **ANALYZE**.

1. Execute **EXPLAIN VERBOSE** to analyze the execution plan and check the warning information:

   ```
   WARNING:Statistics in some tables or columns(public.lineitem.l_receiptdate,
   public.lineitem.l_commitdate, public.lineitem.l_orderkey, public.lineitem.l_suppkey,
   public.orders.o_orderstatus, public.orders.o_orderkey) are not collected.
   HINT:Do analyze for them in order to generate optimized plan.
   ```

2. Check whether the following information exists in the log file in the **pg_log** directory. If it does, the poor query performance was caused by the lack of statistics in some tables or columns.

   ```
   2017-06-14 17:28:30.336 CST 140644024579856 20971684 [BACKEND] LOG:Statistics in some tables
   or columns(public.lineitem.l_receiptdate, public.lineitem.l_commitdate, public.lineitem.l_orderkey,
   public.linei
   tem.l_suppkey, public.orders.o_orderstatus, public.orders.o_orderkey) are not collected.
   2017-06-14 17:28:30.336 CST 140644024579856 20971684 [BACKEND] HINT:Do analyze for them in
   order to generate optimized plan.
   ```

By using any of the preceding methods, you can identify tables or columns whose statistics have not been collected using **ANALYZE**. You can execute **ANALYZE** to warnings or tables and columns recorded in logs to resolve the problem.

## Example 2: Setting cost_param to Optimize Query Performance

See **10.4.5 Case: Setting cost_param and Optimizing Query Performance**.

## Example 3: Optimization is Not Accurate When Intermediate Results Exist in the Query Where JOIN Is Used for Multiple Tables

**Symptom**: Query the personnel who have registered in an Internet cafe within 15 minutes before and after the registration of a specified person.

```
SELECT
C.WBM,
C.DZQH,
C.DZ,
B.ZJHM,
B.SWKSSJ,
B.XWSJ
FROM
b_zyk_wbswxx A,
b_zyk_wbswxx B,
b_zyk_wbcs C
```

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```
WHERE
A.ZJHM = '522522******3824'
AND A.WBDM = B.WBDM
AND A.WBDM = C.WBDM
AND abs(to_date(A.SWKSSJ,'yyyymmddHH24MISS') - to_date(B.SWKSSJ,'yyyymmddHH24MISS')) <
INTERVAL '15 MINUTES'
ORDER BY
B.SWKSSJ,
B.ZJHM
limit 10 offset 0
;
```

**Figure 10-7** shows the execution plan. This query takes about 12s.

**Figure 10-7** Using an unlogged table (1)

```
                                                
```

```
A.WBDM,
to_char((to_date(A.SWKSSJ,'yyyymmddHH24MISS') - INTERVAL '15
MINUTES'),'yyyymmddHH24MISS'),
to_char((to_date(A.SWKSSJ,'yyyymmddHH24MISS') + INTERVAL '15
MINUTES'),'yyyymmddHH24MISS'),
B.WBM,B.DZQH,B.DZ,B.IPDZ
FROM
b_zyk_wbswxx A,
b_zyk_wbcs B
WHERE
A.ZJHM='522522******3824' AND A.WBDM = B.WBDM
;

// Query the personnel who have registered in an Internet cafe before and after 15 minutes of the registration of the specified person. Convert their ID card number format to int8 in comparison.
SELECT
A.WBM,
A.DZQH,
A.DZ,
A.IPDZ,
B.ZJHM,
B.XM,
to_date(B.SWKSSJ,'yyyymmddHH24MISS') as SWKSSJ,
to_date(B.XWSJ,'yyyymmddHH24MISS') as XWSJ,
B.SWZDH
FROM temp_tsw A,
b_zyk_wbswxx B
WHERE
A.ZJHM <> B.ZJHM
AND A.WBDM = B.WBDM
AND (B.SWKSSJ)::int8 > (A.swkssj_start)::int8
AND (B.SWKSSJ)::int8 < (A.swkssj_end)::int8
order by
B.SWKSSJ,
B.ZJHM
limit 10 offset 0
;
```

The query takes about 7s. **Figure 10-8** shows the execution plan.

**Figure 10-8** Using an unlogged table (2)

```
                                                
```

**Figure 10-9** shows the execution plan. The query takes about 3s.

**Figure 10-9** Using an unlogged table (3)

```
                                                
```

```
ORDER BY
SWKSSJ,
ZJHM
LIMIT 10 OFFSET 0;
```

**CAUTION**

Collecting more accurate statistics usually improves the query performance, but may also deteriorate the performance. If the performance deteriorates, you can:

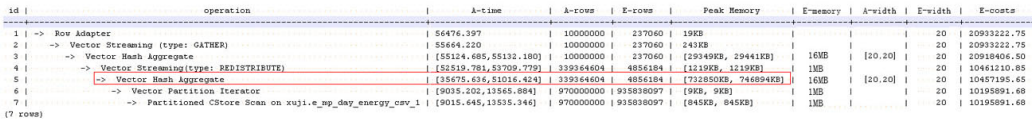
- Restore to the default statistics.
- Use hints to force the optimizer to use the optimal query plan. (For details, see **10.3.9 Hint-based Tuning**.)

## 10.3.6.5 Optimizing Operators

### Background

A query statement needs to go through multiple operator procedures to generate the final result. Sometimes, the overall query performance deteriorates due to long execution time of certain operators, which are regarded as bottleneck operators. In this case, you need to execute the **EXPLAIN ANALYZE** or **EXPLAIN PERFORMANCE** command to view the bottleneck operators, and then perform optimization.

For example, in the following execution process, the execution time of the **Hashagg** operator accounts for about 66% [(51016-13535)/56476 ≈ 66%] of the total execution time. Therefore, the **Hashagg** operator is the bottleneck operator for this query. Optimize this operator first.




### Example

1. Scan the base table. For queries requiring large volume of data filtering, such as point queries or queries that need range scanning, a full table scan using SeqScan will take a long time. To facilitate scanning, you can create indexes on the condition column and select IndexScan for index scanning.

```
openGauss=# explain (analyze on, costs off) select * from store_sales where ss_sold_date_sk = 2450944;
 id |             operation          |       A-time        | A-rows | Peak Memory  | A-width
----+--------------------------------+---------------------+--------+--------------+---------
  1 | ->  Streaming (type: GATHER)   | 3666.020            |   3360 | 195KB        |
  2 |    ->  Seq Scan on store_sales | [3594.611,3594.611] |   3360 | [34KB, 34KB] |
(2 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   2 --Seq Scan on store_sales
         Filter: (ss_sold_date_sk = 2450944)
         Rows Removed by Filter: 4968936
openGauss=# create index idx on store_sales_row(ss_sold_date_sk);
CREATE INDEX
```

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```
openGauss=# explain (analyze on, costs off) select * from store_sales_row where ss_sold_date_sk = 2450944;
 id |                    operation                     |     A-time      | A-rows | Peak Memory  | A-width
----+--------------------------------------------------+-----------------+--------+--------------+----------
  1 | ->  Streaming (type: GATHER)                     | 81.524          |   3360 | 195KB        |
  2 |    ->  Index Scan using idx on store_sales_row | [13.352,13.352] |   3360 | [34KB, 34KB] |
(2 rows)
```

In this example, the full table scan filters much data and returns 3360 records. After an index has been created on the **ss_sold_date_sk** column, the scanning efficiency is significantly boosted from 3.6s to 13 ms by using **IndexScan**.

2: If NestLoop is used for joining tables with a large number of rows, the join may take a long time. In the following example, NestLoop takes 181s. If **enable_mergejoin** is set to **off** to disable merge join and **enable_nestloop** is set to **off** to disable NestLoop so that the optimizer selects hash join, the join takes more than 200 ms.

```
openGauss=# explain analyze select count(*) from store_sales ss, item i where ss.ss_item_sk = i.i_item_sk;
 id |                       operation                       |         A-time          |  A-rows   | E-rows  |  Peak Memory   | E-memory | A-width | E-width |   E-costs
----+-------------------------------------------------------+-------------------------+-----------+---------+----------------+----------+---------+---------+-------------
  1 | ->  Row Adapter                                       | 184300.301              |         1 |       1 | 11KB           |          |         |       0 | 48629179.77
  2 |    ->  Vector Aggregate                               | 184300.280              |         1 |       1 | 181KB          |          |         |       0 | 48629179.77
  3 |       ->  Vector Streaming (type: GATHER)             | 184300.186              |         4 |       4 | 188KB          |          |         |       0 | 48629179.77
  4 |          ->  Vector Aggregate                         | [165575.384,184252.368] |         4 |       4 | [140KB, 140KB] | 1MB      |         |       0 | 48629179.61
  5 |             ->  Vector Nest Loop (6,7)                | [162918.848,181438.162] |   2880404 | 2880404 | [74KB, 74KB]   | 1MB      |         |       0 | 48627379.35
  6 |                ->  CStore Scan on store_sales ss      | [15.660,16.229]         |   2880404 | 2880404 | [490KB, 490KB] | 1MB      |         |       4 | 16683.10
  7 |                ->  Vector Materialize                 | [118314.521,132478.454] | 12968211302 |   18000 | [869KB, 900KB] | 16MB     | [8,8]   |       4 | 3890.00
  8 |                   ->  CStore Scan on item i           | [0.234,0.243]           |     18000 |   18000 | [476KB, 476KB] | 1MB      |         |       4 | 3867.50
(8 rows)
```

```
openGauss=# set enable_nestloop=off;
SET
openGauss=# set enable_mergejoin=off;
SET
openGauss=# explain analyze select count(*) fpostgres=# ales ss, item i where ss.ss_item_sk = i.i_item_sk;
 id |                       operation                       |         A-time          | A-rows  | E-rows  |  Peak Memory   | E-memory | A-width | E-width | E-costs
----+-------------------------------------------------------+-------------------------+---------+---------+----------------+----------+---------+---------+-----------
  1 | ->  Row Adapter                                       | 291.066                 |       1 |       1 | 11KB           |          |         |       0 | 32308.66
  2 |    ->  Vector Aggregate                               | 291.052                 |       1 |       1 | 181KB          |          |         |       0 | 32308.66
  3 |       ->  Vector Streaming (type: GATHER)             | 290.973                 |       4 |       4 | 188KB          |          |         |       0 | 32308.66
  4 |          ->  Vector Aggregate                         | [220.792,234.532]       |       4 |       4 | [140KB, 140KB] | 1MB      |         |       0 | 32308.50
  5 |             ->  Vector Hash Join (6,7)                | [209.987,223.345]       | 2880404 | 2880404 | [236KB, 241KB] | 16MB     | [8,8]   |       0 | 30508.24
  6 |                ->  CStore Scan on store_sales ss      | [13.132,13.717]         | 2880404 | 2880404 | [490KB, 490KB] | 1MB      |         |       4 | 16683.10
  7 |                ->  CStore Scan on item i              | [0.214,0.246]           |   18000 |   18000 | [477KB, 477KB] | 1MB      |         |       4 | 3867.50
(7 rows)
```

3. Generally, query performance can be improved by selecting **HashAgg**. If **Sort** and **GroupAgg** are used for a large result set, you need to set **enable_sort** to **off**. **HashAgg** consumes less time than **Sort** and **GroupAgg**.

```
openGauss=#  explain analyze select count(*) from store_sales group by ss_item_sk;
 id |                       operation                       |         A-time          | A-rows  | E-rows  |      Peak Memory      | E-memory | A-width | E-width | E-costs
----+-------------------------------------------------------+-------------------------+---------+---------+-----------------------+----------+---------+---------+-----------
  1 | ->  Row Adapter                                       | 1977.385                |   18000 |   17644 | 20KB                  |          |         |       4 | 92875.24
  2 |    ->  Vector Streaming (type: GATHER)                | 1973.617                |   18000 |   17644 | 1946KB                |          |         |       4 | 92875.24
  3 |       ->  Vector Sort Aggregate                       | [1784.800,1883.243]     |   18000 |   17644 | [273KB, 273KB]        | 1MB      |         |       4 | 92186.02
  4 |          ->  Vector Sort                              | [1752.270,1848.357]     | 2880404 | 2880404 | [128466KB, 135135KB]  | 16MB     | [8,8]   |       4 | 88541.40
  5 |             ->  CStore Scan on store_sales            | [12.483,13.548]         | 2880404 | 2880404 | [490KB, 490KB]        | 1MB      |         |       4 | 16683.10
(5 rows)
```

```
openGauss=#  set enable_sort=off;
SET
openGauss=#  explain analyze select count(*) from store_sales group by ss_item_sk;
 id |                       operation                       |         A-time          | A-rows  | E-rows  |      Peak Memory      | E-memory | A-width | E-width | E-costs
----+-------------------------------------------------------+-------------------------+---------+---------+-----------------------+----------+---------+---------+-----------
  1 | ->  Row Adapter                                       | 838.218                 |   18000 |   17644 | 20KB                  |          |         |       4 | 21016.93
  2 |    ->  Vector Streaming (type: GATHER)                | 834.264                 |   18000 |   17644 | 228KB                 |          |         |       4 | 21016.93
  3 |       ->  Vector Hash Aggregate                       | [585.017,758.204]       |   18000 |   17644 | [262552KB, 262564KB]  | 16MB     | [8,8]   |       4 | 20327.72
  4 |          ->  CStore Scan on store_sales               | [12.540,13.941]         | 2880404 | 2880404 | [490KB, 490KB]        | 1MB      |         |       4 | 16683.10
(4 rows)
```

## 10.3.6.6 Optimizing Data Skew

Data skew breaks the balance among nodes in the distributed MPP architecture. If the amount of data stored or processed by a node is much greater than that by other nodes, the following problems may occur:

- Storage skew severely limits the system capacity. The skew on a single node hinders system storage utilization.
- Computing skew severely affects performance. The data to be processed on the skew node is much more than that on other nodes, deteriorating overall system performance.

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- Data skew severely affects the scalability of the MPP architecture. During storage or computing, data with the same values is often placed on the same node. Therefore, even if we add nodes after a data skew occurs, the skew data (data with the same values) is still placed on the node and affects the system capacity or performance bottleneck.

GaussDB provides a complete solution for data skew, including storage and computing skew.

## Data Skew in the Storage Layer

In the GaussDB database, data is distributed and stored on each DN. You can improve the query efficiency by using distributed execution. However, if data skew occurs, bottlenecks exist on some DNs during distribution execution, affecting the query performance. This is because the distribution key is not properly selected. This can be solved by adjusting the distribution key.

For example:

```
openGauss=# explain performance select count(*) from inventory;
5 --CStore Scan on lmz.inventory
        dn_6001_6002 (actual time=0.444..83.127 rows=42000000 loops=1)
        dn_6003_6004 (actual time=0.512..63.554 rows=27000000 loops=1)
        dn_6005_6006 (actual time=0.722..99.033 rows=45000000 loops=1)
        dn_6007_6008 (actual time=0.529..100.379 rows=51000000 loops=1)
        dn_6009_6010 (actual time=0.382..71.341 rows=36000000 loops=1)
        dn_6011_6012 (actual time=0.547..100.274 rows=51000000 loops=1)
        dn_6013_6014 (actual time=0.596..118.289 rows=60000000 loops=1)
        dn_6015_6016 (actual time=1.057..132.346 rows=63000000 loops=1)
        dn_6017_6018 (actual time=0.940..110.310 rows=54000000 loops=1)
        dn_6019_6020 (actual time=0.231..41.198 rows=21000000 loops=1)
        dn_6021_6022 (actual time=0.927..114.538 rows=54000000 loops=1)
        dn_6023_6024 (actual time=0.637..118.385 rows=60000000 loops=1)
        dn_6025_6026 (actual time=0.288..32.240 rows=15000000 loops=1)
        dn_6027_6028 (actual time=0.566..118.096 rows=60000000 loops=1)
        dn_6029_6030 (actual time=0.423..82.913 rows=42000000 loops=1)
        dn_6031_6032 (actual time=0.395..78.103 rows=39000000 loops=1)
        dn_6033_6034 (actual time=0.376..51.052 rows=24000000 loops=1)
        dn_6035_6036 (actual time=0.569..79.463 rows=39000000 loops=1)
```

In the performance information, the number of scan lines on each DN in the inventory table is displayed. The maximum number of scan lines is 63000000, and the minimum number is 15000000, which is four times of the actual number. This value difference on the performance of data scan is acceptable, but if the join operator exists in the upper-layer, the impact on the performance cannot be ignored.

Generally, the data table is hash distributed on each DN; therefore, it is important to choose a proper distribution key. Run **table_skewness()** to view data skew of each DN in the inventory table. The query result is as follows:

```
openGauss=# select table_skewness('inventory');
              table_skewness
-------------------------------------------
 ("dn_6015_6016         ",63000000,8.046%)
 ("dn_6013_6014         ",60000000,7.663%)
 ("dn_6023_6024         ",60000000,7.663%)
 ("dn_6027_6028         ",60000000,7.663%)
 ("dn_6017_6018         ",54000000,6.897%)
 ("dn_6021_6022         ",54000000,6.897%)
 ("dn_6007_6008         ",51000000,6.513%)
 ("dn_6011_6012         ",51000000,6.513%)
 ("dn_6005_6006         ",45000000,5.747%)
```

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```
 ("dn_6001_6002          ",42000000,5.364%)
 ("dn_6029_6030          ",42000000,5.364%)
 ("dn_6031_6032          ",39000000,4.981%)
 ("dn_6035_6036          ",39000000,4.981%)
 ("dn_6009_6010          ",36000000,4.598%)
 ("dn_6003_6004          ",27000000,3.448%)
 ("dn_6033_6034          ",24000000,3.065%)
 ("dn_6019_6020          ",21000000,2.682%)
 ("dn_6025_6026          ",15000000,1.916%)
(18 rows)
```

The table definition indicates that the table uses the **inv_date_sk** column as the distribution key, which causes a data skew. Based on the data distribution of each column, change the distribution key to **inv_item_sk**. The skew status is as follows:

```
openGauss=# select table_skewness('inventory');
              table_skewness
-----------------------------------------
 ("dn_6001_6002          ",43934200,5.611%)
 ("dn_6007_6008          ",43829420,5.598%)
 ("dn_6003_6004          ",43781960,5.592%)
 ("dn_6031_6032          ",43773880,5.591%)
 ("dn_6033_6034          ",43763280,5.589%)
 ("dn_6011_6012          ",43683600,5.579%)
 ("dn_6013_6014          ",43551660,5.562%)
 ("dn_6027_6028          ",43546340,5.561%)
 ("dn_6009_6010          ",43508700,5.557%)
 ("dn_6023_6024          ",43484540,5.554%)
 ("dn_6019_6020          ",43466800,5.551%)
 ("dn_6021_6022          ",43458500,5.550%)
 ("dn_6017_6018          ",43448040,5.549%)
 ("dn_6015_6016          ",43247700,5.523%)
 ("dn_6005_6006          ",43200240,5.517%)
 ("dn_6029_6030          ",43181360,5.515%)
 ("dn_6025_6026          ",43179700,5.515%)
 ("dn_6035_6036          ",42960080,5.487%)
(18 rows)
```

Data skew is solved.

In addition to the **table_skewness()** view, you can use the **table_distribution** function and the **15.3.192 PGXC_GET_TABLE_SKEWNESS** view to efficiently query the data skew status of each table.

## Data Skew in the Computing Layer

Even if data is balanced across nodes after you change the distribution key of a table, data skew may still occur during a query. If data skew occurs in the result set of an operator on a DN, skew will also occur during the computing that involves the operator. Generally, this is caused by data redistribution during the execution.

During a query, **JOIN** keys and **GROUP BY** keys are not used as distribution keys. Data is redistributed among DNs based on the hash values of data on the keys. The redistribution is implemented using the Redistribute operator in an execution plan. Data skew in redistribution columns can lead to data skew during system operation. After the redistribution, some nodes will have much more data, process more data, and will have much lower performance than others.

In the following example, the **s** and **t** tables are joined, and **s.x** and **t.x** columns in the join condition are not their distribution keys. Table data is redistributed using the **REDISTRIBUTE** operator. Data skew occurs in the **s.x** column and not in the **t.x** column. The result set of the **Streaming** operator (**id** being **6**) on datanode2 has data three times that of other DNs and causes a skew.

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```
select * from skew s,test t where s.x = t.x order by s.a limit 1;
 id |                    operation                    |        A-time
----+-------------------------------------------------+----------------------
  1 | ->  Limit                                       | 52622.382
  2 |    ->  Streaming (type: GATHER)                 | 52622.374
  3 |       ->  Limit                                 | [30138.494,52598.994]
  4 |         ->  Sort                                | [30138.486,52598.986]
  5 |           ->  Hash Join (6,8)                   | [30127.013,41483.275]
  6 |             ->  Streaming(type: REDISTRIBUTE)   | [11365.110,22024.845]
  7 |               ->  Seq Scan on public.skew s     | [2019.168,2175.369]
  8 |             ->  Hash                            | [2460.108,2499.850]
  9 |               ->  Streaming(type: REDISTRIBUTE) | [1056.214,1121.887]
 10 |                 ->  Seq Scan on public.test t   | [310.848,325.569]
(10 rows)
 6 --Streaming(type: REDISTRIBUTE)
       datanode1 (rows=5050368)
       datanode2 (rows=15276032)
       datanode3 (rows=5174272)
       datanode4 (rows=5219328)
```

Computing skew is more difficult to detect than storage skew. To solve computing skew, GaussDB provides the Runtime Load Balance Technology (RLBT) solution, controlled by the **skew_option** parameter. The RLBT solution addresses how to detect and solve data skew.

1. Detect data skew.

   The solution first checks whether skew data exists in redistribution columns used for computing. RLBT can detect data skew based on statistics, specified hints, or rules.

   - Detection based on statistics

     Run the **ANALYZE** statement to collect statistics on tables. The optimizer will automatically identify skew data on redistribution keys based on the statistics and generate optimization plans for queries having potential skew. When the redistribution key has multiple columns, statistics information can be used for identification only when all columns belong to the same base table.

     The statistics information can only provide the skew of the base table. When a column in the base table is skewed, other columns have filtering conditions, or after the join of other tables, the skewed data may still exist on the skewed column. If **skew_option** is **normal**, it indicates that the skew data still exists, and the base tables will be optimized to solve skew. If **skew_option** is **lazy**, it indicates that no more skew data exists and the optimization will stop.

   - Detection based on specified hints

     The intermediate results of complex queries are difficult to estimate based on statistics. In this case, you can specify hints to provide the skew information based on which the optimizer optimizes queries. For details about the syntax of hints, see **10.3.9.8 Skew Hints**.

   - Detection based on rules

     In a business intelligence (BI) system, a large number of SQL statements having outer joins (including left joins, right joins, and full joins) are generated, and many NULL values will be generated in empty columns that have no match for outer joins. If JOIN or GROUP BY operations are performed on the columns, data skew will occur. RLBT can automatically identify this scenario and generate an optimization plan for NULL value skew.

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2. Solve computing skew.

   **Join** and **Aggregate** operators are optimized to solve skew.

   – **Join** optimization

   Skew and non-skew data is separately processed. Details are as follows:

   a. When redistribution is required on both sides of a join:

      Use **PART_REDISTRIBUTE_PART_ROUNDROBIN** on the side with skew. Specifically, perform round-robin on skew data and redistribution on non-skew data.

      Use **PART_REDISTRIBUTE_PART_BROADCAST** on the side with no skew. Specifically, perform broadcast on skew data and redistribution on non-skew data.

   b. When redistribution is required on only one side of a join:

      Use **PART_REDISTRIBUTE_PART_ROUNDROBIN** on the side where redistribution is required.

      Use **PART_LOCAL_PART_BROADCAST** on the side where redistribution is not required. Specifically, perform broadcast on skew data and retain other data locally.

   c. When a table has NULL values padded:

      Use **PART_REDISTERIBUTE_PART_LOCAL** on the table. Specifically, retain the NULL values locally and perform redistribution on other data.

   In the example query, the **s.x** column contains skewed data and its value is **0**. The optimizer identifies the skew data in statistics and generates the following optimization plan:

```
 id |                                operation                                 |        A-time
----+--------------------------------------------------------------------------+-----------------------
  1 | ->  Limit                                                                | 23642.049
  2 |    ->  Streaming (type: GATHER)                                          | 23642.041
  3 |       ->  Limit                                                          | [23310.768,23618.021]
  4 |          ->  Sort                                                        | [23310.761,23618.012]
  5 |             ->  Hash Join (6,8)                                          | [20898.341,21115.272]
  6 |                ->  Streaming(type: PART REDISTRIBUTE PART ROUNDROBIN)    |
[7125.834,7472.111]
  7 |                   ->  Seq Scan on public.skew s                          | [1837.079,1911.025]
  8 |                ->  Hash                                                  | [2612.484,2640.572]
  9 |                   ->  Streaming(type: PART REDISTRIBUTE PART BROADCAST)  | [1193.548,1297.894]
 10 |                      ->  Seq Scan on public.test t                       | [314.343,328.707]
(10 rows)
   5 --Vector Hash Join (6,8)
       Hash Cond: s.x = t.x
       Skew Join Optimizated by Statistic
   6 --Streaming(type: PART REDISTRIBUTE PART ROUNDROBIN)
       datanode1 (rows=7635968)
       datanode2 (rows=7517184)
       datanode3 (rows=7748608)
       datanode4 (rows=7818240)
```

   In the preceding execution plan, **Skew Join Optimizated by Statistic** indicates that this is an optimized plan used for handling data skew. The **Statistic** keyword indicates that the plan optimization is based on statistics; **Hint** indicates that the optimization is based on hints; **Rule** indicates that the optimization is based on rules. In this plan, skew and non-skew data are separately processed. Non-skew data in the **s** table is redistributed based on its hash values, and skew data (whose value is **0**) is evenly distributed on all nodes in round-robin mode. In this way, data skew is solved.

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To ensure result correctness, the **t** table also needs to be processed. In the **t** table, the data whose value is **0** (skew value in the **s.x** table) is broadcast and other data is redistributed based on its hash values.

In this way, data skew in **JOIN** operations is solved. The above result shows that the output of the **Streaming** operator (**id** being **6**) is balanced and the end-to-end performance of the query is doubled.

– **Aggregate** optimization

For aggregation, data on each DN is deduplicated based on the **GROUP BY** key and then redistributed. After the deduplication on DNs, the global occurrences of each value will not be greater than the number of DNs. Therefore, no serious data skew will occur. Take the following query as an example:

```
select c1, c2, c3, c4, c5, c6, c7, c8, c9, count(*) from t group by c1, c2, c3, c4, c5, c6, c7, c8, c9 limit 10;
```

The command output is as follows:

```
 id |                operation                 |         A-time         | A-rows
----+------------------------------------------+------------------------+----------
  1 | ->  Streaming (type: GATHER)             | 130621.783             |       12
  2 |    ->  GroupAggregate                    | [85499.711,130432.341] |       12
  3 |       ->  Sort                           | [85499.509,103145.632] | 36679237
  4 |         ->  Streaming(type: REDISTRIBUTE) | [25668.897,85499.050]  | 36679237
  5 |           ->  Seq Scan on public.t       | [9835.069,10416.388]   | 36679237
(5 rows)

  4 --Streaming(type: REDISTRIBUTE)
        datanode1 (rows=36678837)
        datanode2 (rows=100)
        datanode3 (rows=100)
        datanode4 (rows=200)
```

A large amount of skew data exists. As a result, after data is redistributed based on its **GROUP BY** key, the data volume of datanode1 is hundreds of thousands of times that of others. After optimization, a **GROUP BY** operation is performed on the DN to deduplicate data. After redistribution, no data skew occurs.

```
 id |                operation                 |         A-time
----+------------------------------------------+------------------------
  1 | ->  Streaming (type: GATHER)             | 10961.337
  2 |    ->  HashAggregate                     | [10953.014,10953.705]
  3 |       ->  HashAggregate                  | [10952.957,10953.632]
  4 |         ->  Streaming(type: REDISTRIBUTE) | [10952.859,10953.502]
  5 |           ->  HashAggregate              | [10084.280,10947.139]
  6 |             ->  Seq Scan on public.t     | [4757.031,5201.168]
(6 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
  3 --HashAggregate
        Skew Agg Optimized by Statistic
(2 rows)

  4 --Streaming(type: REDISTRIBUTE)
        datanode1 (rows=17)
        datanode2 (rows=8)
        datanode3 (rows=8)
        datanode4 (rows=14)
```

Applicability

– **Join** operator

  - **nest loop**, **merge join**, and **hash join** can be optimized.

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    - If skew data is on the left to the join, **inner join**, **left join**, **semi join**, and **anti join** are supported. If skew data is on the right to the join, **inner join**, **right join**, **right semi join**, and **right anti join** are supported.
    - For an optimization plan generated based on statistics, the optimizer checks whether it is optimal by estimating its cost. Optimization plans based on hints or rules are forcibly generated.
  - **Aggregate** operator
    - **array_agg**, **string_agg**, and **subplan in agg qual** cannot be optimized.
    - A plan generated based on statistics is affected by its cost, the **plan_mode_seed** parameter, and the **best_agg_plan** parameter. A plan generated based on hints or rules are not affected by them.

## 10.3.7 Experience in Rewriting SQL Statements

Based on the SQL execution mechanism and a large number of practices, SQL statements can be optimized by following certain rules to enable the database to execute SQL statements more quickly and obtain correct results. You can comply with these rules to improve service query efficiency.

- Replace **UNION** with **UNION ALL**.

  **UNION** eliminates duplicate rows while merging two result sets but **UNION ALL** merges the two result sets without deduplication. Therefore, replace **UNION** with **UNION ALL** if you are sure that the two result sets do not contain duplicate rows based on the service logic.

- Add **NOT NULL** to the join columns.

  If there are many NULL values in the **JOIN** columns, you can add the filter criterion **IS NOT NULL** to filter data in advance to improve the **JOIN** efficiency.

- Convert **NOT IN** to **NOT EXISTS**.

  **nestloop anti join** must be used to implement **NOT IN**, and **hash anti join** is required for **NOT EXISTS**. If no NULL value exists in the **JOIN** columns, **NOT IN** is equivalent to **NOT EXISTS**. Therefore, if you are sure that no NULL value exists, you can convert **NOT IN** to **NOT EXISTS** to generate **hash join** and to improve the query performance.

  As shown in the following statement, the **t2.d2** column does not contain null values (it is set to **NOT NULL**) and **NOT EXISTS** is used for the query.

  ```
  SELECT * FROM t1 WHERE  NOT EXISTS (SELECT * FROM t2 WHERE t1.c1=t2.d2);
  ```

  The generated execution plan is as follows:

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**Figure 10-10 NOT EXISTS** execution plan

```
 id |                  operation
----+-------------------------------------------
  1 | ->  Streaming (type: GATHER)
  2 |    ->  Hash Anti Join (3, 4)
  3 |       ->  Seq Scan on t1
  4 |       ->  Hash
  5 |          ->  Streaming(type: REDISTRIBUTE)
  6 |             ->  Seq Scan on t2
(6 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   2 --Hash Anti Join (3, 4)
         Hash Cond: (t1.c1 = t2.d2)
(2 rows)
```

- Use **hashagg**.

  If a plan involving groupAgg and SORT operations generated by the **GROUP BY** statement is poor in performance, you can set **work_mem** to a larger value to generate a **hashagg** plan, which does not require sorting and improves the performance.

- Replace functions with **CASE** statements.

  The GaussDB performance greatly deteriorates if a large number of functions are called. In this case, you can modify the pushdown functions to **CASE** statements.

- Do not use functions or expressions for indexes.

  Using functions or expressions for indexes stops indexing. Instead, it enables scanning on the full table.

- Do not use **!=** or **<>** operators, **NULL**, **OR**, or implicit parameter conversion in **WHERE** clauses.

- Split complex SQL statements.

  You can split an SQL statement into several ones and save the execution result to a temporary table if the SQL statement is too complex to be tuned using the solutions above, including but not limited to the following scenarios:

  - The same subquery is involved in multiple SQL statements of a job and the subquery contains large amounts of data.
  - Incorrect plan cost causes a small hash bucket of subquery. For example, the actual number of rows is 10 million, but only 1000 rows are in hash bucket.
  - Functions such as **substr** and **to_number** cause incorrect measures for subqueries containing large amounts of data.
  - **BROADCAST** subqueries are performed on large tables in multi-DN environment.

## 10.3.8 Configuring Key Parameters for SQL Tuning

This section describes key CN parameters that affect tuning of SQL statements in GaussDB. For details about how to configure the parameters, see **11 Configuring Running Parameters**.

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**Table 10-3** CN parameters

| Parameter/ Reference Value | Description |
| --- | --- |
| enable_nestloop=on | Specifies how the optimizer uses Nest Loop Join. If this parameter is set to **on**, the optimizer preferentially uses Nest Loop Join. If it is set to **off**, the optimizer preferentially uses other methods, if any.<br>**NOTE**<br>If you only want to temporarily change the value of this parameter during the current database connection (that is, the current session), execute the following SQL statement:<br>`SET enable_nestloop to off;`<br>You can determine whether to disable this function based on the actual requirements. Generally, among the three join modes (Nested Loop, Merge Join, and Hash Join), Nested Loop is applicable to scenarios with small data volume or indexes, and Hash Join is applicable to big data analysis scenarios. |
| enable_bitmapscan=on | Specifies whether the optimizer uses bitmap scan. If the value is **on**, bitmap scan is used. If the value is **off**, it is not used.<br>**NOTE**<br>If you only want to temporarily change the value of this parameter during the current database connection (that is, the current session), execute the following SQL statement:<br>`SET enable_bitmapscan to off;`<br>The bitmap scan applies only in the query condition **where a > 1 and b > 1** and indexes are created on columns **a** and **b**. However, the performance of bitmapscan is sometimes inferior to that of indexscan. During tuning, if the query performance is poor and bitmapscan operators are in the execution plan, set this parameter to **off** and check whether the performance is improved. |
| enable_fast_query_shipping=on | Specifies whether the optimizer uses a distribution framework to execute quick execution plans. If the value is **on**, the execution plan is generated on both CNs and DNs. If the value is **off**, the distribution framework is used, that is, the execution plan is generated on the CN and then sent to the DN for execution.<br>**NOTE**<br>If you only want to temporarily change the value of this parameter during the current database connection (that is, the current session), execute the following SQL statement:<br>`SET enable_fast_query_shipping to off;` |
| enable_hashagg=on | Specifies whether the optimizer uses hash aggregate plans. |
| enable_hashjoin=on | Specifies whether the optimizer uses hash join plans. |

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| Parameter/ Reference Value | Description |
| --- | --- |
| enable_mergejoin=on | Specifies whether the optimizer uses merge join plans. |
| enable_indexscan=on | Specifies whether the optimizer uses index scan plans. |
| enable_indexonlyscan=on | Specifies whether the optimizer uses index-only scan plans. |
| enable_seqscan=on | Specifies whether the optimizer uses sequential scan plans. It is impossible to suppress sequential scans entirely, but setting this variable to **off** encourages the optimizer to choose other methods if available. |
| enable_sort=on | Specifies the optimizer sorting order. It is impossible to fully suppress explicit sorting, but setting this variable to **off** encourages the optimizer to choose other methods if available. |
| enable_broadcast=on | Specifies whether the optimizer uses data broadcast. In data broadcast, a large amount of data is transferred on the network. When the number of transmission nodes (stream) is large and the estimation is inaccurate, set this parameter to **off** and check whether the performance is improved. |
| rewrite_rule | Specifies whether the optimizer enables the LAZYAGG, MAGICSET, PARTIALPUSH, UNIQUECHECK, DISABLEREP, INTARGETLIST, and PREDPUSH rewriting rules. |
| sql_beta_feature | Specifies whether the optimizer enables the SEL_SEMI_POISSON, NO_UNIQUE_INDEX_FIRST, JOIN_SEL_WITH_CAST_FUNC, SEL_EXPR_INSTR, PARAM_PATH_GEN, RAND_COST_OPT, PARAM_PATH_OPT, PAGE_EST_OPT, CANONICAL_PATHKEY, INDEX_COST_WITH_INDEX_COST_WITH_LEAF_PAGES_ONLY, PARTITION_OPFUSION, PREDPUSH_SAME_LEVEL, PARTITION_FDW_ON, or DISABLE_BITMAP_COST_WITH_LOSSY_PAGES beta feature. |

# 10.3.9 Hint-based Tuning

## 10.3.9.1 Plan Hint Optimization

In plan hints, you can specify a join order; join, stream, and scan operations, the number of rows in a result, and redistribution skew information to tune an execution plan, improving query performance.

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## Function

Plan hints are specified in the following format after keywords such as SELECT, INSERT, UPDATE, DELETE, and MERGE:

```
/*+ <plan hint>*/
```

You can specify multiple hints for a query plan and separate them with spaces. A hint specified for a query plan does not apply to its subquery plans. To specify a hint for a subquery, add the hint following the **SELECT** of this subquery.

Example:

```
select /*+ <plan_hint1> <plan_hint2> */ * from t1, (select /*+ <plan_hint3> */ * from t2) where 1=1;
```

In the preceding command, <*plan_hint1*> and <*plan_hint2*> are the hints of a query, and <*plan_hint3*> is the hint of its subquery.

**NOTICE**

If a hint is specified in the **CREATE VIEW** statement, the hint will be applied each time this view is used.

If the random plan function is enabled (**plan_mode_seed** is set to a value other than 0), the specified hint will not be used.

## Scope

Currently, the following hints are supported:

- Join order hints (**leading**)
- Join operation hints, excluding the **semi join**, **anti join**, and **unique plan** hints
- Rows hints
- Stream operation hints
- Scan operation hints, supporting only the **tablescan**, **indexscan**, and **indexonlyscan** hints
- Sublink name hints
- Skew hints, supporting only the skew in the redistribution involving Join or HashAgg
- Hints of the GUC parameter that takes effect in a query. The hints do not take effect if they are used in views.
- Hints that use the custom plan or generic plan. The hints are valid only for query statements executed by PBE.
- Hints specifying not to expand subqueries
- Hints specifying that the current query statement does not enter the global plan cache. The hints are valid only when **enable_global_plancache** is enabled and the current statement is executed by PBE.

## Precautions

- Hints do not support **Agg**, **Sort**, **Setop**, or **Subplan**.

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- Hints do not support SMP or Node Groups.

## Example

The following is the original plan and is used for comparing with the optimized ones:

```
explain
select i_product_name product_name
,i_item_sk item_sk
,s_store_name store_name
,s_zip store_zip
,ad2.ca_street_number c_street_number
,ad2.ca_street_name c_street_name
,ad2.ca_city c_city
,ad2.ca_zip c_zip
,count(*) cnt
,sum(ss_wholesale_cost) s1
,sum(ss_list_price) s2
,sum(ss_coupon_amt) s3
FROM   store_sales
,store_returns
,store
,customer
,promotion
,customer_address ad2
,item
WHERE  ss_store_sk = s_store_sk AND
ss_customer_sk = c_customer_sk AND
ss_item_sk = i_item_sk and
ss_item_sk = sr_item_sk and
ss_ticket_number = sr_ticket_number and
c_current_addr_sk = ad2.ca_address_sk and
ss_promo_sk = p_promo_sk and
i_color in ('maroon','burnished','dim','steel','navajo','chocolate') and
i_current_price between 35 and 35 + 10 and
i_current_price between 35 + 1 and 35 + 15
group by i_product_name
,i_item_sk
,s_store_name
,s_zip
,ad2.ca_street_number
,ad2.ca_street_name
,ad2.ca_city
,ad2.ca_zip
;
```

```
 id |                                operation                                 |   E-rows   | E-memory | E-width |  E-costs
----+--------------------------------------------------------------------------+------------+----------+---------+------------
  1 | ->  Row Adapter                                                          |          6 |          |     273 | 3401632.49
  2 |    ->  Vector Streaming (type: GATHER)                                   |          6 |          |     273 | 3401632.49
  3 |       ->  Vector Hash Aggregate                                          |          6 | 16MB     |     273 | 3401630.82
  4 |          ->  Vector Streaming(type: REDISTRIBUTE)                        |          6 | 1MB      |     169 | 3401630.78
  5 |             ->  Vector Hash Join (6,21)                                  |          6 | 16MB     |     169 | 3401630.42
  6 |                ->  Vector Hash Join (7,20)                               |          7 | 43MB     |     173 | 3400343.15
  7 |                   ->  Vector Streaming(type: REDISTRIBUTE)               |          7 | 1MB      |     123 | 3395775.64
  8 |                      ->  Vector Hash Join (9,19)                         |          7 | 27MB     |     123 | 3395775.48
  9 |                         ->  Vector Streaming(type: REDISTRIBUTE)         |          7 | 1MB      |     123 | 3386294.72
 10 |                            ->  Vector Hash Join (11,18)                  |          7 | 16MB     |     123 | 3386294.56
 11 |                               ->  Vector Hash Join (12,14)               |          7 | 19MB     |     112 | 3384018.02
 12 |                                  ->  Vector Partition Iterator           |  287999764 | 1MB      |      12 | 227383.99
 13 |                                     ->  Partitioned CStore Scan on store_returns |  287999764 | 1MB      |      12 | 227383.99
 14 |                                  ->  Vector Hash Join (15,17)            |    1516824 | 16MB     |     124 | 3065686.08
 15 |                                     ->  Vector Partition Iterator        | 2879987999 | 1MB      |      66 | 2756066.50
 16 |                                        ->  Partitioned CStore Scan on store_sales | 2879987999 | 1MB      |      66 | 2756066.50
 17 |                                     ->  CStore Scan on item              |        158 | 1MB      |      58 | 4051.25
 18 |                               ->  CStore Scan on store                   |      24048 | 1MB      |      19 | 2264.00
 19 |                            ->  CStore Scan on customer                   |   12000000 | 1MB      |       8 | 12923.00
 20 |                         ->  CStore Scan on customer_address ad2          |    6000000 | 1MB      |      58 | 5770.00
 21 |                      ->  CStore Scan on promotion                        |      36000 | 1MB      |       4 | 1268.50
(21 rows)
```

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## 10.3.9.2 Join Order Hints

### Function

Theses hints specify the join order and outer/inner tables.

### Syntax

- Specify only the join order.

```
leading(join_table_list)
```

- Specify the join order and outer/inner tables. The outer/inner tables are specified by the outermost parentheses.

```
leading((join_table_list))
```

### Parameter Description

*join_table_list* specifies the tables to be joined. The values can be table names or table aliases. If a subquery is pulled up, the value can also be the subquery alias. Separate the values with spaces. You can add parentheses to specify the join priorities of tables.

**NOTICE**

A table name or alias can only be a string without a schema name.

An alias (if any) is used to represent a table.

To prevent semantic errors, tables in the list must meet the following requirements:

- The tables must exist in the query or its subquery to be pulled up.
- The table names must be unique in the query or subquery to be pulled up. If they are not, their aliases must be unique.
- A table appears only once in the list.
- An alias (if any) is used to represent a table.

For example:

**leading(t1 t2 t3 t4 t5)**: **t1**, **t2**, **t3**, **t4**, and **t5** are joined. The join order and outer/inner tables are not specified.

**leading((t1 t2 t3 t4 t5))**: **t1**, **t2**, **t3**, **t4**, and **t5** are joined in sequence. The table on the right is used as the inner table in each join.

**leading(t1 (t2 t3 t4) t5)**: First, **t2**, **t3**, and **t4** are joined and the outer/inner tables are not specified. Then, the result is joined with **t1** and **t5**, and the outer/inner tables are not specified.

**leading((t1 (t2 t3 t4) t5))**: First, **t2**, **t3**, and **t4** are joined and the outer/inner tables are not specified. Then, the result is joined with **t1**, and **(t2 t3 t4)** is used as the inner table. Finally, the result is joined with **t5**, and **t5** is used as the inner table.

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**leading((t1 (t2 t3) t4 t5)) leading((t3 t2))**: First, **t2** and **t3** are joined and **t2** is used as the inner table. Then, the result is joined with **t1**, and **(t2 t3)** is used as the inner table. Finally, the result is joined with **t4** and then **t5**, and the table on the right in each join is used as the inner table.

## Example

Hint the query plan in **Example** as follows:

```
explain
select /*+ leading((((((store_sales store) promotion) item) customer) ad2) store_returns) leading((store store_sales))*/ i_product_name product_name ...
```

First, **store_sales** and **store** are joined and **store_sales** is the inner table. Then, the result is joined with **promotion**, **item**, **customer**, **ad2**, and **store_returns** in sequence. The optimized plan is as follows:

```
WARNING:  Duplicated or conflict hint: Leading(store_sales store), will be discarded.
 id |                                operation                                 |   E-rows   | E-memory | E-width |   E-costs
----+--------------------------------------------------------------------------+------------+----------+---------+-------------
  1 | ->  Row Adapter                                                          |          6 |          |     273 | 16308094.34
  2 |    ->  Vector Streaming (type: GATHER)                                   |          6 |          |     273 | 16308094.34
  3 |       ->  Vector Hash Aggregate                                          |          6 | 16MB     |     273 | 16308092.67
  4 |          ->  Vector Hash Join (5,20)                                     |          6 | 585MB    |     169 | 16308092.63
  5 |             ->  Vector Streaming(type: REDISTRIBUTE)                     |    1320811 | 1MB      |     181 | 16069870.93
  6 |                ->  Vector Hash Join (7,19)                               |    1320811 | 43MB     |     181 | 16061891.00
  7 |                   ->  Vector Streaming(type: REDISTRIBUTE)               |    1320811 | 1MB      |     131 | 16056566.78
  8 |                      ->  Vector Hash Join (9,18)                         |    1320811 | 27MB     |     131 | 16048586.85
  9 |                         ->  Vector Streaming(type: REDISTRIBUTE)         |    1383248 | 1MB      |     131 | 16038321.62
 10 |                            ->  Vector Hash Join (11,17)                  |    1383248 | 16MB     |     131 | 16029664.50
 11 |                               ->  Vector Hash Join (12,16)               | 2626366951 | 16MB     |      73 | 15751384.88
 12 |                                  ->  Vector Hash Join (13,14)            | 2750085660 | 2156MB   |      77 | 14226077.19
 13 |                                     ->  CStore Scan on store             |      24048 | 1MB      |      19 | 2264.00
 14 |                                     ->  Vector Partition Iterator        | 2879987999 | 1MB      |      66 | 2756066.50
 15 |                                        ->  Partitioned CStore Scan on store_sales | 2879987999 | 1MB | 66 | 2756066.50
 16 |                                  ->  CStore Scan on promotion            |      36000 | 1MB      |       4 | 1268.50
 17 |                               ->  CStore Scan on item                    |        158 | 1MB      |      58 | 4051.25
 18 |                         ->  CStore Scan on customer                      |   12000000 | 1MB      |       8 | 12923.00
 19 |                      ->  CStore Scan on customer_address ad2             |    6000000 | 1MB      |      58 | 5770.00
 20 |                ->  Vector Partition Iterator                             |  287999764 | 1MB      |      12 | 227383.99
 21 |                   ->  Partitioned CStore Scan on store_returns           |  287999764 | 1MB      |      12 | 227383.99
(21 rows)
```

For details about the warning at the top of the plan, see **10.3.9.10 Hint Errors, Conflicts, and Other Warnings**.

## 10.3.9.3 Join Operation Hints

## Function

These hints specify the join method, which can be nested loop join, hash join, or merge join.

## Syntax

```
[no] nestloop|hashjoin|mergejoin(table_list)
```

## Parameter Description

- **no** indicates that the specified hint will not be used for a join.
- *table_list* specifies the tables to be joined. The values are the same as those of **join_table_list** but contain no parentheses.

For example:

**no nestloop(t1 t2 t3)**: **nestloop** is not used for joining **t1**, **t2**, and **t3**. The three tables may be joined in either of the two ways: Join **t2** and **t3**, and then **t1**; join **t1**

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and **t2**, and then **t3**. This hint takes effect only for the last join. If necessary, you can hint other joins. For example, you can add **no nestloop(t2 t3)** to join **t2** and **t3** first and to forbid the use of **nestloop**.

## Example

Hint the query plan in **Example** as follows:

```
explain
select /*+ nestloop(store_sales store_returns item) */ i_product_name product_name ...
```

**nestloop** is used for the last join between **store_sales**, **store_returns**, and **item**. The optimized plan is as follows:

```
 id |                                operation                                 |   E-rows   | E-memory | E-width |     E-costs
----+--------------------------------------------------------------------------+------------+----------+---------+-----------------
  1 | ->  Row Adapter                                                          |          6 |          |     273 | 100061693161.06
  2 |    ->  Vector Streaming (type: GATHER)                                   |          6 |          |     273 | 100061693161.06
  3 |       ->  Vector Hash Aggregate                                          |          6 | 16MB     |     273 | 100061693159.40
  4 |          ->  Vector Streaming(type: REDISTRIBUTE)                        |          6 | 1MB      |     169 | 100061693159.36
  5 |             ->  Vector Hash Join (6,22)                                  |          6 | 43MB     |     169 | 100061693158.99
  6 |                ->  Vector Streaming(type: REDISTRIBUTE)                  |          6 | 1MB      |     119 | 100061688591.48
  7 |                   ->  Vector Hash Join (8,21)                            |          6 | 16MB     |     119 | 100061688591.30
  8 |                      ->  Vector Hash Join (9,20)                         |          7 | 27MB     |     123 | 100061687304.04
  9 |                         ->  Vector Streaming(type: REDISTRIBUTE)         |          7 | 1MB      |     123 | 100061677823.27
 10 |                            ->  Vector Hash Join (11,19)                  |          7 | 16MB     |     123 | 100061677823.12
 11 |                               ->  Vector Nest Loop (12,17)               |          7 | 1MB      |     112 | 100061675546.57
 12 |                                  ->  Vector Hash Join (13,15)            |      13670 | 585MB    |      62 | 6163443.54
 13 |                                     ->  Vector Partition Iterator        | 2879987999 | 1MB      |      66 | 2756066.50
 14 |                                        ->  Partitioned CStore Scan on store_sales | 2879987999 | 1MB |  66 | 2756066.50
 15 |                                     ->  Vector Partition Iterator        |  287999764 | 1MB      |      12 | 227383.99
 16 |                                        ->  Partitioned CStore Scan on store_returns | 287999764 | 1MB | 12 | 227383.99
 17 |                                  ->  Vector Materialize                  |        158 | 16MB     |      58 | 4051.28
 18 |                                     ->  CStore Scan on item              |        158 | 1MB      |      58 | 4051.25
 19 |                               ->  CStore Scan on store                   |      24048 | 1MB      |      19 | 2264.00
 20 |                            ->  CStore Scan on customer                   |   12000000 | 1MB      |       8 | 12923.00
 21 |                         ->  CStore Scan on promotion                     |      36000 | 1MB      |       4 | 1268.50
 22 |                   ->  CStore Scan on customer_address ad2                |    6000000 | 1MB      |      58 | 5770.00
(22 rows)
```

## 10.3.9.4 Rows Hints

## Function

These hints specify the number of rows in an intermediate result set. Both absolute values and relative values are supported.

## Syntax

```
rows(table_list #|+|-|* const)
```

## Parameter Description

- **#**, **+**, **-**, and ***** are operators used for hinting the estimation. **#** indicates that the original estimation is used without any calculation. **+**, **-**, and ***** indicate that the original estimation is calculated using these operators. The minimum calculation result is 1. *table_list* specifies the tables to be joined. The values are the same as those of **table_list** in **10.3.9.3 Join Operation Hints**.
- *const* can be any non-negative number and supports scientific notation.

For example:

**rows(t1 #5)**: The result set of **t1** is five rows.

**rows(t1 t2 t3 *1000)**: Multiply the result set of joined **t1**, **t2**, and **t3** by 1000.

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## Suggestion

- The hint using * for two tables is recommended. This hint will be triggered if the two tables appear on two sides of a join. For example, if the hint is **rows(t1 t2 * 3)**, the join result of **(t1 t3 t4)** and **(t2 t5 t6)** will be multiplied by 3 because **t1** and **t2** appear on both sides of the join.
- **rows** hints can be specified for the result sets of a single table, multiple tables, function tables, and subquery scan tables.

## Example

Hint the query plan in **Example** as follows:

```
explain
select /*+ rows(store_sales store_returns *50) */ i_product_name product_name ...
```

Multiply the result set of joined **store_sales** and **store_returns** by 50. The optimized plan is as follows:

```
 id |                                operation                                 |   E-rows   | E-memory | E-width |  E-costs
----+--------------------------------------------------------------------------+------------+----------+---------+------------
  1 | ->  Row Adapter                                                          |        312 |          |     273 | 3401656.58
  2 |    ->  Vector Streaming (type: GATHER)                                   |        312 |          |     273 | 3401656.58
  3 |       ->  Vector Hash Aggregate                                          |        312 | 16MB     |     273 | 3401634.91
  4 |          ->  Vector Streaming(type: REDISTRIBUTE)                        |        313 | 1MB      |     169 | 3401634.39
  5 |             ->  Vector Hash Join (6,21)                                  |        313 | 43MB     |     169 | 3401633.06
  6 |                ->  Vector Streaming(type: REDISTRIBUTE)                  |        313 | 1MB      |     119 | 3397065.38
  7 |                   ->  Vector Hash Join (8,20)                            |        313 | 27MB     |     119 | 3397064.31
  8 |                      ->  Vector Streaming(type: REDISTRIBUTE)            |        328 | 1MB      |     119 | 3387583.37
  9 |                         ->  Vector Hash Join (10,19)                     |        328 | 16MB     |     119 | 3387582.18
 10 |                            ->  Vector Hash Join (11,18)                  |        344 | 16MB     |     123 | 3386294.74
 11 |                               ->  Vector Hash Join (12,14)               |        360 | 19MB     |     112 | 3384018.02
 12 |                                  ->  Vector Partition Iterator           |  287999764 | 1MB      |      12 | 227383.99
 13 |                                     ->  Partitioned CStore Scan on store_returns | 287999764 | 1MB |      12 | 227383.99
 14 |                                  ->  Vector Hash Join (15,17)            |    1516824 | 16MB     |     124 | 3065686.08
 15 |                                     ->  Vector Partition Iterator        | 2879987999 | 1MB      |      66 | 2756066.50
 16 |                                        ->  Partitioned CStore Scan on store_sales | 2879987999 | 1MB |      66 | 2756066.50
 17 |                                     ->  CStore Scan on item              |        158 | 1MB      |      58 | 4051.25
 18 |                                  ->  CStore Scan on store                |      24048 | 1MB      |      19 | 2264.00
 19 |                               ->  CStore Scan on promotion               |      36000 | 1MB      |       4 | 1268.50
 20 |                         ->  CStore Scan on customer                      |   12000000 | 1MB      |       8 | 12923.00
 21 |                   ->  CStore Scan on customer_address ad2                |    6000000 | 1MB      |      58 | 5770.00
(21 rows)
```

The estimation value after the hint in row 11 is **360**, and the original value is rounded off to 7.

## 10.3.9.5 Stream Operation Hints

## Function

These hints specify a stream operation, which can be **broadcast** or **redistribute**. You can also directly specify a method to generate a gather plan.

## Syntax

```
[no] broadcast|redistribute(table_list)
gather(REL|JOIN|ALL)
```

## Parameter Description

- **broadcast** and **redistribute**
  - **no** specifies that the specified hint will not be used for a stream operation.

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  - *table_list* specifies the table on which a stream operation is to be performed or the tables to be joined. For details, see **Parameter Description**.

- gather

  The gather hint can specify the following plan generation modes:

  - **REL**: Only the gather path based on the base table is generated, and then the remaining plan is executed on the CN.
  - **JOIN**: A join-based gather path is generated as much as possible and is added to the join subplan that can be pushed down (the join subplan does not contain the redistribution node), and the remaining plan is executed on the CN. For a join plan that requires node redistribution, such a join-based gather path cannot be generated. Instead, a base table-based gather path is generated.

    **CAUTION**

    After **Hint(JOIN)** is specified, the plan expected by **Hint(JOIN)** cannot be generated if the distribution table and replication table are joined, because the optimizer has found a better plan for replacement.

  - **ALL**: The **Gather Rel** or **Gather Join** path is selected based on the optimal mode.

## Example

Hint the query plan in **Example** as follows:

```
explain
select /*+ no redistribute(store_sales store_returns item store) leading(((store_sales store_returns item
store) customer)) */ i_product_name product_name ...
```

In the original plan, the join result of **store_sales**, **store_returns**, **item**, and **store** is redistributed before it is joined with **customer**. After the hinting, the redistribution is disabled and the join order is retained. The optimized plan is as follows:

```
 id |                                operation                                |   E-rows   | E-memory | E-width |  E-costs
----+-------------------------------------------------------------------------+------------+----------+---------+------------
  1 | ->  Row Adapter                                                         |          6 |          |     273 | 5718448.94
  2 |    ->  Vector Streaming (type: GATHER)                                  |          6 |          |     273 | 5718448.94
  3 |       ->  Vector Hash Aggregate                                         |          6 | 16MB     |     273 | 5718447.27
  4 |          ->  Vector Streaming(type: REDISTRIBUTE)                       |          6 | 1MB      |     169 | 5718447.23
  5 |             ->  Vector Hash Join (6,21)                                 |          6 | 16MB     |     169 | 5718446.86
  6 |                ->  Vector Hash Join (7,20)                              |          7 | 43MB     |     173 | 5717159.60
  7 |                   ->  Vector Streaming(type: REDISTRIBUTE)              |          7 | 1MB      |     123 | 5712592.09
  8 |                      ->  Vector Hash Join (9,18)                        |          7 | 585MB    |     123 | 5712591.93
  9 |                         ->  Vector Hash Join (10,17)                    |          7 | 16MB     |     123 | 3386294.56
 10 |                            ->  Vector Hash Join (11,13)                 |          7 | 19MB     |     112 | 3384018.02
 11 |                               ->  Vector Partition Iterator             |  287999764 | 1MB      |      12 | 227383.99
 12 |                                  ->  Partitioned CStore Scan on store_returns | 287999764 | 1MB |      12 | 227383.99
 13 |                               ->  Vector Hash Join (14,16)              |    1516824 | 16MB     |     124 | 3065686.08
 14 |                                  ->  Vector Partition Iterator          | 2879987999 | 1MB      |      66 | 2756066.50
 15 |                                     ->  Partitioned CStore Scan on store_sales | 2879987999 | 1MB |      66 | 2756066.50
 16 |                                  ->  CStore Scan on item                |        158 | 1MB      |      58 | 4051.25
 17 |                            ->  CStore Scan on store                     |      24048 | 1MB      |      19 | 2264.00
 18 |                         ->  Vector Streaming(type: BROADCAST)           |  288000000 | 1MB      |       8 | 2176297.36
 19 |                            ->  CStore Scan on customer                  |   12000000 | 1MB      |       8 | 12923.00
 20 |                      ->  CStore Scan on customer_address ad2            |    6000000 | 1MB      |      58 | 5770.00
 21 |                   ->  CStore Scan on promotion                          |      36000 | 1MB      |       4 | 1268.50
(21 rows)
```

Specify the gather hint for a statement.

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1. Generate the gather plan **/* + GATHER(REL)*/** based on the base table.

```
openGauss=# explain select /*+ GATHER(REL)*/* from t1, t2, t3 where t1.c2 = t2.c2 and t2.c2 = t3.c2;
QUERY PLAN
------------------------------------------------------------------------------
Hash Join  (cost=3.29..5.08 rows=10 width=24)
Hash Cond: (t1.c2 = t3.c2)
->  Hash Join  (cost=1.64..3.30 rows=10 width=16)
Hash Cond: (t1.c2 = t2.c2)
->  Streaming (type: GATHER)  (cost=0.31..1.52 rows=10 width=8)
Node/s: All datanodes
->  Seq Scan on t1  (cost=0.00..1.05 rows=10 width=8)
->  Hash  (cost=1.52..1.52 rows=10 width=8)
->  Streaming (type: GATHER)  (cost=0.31..1.52 rows=10 width=8)
Node/s: All datanodes
->  Seq Scan on t2  (cost=0.00..1.05 rows=10 width=8)
->  Hash  (cost=1.52..1.52 rows=10 width=8)
->  Streaming (type: GATHER)  (cost=0.31..1.52 rows=10 width=8)
Node/s: All datanodes
->  Seq Scan on t3  (cost=0.00..1.05 rows=10 width=8)
(15 rows)
```

2. Generate the join gather plan **/*+ GATHER(REL)*/** that can be pushed down.

```
openGauss=# explain select /*+ GATHER(JOIN)*/* from t1, t2, t3 where t1.c1 = t2.c1 and t2.c2 = t3.c2;
QUERY PLAN
------------------------------------------------------------------------------
Hash Join  (cost=2.76..4.48 rows=10 width=24)
Hash Cond: (t2.c2 = t3.c2)
->  Streaming (type: GATHER)  (cost=1.43..2.70 rows=10 width=16)
Node/s: All datanodes
->  Hash Join  (cost=1.11..2.23 rows=10 width=16)
Hash Cond: (t1.c1 = t2.c1)
->  Seq Scan on t1  (cost=0.00..1.05 rows=10 width=8)
->  Hash  (cost=1.05..1.05 rows=10 width=8)
->  Seq Scan on t2  (cost=0.00..1.05 rows=10 width=8)
->  Hash  (cost=1.52..1.52 rows=10 width=8)
->  Streaming (type: GATHER)  (cost=0.31..1.52 rows=10 width=8)
Node/s: All datanodes
->  Seq Scan on t3  (cost=0.00..1.05 rows=10 width=8)
(13 rows)
```

3. Generate the gather plan **/*+ GATHER(ALL)*/** based on the optimal mode.

   The **GATHER(REL)** or **GATHER(JOIN)** path is selected based on the optimal mode and rules.

```
openGauss=# explain select /*+ GATHER(ALL)*/* from t1, t2, t3 where t1.c1 = t2.c1 and t2.c2 = t3.c2;
QUERY PLAN
------------------------------------------------------------------------------
Hash Join  (cost=2.76..4.48 rows=10 width=24)
Hash Cond: (t2.c2 = t3.c2)
->  Streaming (type: GATHER)  (cost=1.43..2.70 rows=10 width=16)
Node/s: All datanodes
->  Hash Join  (cost=1.11..2.23 rows=10 width=16)
Hash Cond: (t1.c1 = t2.c1)
->  Seq Scan on t1  (cost=0.00..1.05 rows=10 width=8)
->  Hash  (cost=1.05..1.05 rows=10 width=8)
->  Seq Scan on t2  (cost=0.00..1.05 rows=10 width=8)
->  Hash  (cost=1.52..1.52 rows=10 width=8)
->  Streaming (type: GATHER)  (cost=0.31..1.52 rows=10 width=8)
Node/s: All datanodes
->  Seq Scan on t3  (cost=0.00..1.05 rows=10 width=8)
(13 rows)
```

## 10.3.9.6 Scan Operation Hints

## Function

These hints specify a scan operation, which can be **tablescan**, **indexscan**, or **indexonlyscan**.

## Syntax

```
[no] tablescan|indexscan|indexonlyscan(table [index])
```

## Parameter Description

- **no** indicates that the specified hint will not be used for a join.
- *table* specifies the table to be scanned. You can specify only one table. Use a table alias (if any) instead of a table name.
- *index* indicates the index for **indexscan** or **indexonlyscan**. You can specify only one index.

NOTE

**indexscan** and **indexonlyscan** hints can be used only when the specified index belongs to the table.

Scan operation hints can be used for row-store tables, column-store tables, OBS tables (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.), and subquery tables.

## Example

To specify an index-based hint for a scan, create an index named **i** on the **i_item_sk** column of the **item** table.

```
create index i on item(i_item_sk);
```

Hint the query plan in **Example** as follows:

```
explain
select /*+ indexscan(item i) */ i_product_name product_name ...
```

**item** is scanned based on an index. The optimized plan is as follows:

```
 id |                                operation                                 |   E-rows   | E-memory | E-width |     E-costs
----+--------------------------------------------------------------------------+------------+----------+---------+-----------------
  1 | ->  Row Adapter                                                          |          6 |          |     273 | 100061674938.26
  2 |    ->  Vector Streaming (type: GATHER)                                   |          6 |          |     273 | 100061674938.26
  3 |       ->  Vector Hash Aggregate                                          |          6 | 16MB     |     273 | 100061674936.59
  4 |          ->  Vector Streaming(type: REDISTRIBUTE)                        |          6 | 1MB      |     169 | 100061674936.55
  5 |             ->  Vector Hash Join (6,21)                                  |          6 | 43MB     |     169 | 100061674936.19
  6 |                ->  Vector Streaming(type: REDISTRIBUTE)                  |          6 | 1MB      |     119 | 100061670368.67
  7 |                   ->  Vector Hash Join (8,20)                            |          6 | 16MB     |     119 | 100061670368.50
  8 |                      ->  Vector Hash Join (9,19)                         |          7 | 27MB     |     123 | 100061669081.23
  9 |                         ->  Vector Streaming(type: REDISTRIBUTE)         |          7 | 1MB      |     123 | 100061659600.47
 10 |                            ->  Vector Hash Join (11,18)                  |          7 | 16MB     |     123 | 100061659600.31
 11 |                               ->  Vector Nest Loop (12,17)               |          7 | 1MB      |     112 | 100061657323.77
 12 |                                  ->  Vector Hash Join (13,15)            |      13670 | 585MB    |      62 | 6163443.54
 13 |                                     ->  Vector Partition Iterator        | 2879987999 | 1MB      |      66 | 2756066.50
 14 |                                        ->  Partitioned CStore Scan on store_sales | 2879987999 | 1MB |  66 | 2756066.50
 15 |                                     ->  Vector Partition Iterator        |  287999764 | 1MB      |      12 | 227383.99
 16 |                                        ->  Partitioned CStore Scan on store_returns | 287999764 | 1MB |  12 | 227383.99
 17 |                                  ->  CStore Index Scan using i on item   |          1 | 1MB      |      58 | 4.01
 18 |                               ->  CStore Scan on store                   |      24048 | 1MB      |      19 | 2264.00
 19 |                            ->  CStore Scan on customer                   |   12000000 | 1MB      |       8 | 12923.00
 20 |                         ->  CStore Scan on promotion                     |      36000 | 1MB      |       4 | 1268.50
 21 |                   ->  CStore Scan on customer_address ad2                |    6000000 | 1MB      |      58 | 5770.00
(21 rows)
```

## 10.3.9.7 Sublink Name Hints

## Function

These hints specify the name of a sublink block.

## Syntax

```
blockname (table)
```

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## Parameter Description

- *table* specifies the name you have specified for a sublink block.

  NOTE

  - The **blockname** hint is used by an outer query only when the corresponding sublink is not pulled up. Currently, only the **Agg** equivalent join, **IN**, and **EXISTS** sublinks can be pulled up. This hint is usually used together with the hints described in the previous sections.
  - The subquery after the **FROM** keyword is hinted by using the subquery alias. In this case, **blockname** becomes invalid.
  - If a sublink contains multiple tables, the tables will be joined with the outer-query tables in a random sequence after the sublink is pulled up. In this case, **blockname** also becomes invalid.

## Examples

```
explain select /*+nestloop(store_sales tt) */ * from store_sales where ss_item_sk in (select /*
+blockname(tt)*/ i_item_sk from item group by 1);
```

**tt** indicates the sublink block name. After being pulled up, the sublink is joined with the outer-query table **store_sales** by using **nestloop**. The optimized plan is as follows:

```
 id |                       operation                       |   E-rows   | E-memory | E-width |     E-costs
----+-------------------------------------------------------+------------+----------+---------+-----------------
  1 | ->  Row Adapter                                       | 1439994000 |          |     216 | 325105765847.91
  2 |    ->  Vector Streaming (type: GATHER)                | 1439994000 |          |     216 | 325105765847.91
  3 |       ->  Vector Nest Loop Semi Join (4, 6)           | 1439994000 | 1MB      |     216 | 325026664615.00
  4 |          ->  Vector Partition Iterator                | 2879987999 | 1MB      |     216 | 2756066.50
  5 |             ->  Partitioned CStore Scan on store_sales | 2879987999 | 1MB      |     216 | 2756066.50
  6 |          ->  Vector Materialize                       |     300000 | 16MB     |       4 | 4176.25
  7 |             ->  Vector Hash Aggregate                 |     300000 | 16MB     |       4 | 3988.75
  8 |                ->  CStore Scan on item                |     300000 | 1MB      |       4 | 3832.50
(8 rows)
```

## 10.3.9.8 Skew Hints

## Function

Theses hints specify redistribution keys containing skew data and skew values, and are used to optimize redistribution involving Join or HashAgg.

## Syntax

- Specify single-table skew.
  ```
  skew(table (column) [(value)])
  ```
- Specify intermediate result skew.
  ```
  skew((join_rel) (column) [(value)])
  ```

## Parameter Description

- *table* specifies the table where skew occurs.
- *join_rel* specifies two or more joined tables. For example, **(t1 t2)** indicates that the result of joining **t1** and **t2** tables contains skew data.
- *column* specifies one or more columns where skew occurs.
- *value* specifies one or more skew values.

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NOTE

- Skew hints are used only if redistribution is required and the specified skew information matches the redistribution information.
- Skew hints are controlled by the GUC parameter **skew_option**. If the parameter is disabled, skew hints cannot be used for solving skew.
- Currently, skew hints support only the table relationships of the ordinary table and subquery types. Hints can be specified for base tables, subqueries, and **WITH ... AS** clauses. Unlike other hints, a subquery can be used in skew hints regardless of whether it is pulled up.
- Use an alias (if any) to specify a table where data skew occurs.
- You can use a name or an alias to specify a skew column as long as it is not ambiguous. The columns in skew hints cannot be expressions. If data skew occurs in the redistribution that uses an expression as a redistribution key, set the redistribution key as a new column and specify the column in skew hints.
- The number of skew values must be an integer multiple of the number of columns. Skew values must be grouped based on the column sequence, with each group containing a maximum of 10 values. You can specify duplicate values to group skew columns having different number of skew values. For example, the **c1** and **c2** columns of the **t1** table contain skew data. The skew value of the **c1** column is **a1**, and the skew values of the **c2** column are **b1** and **b2**. In this case, the skew hint is **skew(t1 (c1 c2) ((a1 b1)(a1 b2)))**. **(a1 b1)** is a value group, where **NULL** is allowed as a skew value. Each hint can contain a maximum of 10 groups and the number of groups should be an integer multiple of the number of columns.
- In the redistribution optimization of Join, a skew value must be specified for skew hints. The skew value can be left empty for HashAgg.
- If multiple tables, columns, or values are specified, separate items of the same type with spaces.
- The type of skew values cannot be forcibly converted in hints. To specify a string, enclose it with single quotation marks (' ').

Example:

- Specify single-table skew.

  Each skew hint describes the skew information of one table relationship. To describe the skews of multiple table relationships in a query, specify multiple skew hints.

  Skew hints have the following formats:

  - One skew value in one column: **skew(t (c1) (v1))**

    Description: The **v1** value in the **c1** column of the **t** table relationship causes skew in query execution.
  - Multiple skew values in one column: **skew(t (c1) (v1 v2 v3 ...))**

    Description: Values including **v1, v2**, and **v3** in the **c1** column of the **t** table relationship cause skew in query execution.
  - Multiple columns, each having one skew value: **skew(t (c1 c2) (v1 v2))**

    Description: The **v1** value in the **c1** column and the **v2** value in the **c2** column of the **t** table relationship cause skew in query execution.
  - Multiple columns, each having multiple skew values: **skew(t (c1 c2) ((v1 v2) (v3 v4) (v5 v6) ...))**

    Description: Values including **v1, v3**, and **v5** in the **c1** column and values including **v2, v4**, and **v6** in the **c2** column of the **t** table relationship cause skew in query execution.

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**NOTICE**

In the last format, parentheses for skew value groups can be omitted, for example, **skew(t (c1 c2) (v1 v2 v3 v4 v5 v6 ...))**. In a skew hint, either use parentheses for all skew value groups or for none of them.

Otherwise, a syntax error will be generated. For example, **skew(t (c1 c2) (v1 v2 v3 v4 (v5 v6) ...))** will generate an error.

- Specify intermediate result skew.

  If data skew does not occur in base tables but in an intermediate result during query execution, specify skew hints of the intermediate result to solve the skew. skew((t1 t2) (c1) (v1))

  Description: Data skew occurs after the table relationships **t1** and **t2** are joined. The **c1** column of the **t1** table contains skew data and its skew value is **v1**.

  **c1** can exist only in a table relationship of **join_rel**. If there is another column having the same name, use aliases to avoid ambiguity.

## Suggestion

- For a multi-level query, write the hint on the layer where data skew occurs.
- For a listed subquery, you can specify the subquery name in a hint. If you know data skew occurs on which base table, directly specify the table.
- Aliases are preferred when you specify a table or column in a hint.

## Example

Specify single-table skew.

- Specify hints in the original query.

  For example, the original query is as follows:

```
explain
with customer_total_return as
(select sr_customer_sk as ctr_customer_sk
,sr_store_sk as ctr_store_sk
,sum(SR_FEE) as ctr_total_return
from store_returns
,date_dim
where sr_returned_date_sk = d_date_sk
and d_year =2000
group by sr_customer_sk
,sr_store_sk)
 select  c_customer_id
from customer_total_return ctr1
,store
,customer
where ctr1.ctr_total_return > (select avg(ctr_total_return)*1.2
from customer_total_return ctr2
where ctr1.ctr_store_sk = ctr2.ctr_store_sk)
and s_store_sk = ctr1.ctr_store_sk
and s_state = 'NM'
and ctr1.ctr_customer_sk = c_customer_sk
order by c_customer_id
limit 100;
```

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```
 id |                                operation                                 |  E-rows   |    E-memory    | E-width |  E-costs
----+--------------------------------------------------------------------------+-----------+----------------+---------+-----------
  1 | ->  Row Adapter                                                          |       100 |                |      20 | 911254.47
  2 |    ->  Vector Limit                                                      |       100 |                |      20 | 911254.47
  3 |       ->  Vector Streaming (type: GATHER)                                |      2400 |                |      20 | 911325.75
  4 |          ->  Vector Limit                                                |      2400 | 1MB            |      20 | 911247.62
  5 |             ->  Vector Sort                                              |   3684816 | 16MB           |      20 | 911631.21
  6 |                ->  Vector Hash Join (7,29)                               |   3684817 | 41MB(12374MB)  |      20 | 905379.41
  7 |                   ->  Vector Streaming(type: REDISTRIBUTE)               |   3684817 | 384KB          |       4 | 883010.31
  8 |                      ->  Vector Hash Join (9,19)                         |   3684817 | 16MB           |       4 | 861302.05
  9 |                         ->  Vector Hash Join (10,18)                     |  11054450 | 16MB           |      44 | 427109.71
 10 |                            ->  Vector Hash Aggregate                     |  50247501 | 397MB(12671MB) |      54 | 395302.57
 11 |                               ->  Vector Streaming(type: REDISTRIBUTE)   |  50247501 | 384KB          |      22 | 358663.76
 12 |                                  ->  Vector Hash Join (13,15)            |  50247501 | 16MB           |      22 | 294300.51
 13 |                                     ->  Vector Partition Iterator        | 287999764 | 1MB            |      26 | 227383.99
 14 |                                        ->  Partitioned CStore Scan on store_returns | 287999764 | 1MB |      26 | 227383.99
 15 |                                     ->  Vector Streaming(type: BROADCAST)|      8712 | 384KB          |       4 | 975.56
 16 |                                        ->  Vector Partition Iterator     |       363 | 1MB            |       4 | 910.65
 17 |                                           ->  Partitioned CStore Scan on date_dim |  363 | 1MB          |       4 | 910.65
 18 |                               ->  CStore Scan on store                   |        44 | 1MB            |       4 | 1006.39
 19 |                            ->  Vector Hash Aggregate                     |       192 | 16MB           |      68 | 426707.38
 20 |                               ->  Vector Subquery Scan on ctr2           |  50247501 | 1MB            |      36 | 416239.03
 21 |                                  ->  Vector Hash Aggregate               |  50247501 | 397MB(12671MB) |      54 | 395302.57
 22 |                                     ->  Vector Streaming(type: REDISTRIBUTE) |  50247501 | 384KB      |      22 | 358663.76
 23 |                                        ->  Vector Hash Join (24,26)      |  50247501 | 16MB           |      22 | 294300.51
 24 |                                           ->  Vector Partition Iterator  | 287999764 | 1MB            |      26 | 227383.99
 25 |                                              ->  Partitioned CStore Scan on store_returns | 287999764 | 1MB |  26 | 227383.99
 26 |                                           ->  Vector Streaming(type: BROADCAST) |  8712 | 384KB          |       4 | 975.56
 27 |                                              ->  Vector Partition Iterator |       363 | 1MB            |       4 | 910.65
 28 |                                                 ->  Partitioned CStore Scan on date_dim |  363 | 1MB      |       4 | 910.65
 29 |                   ->  CStore Scan on customer                            |  12000000 | 1MB            |      24 | 12923.00
(29 rows)
```

Specify the hints of HashAgg in the inner **with** clause and of the outer Hash Join. The query containing hints is as follows:

```
explain
with customer_total_return as
(select /*+ skew(store_returns(sr_store_sk sr_customer_sk)) */sr_customer_sk as ctr_customer_sk
,sr_store_sk as ctr_store_sk
,sum(SR_FEE) as ctr_total_return
from store_returns
,date_dim
where sr_returned_date_sk = d_date_sk
and d_year =2000
group by sr_customer_sk
,sr_store_sk)
 select  /*+ skew(ctr1(ctr_customer_sk)(11))*/  c_customer_id
from customer_total_return ctr1
,store
,customer
where ctr1.ctr_total_return > (select avg(ctr_total_return)*1.2
from customer_total_return ctr2
where ctr1.ctr_store_sk = ctr2.ctr_store_sk)
and s_store_sk = ctr1.ctr_store_sk
and s_state = 'NM'
and ctr1.ctr_customer_sk = c_customer_sk
order by c_customer_id
limit 100;
```

The hints indicate that the **group by** in the inner **with** clause contains skew data during redistribution by HashAgg, corresponding to the original Hash Agg operators 10 and 21; and that the **ctr_customer_sk** column in the outer **ctr1** table contains skew data during redistribution by Hash Join, corresponding to operator 6 in the original plan. The optimized plan is as follows:

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```
 id |                                operation                                 |  E-rows   |  E-memory   | E-width |  E-costs
----+--------------------------------------------------------------------------+-----------+-------------+---------+-----------
  1 | ->  Row Adapter                                                          |       100 |             |      20 | 1061778.14
  2 |    ->  Vector Limit                                                      |       100 |             |      20 | 1061778.14
  3 |       ->  Vector Streaming (type: GATHER)                                |      2400 |             |      20 | 1061849.41
  4 |          ->  Vector Limit                                                |      2400 | 1MB         |      20 | 1061771.29
  5 |             ->  Vector Sort                                              |   3684816 | 16MB        |      20 | 1062154.87
  6 |                ->  Vector Hash Join (7,31)                               |   3684817 | 41MB(12344MB) |      20 | 1055903.08
  7 |                   ->  Vector Streaming(type: PART REDISTRIBUTE PART ROUNDROBIN) |   3684817 | 384KB       |       4 | 1013056.49
  8 |                      ->  Vector Hash Join (9,20)                         |   3684817 | 16MB        |       4 | 1000006.10
  9 |                         ->  Vector Hash Join (10,19)                     |  11054450 | 16MB        |      44 | 496461.73
 10 |                            ->  Vector Hash Aggregate                     |  50247501 | 397MB(12010MB) |      54 | 464654.59
 11 |                               ->  Vector Streaming(type: REDISTRIBUTE)   |  50247501 | 384KB       |      54 | 428015.79
 12 |                                  ->  Vector Hash Aggregate               |  50247501 | 397MB(12010MB) |      54 | 330939.31
 13 |                                     ->  Vector Hash Join (14,16)         |  50247501 | 16MB        |      22 | 294300.51
 14 |                                        ->  Vector Partition Iterator     | 287999764 | 1MB         |      26 | 227383.99
 15 |                                           ->  Partitioned CStore Scan on store_returns | 287999764 | 1MB |      26 | 227383.99
 16 |                                        ->  Vector Streaming(type: BROADCAST) |      8712 | 384KB       |       4 | 975.56
 17 |                                           ->  Vector Partition Iterator  |       363 | 1MB         |       4 | 910.65
 18 |                                              ->  Partitioned CStore Scan on date_dim |       363 | 1MB |       4 | 910.65
 19 |                               ->  CStore Scan on store                   |        44 | 1MB         |       4 | 1006.39
 20 |                            ->  Vector Hash Aggregate                     |       192 | 16MB        |      68 | 496059.40
 21 |                               ->  Vector Subquery Scan on ctr2           |  50247501 | 1MB         |      36 | 485591.05
 22 |                                  ->  Vector Hash Aggregate               |  50247501 | 397MB(12010MB) |      54 | 464654.59
 23 |                                     ->  Vector Streaming(type: REDISTRIBUTE) |  50247501 | 384KB       |      54 | 428015.79
 24 |                                        ->  Vector Hash Aggregate         |  50247501 | 397MB(12010MB) |      54 | 330939.31
 25 |                                           ->  Vector Hash Join (26,28)   |  50247501 | 16MB        |      22 | 294300.51
 26 |                                              ->  Vector Partition Iterator | 287999764 | 1MB         |      26 | 227383.99
 27 |                                                 ->  Partitioned CStore Scan on store_returns | 287999764 | 1MB |      26 | 227383.99
 28 |                                              ->  Vector Streaming(type: BROADCAST) |      8712 | 384KB       |       4 | 975.56
 29 |                                                 ->  Vector Partition Iterator |       363 | 1MB         |       4 | 910.65
 30 |                                                    ->  Partitioned CStore Scan on date_dim |       363 | 1MB |       4 | 910.65
 31 |                   ->  Vector Streaming(type: PART LOCAL PART BROADCAST)  |  12000000 | 384KB       |      24 | 34485.50
 32 |                      ->  CStore Scan on customer                         |  12000000 | 1MB         |      24 | 12923.00
(32 rows)
```

To solve data skew in the redistribution, Hash Agg is changed to double-level Agg operators and the redistribution operators used by Hash Join are changed in the optimized plan.

- Modify the query and then specify hints.

  For example, the original query and its plan are as follows:

```
explain select count(*) from store_sales_1 group by round(ss_list_price);
```

```
 id |                                operation                                 |  E-rows  |  E-memory  | E-width |  E-costs
----+--------------------------------------------------------------------------+----------+------------+---------+----------
  1 | ->  Row Adapter                                                          |    16672 |            |      14 | 62261.28
  2 |    ->  Vector Streaming (type: GATHER)                                   |    16672 |            |      14 | 62261.28
  3 |       ->  Vector Streaming(type: LOCAL GATHER dop: 1/2)                  |    16672 | 32KB       |      14 | 61479.78
  4 |          ->  Vector Hash Aggregate                                       |    16672 | 16MB       |      14 | 61452.00
  5 |             ->  Vector Streaming(type: SPLIT REDISTRIBUTE dop: 2/2)      |  3112836 | 128KB      |       6 | 57498.43
  6 |                ->  CStore Scan on store_sales_1                          |  3112836 | 1MB        |       6 | 21810.25
(6 rows)
```

  Columns in hints do not support expressions. To specify hints, rewrite the query as several subqueries. The rewritten query and its plan are as follows:

```
explain
select count(*)
from (select round(ss_list_price),ss_hdemo_sk
from store_sales_1)tmp(a,ss_hdemo_sk)
group by a;
```

```
 id |                                operation                                 |  E-rows  |  E-memory  | E-width |  E-costs
----+--------------------------------------------------------------------------+----------+------------+---------+----------
  1 | ->  Row Adapter                                                          |    16672 |            |      14 | 62261.28
  2 |    ->  Vector Streaming (type: GATHER)                                   |    16672 |            |      14 | 62261.28
  3 |       ->  Vector Streaming(type: LOCAL GATHER dop: 1/2)                  |    16672 | 32KB       |      14 | 61479.78
  4 |          ->  Vector Hash Aggregate                                       |    16672 | 16MB       |      14 | 61452.00
  5 |             ->  Vector Streaming(type: SPLIT REDISTRIBUTE dop: 2/2)      |  3112836 | 128KB      |       6 | 57498.43
  6 |                ->  CStore Scan on store_sales_1                          |  3112836 | 1MB        |       6 | 21810.25
(6 rows)
```

  Ensure that the service logic is not changed during the rewriting.

  Specify hints in the rewritten query as follows:

```
explain
select /*+ skew(tmp(a)) */ count(*)
from (select round(ss_list_price),ss_hdemo_sk
from store_sales_1)tmp(a,ss_hdemo_sk)
group by a;
```

```
 id |                                operation                                 |  E-rows  | E-memory | E-width |  E-costs
----+--------------------------------------------------------------------------+----------+----------+---------+-----------
  1 | ->  Row Adapter                                                          |    16672 |          |      14 | 27771.82
  2 |    ->  Vector Streaming (type: GATHER)                                   |    16672 |          |      14 | 27771.82
  3 |       ->  Vector Streaming(type: LOCAL GATHER dop: 1/2)                  |    16672 | 32KB     |      14 | 26990.32
  4 |          ->  Vector Hash Aggregate                                       |    16671 | 16MB     |      14 | 26962.54
  5 |             ->  Vector Streaming(type: SPLIT REDISTRIBUTE dop: 2/2)      |    66216 | 128KB    |      14 | 26838.09
  6 |                ->  Vector Hash Aggregate                                 |    66216 | 16MB     |      14 | 25949.61
  7 |                   ->  CStore Scan on store_sales_1                       |  3112836 | 1MB      |       6 | 21810.25
(7 rows)
```

  The plan shows that after Hash Agg is changed to double-layer Agg operators, redistributed data is greatly reduced and redistribution time is shortened.

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You can specify hints in columns in a subquery, for example:

```
explain
select /*+ skew(tmp(b)) */ count(*)
from (select round(ss_list_price) b,ss_hdemo_sk
from store_sales_1)tmp(a,ss_hdemo_sk)
group by a;
```

## 10.3.9.9 Parameterized Path Hint

### Function

Specifies the parameterized path and the conditional predicate pushdown method.

### Syntax

```
predpush(src1 src2)
predpush(src, dest)
```

### Parameter Description

- **src**, **src1**, and **src2** indicate the set of candidates tables pushed down by **predpush**.
- **dest** indicates the specified destination table pushed down by **predpush**.
- If **predpush** does not contain commas (,), all tables are candidates table. If **predpush** contains commas (,), both candidates tables and destination tables are specified.

NOTE

Use the **predpush** hint to move the filter expression as close to the data source as possible to optimize the query.

- Before using the **predpush** hint, ensure that the **rewrite_rule** GUC parameter contains the **PREDPUSH|REDPUSHFORCE|PREDPUSHNORMAL** option.
- **subquery_block** can also be a view or materialized view.

### Examples

Use the **predpush** hint to improve the statement execution efficiency. Example:

```
set rewrite_rule = 'predpushnormal';
explain (costs off) SELECT /*+PREDPUSH(t2, st3)*/ *
FROM t2,
   (SELECT sum(t3.b), t3.a FROM t3, t4 where t3.a = t4.a GROUP BY t3.a) st3
WHERE st3.a = t2.a;
 id |                     operation
----+-----------------------------------------------------
  1 | ->  Streaming (type: GATHER)
  2 |    ->  Nested Loop (3,4)
  3 |       ->  Seq Scan on t2
  4 |       ->  GroupAggregate
  5 |          ->  Nested Loop (6,7)
  6 |             ->  Index Only Scan using t4_a_idx on t4
  7 |             ->  Materialize
  8 |                ->  Index Scan using t3_a_idx on t3
(8 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
  6 --Index Only Scan using t4_a_idx on t4
       Index Cond: (a = t2.a)
```

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```
  8 --Index Scan using t3_a_idx on t3
        Index Cond: (a = t2.a)
(4 rows)
```

If the **predpush** hint is not used, t3 and t4 in the subquery are not processed outside the query block before being joined. As a result, the returned result set is large, causing performance waste.

However, as shown in the preceding plan, after the **predpush** hint is used, condition filtering is performed on t3 and t4 based on t2 before they are joined. The result set returned after joining is small, which effectively improves the performance.

## 10.3.9.10 Hint Errors, Conflicts, and Other Warnings

Plan hints change an execution plan. You can run **EXPLAIN** to view the changes.

Hints containing errors are invalid and do not affect statement execution. The errors will be displayed in different ways based on statement types. Hint errors in an **EXPLAIN** statement are displayed as a warning on the interface. Hint errors in other statements will be recorded in debug1-level logs containing the **PLANHINT** keyword.

Hint error types are as follows:

- Syntax errors

  An error will be reported if the syntax tree fails to be reduced. The No. of the row generating an error is displayed in the error details.

  For example, the hint keyword is incorrect, no table or only one table is specified in the **leading** or **join** hint, or no tables are specified in other hints. The parsing of a hint is terminated immediately after a syntax error is detected. Only the hints that have been parsed successfully are valid.

  Example:

  ```
  leading((t1 t2)) nestloop(t1) rows(t1 t2 #10)
  ```

  The syntax of **nestloop(t1)** is wrong and its parsing is terminated. Only **leading(t1 t2)** that has been successfully parsed before **nestloop(t1)** is valid.
- Semantic errors
  - An error will be reported if the specified tables do not exist, multiple tables are found based on the hint setting, or a table is used more than once in the **leading** or **join** hint.
  - An error will be reported if the index specified in a scan hint does not exist.
  - If multiple tables with the same name exist after a subquery is pulled up and some of them need to be hinted, add aliases for them to avoid name duplication.
- Duplicated or conflicted hints

  If hint duplication or conflicts occur, only the first hint takes effect. A message will be displayed to describe the situation.
  - Hint duplication indicates that a hint is used more than once in the same query, for example, **nestloop(t1 t2) nestloop(t1 t2)**.
  - A hint conflict indicates that the functions of two hints with the same table list conflict with each other.

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For example, if **nestloop (t1 t2) hashjoin (t1 t2)** is used, **hashjoin (t1 t2)** becomes invalid. **nestloop(t1 t2)** does not conflict with **no mergejoin(t1 t2)**.

**NOTICE**

The table list in the **leading** hint is disassembled. For example, **leading ((t1 t2 t3))** will be disassembled as **leading((t1 t2)) leading(((t1 t2) t3))**, which will conflict with **leading((t2 t1))** (if any). In this case, the latter **leading(t2 t1)** becomes invalid. If two hints use duplicated table lists and only one of them has the specified outer/inner table, the one without a specified outer/inner table becomes invalid.

- A hint becomes invalid after a sublink is pulled up.

  In this case, a message will be displayed. Generally, such invalidation occurs when a sublink contains multiple tables to be joined. After the sublink is pulled up, the tables will not be join members.

- Unsupported column types
  - Skew hints are specified to optimize redistribution. They will be invalid if their corresponding columns do not support redistribution.
- Hints are not used.
  - If **hashjoin** or **mergejoin** is specified for non-equivalent joins, it will not be used.
  - If **indexscan** or **indexonlyscan** is specified for a table that does not have an index, it will not be used.
  - If **indexscan hint** or **indexonlyscan** is specified for a full-table scan or for a scan whose filtering conditions are not set on index columns, it will not be used.
  - The specified **indexonlyscan** hint is used only when the output column contains only indexes.
  - In equivalent joins, only the joins containing equivalence conditions are valid. Therefore, the **leading**, **join**, and **rows** hints specified for the joins without an equivalence condition will not be used. For example, **t1**, **t2**, and **t3** are to be joined, and the join between **t1** and **t3** does not contain an equivalence condition. In this case, **leading(t1 t3)** will not be used.
  - To generate a streaming plan, if the distribution key of a table is the same as its join key, **redistribute** specified for this table will not be used. If the distribution key and join key are different for this table but the same for the other table in the join, **redistribute** specified for this table will be used but **broadcast** will not.
  - If no sublink is pulled up, the specified **blockname** hint will not be used.
  - Skew hints are not used possibly because:
    - The plan does not require redistribution.
    - The columns specified by hints contain distribution keys.
    - Skew information specified in hints is incorrect or incomplete, for example, no value is specified for join optimization.

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- Skew optimization is disabled by GUC parameters.

### 10.3.9.11 Plan Hint Cases

This section takes the statements in TPC-DS (Q24) as an example to describe how to optimize an execution plan by using hints in 1000X+24DN environments. For example:

```
select avg(netpaid) from
(select c_last_name
,c_first_name
,s_store_name
,ca_state
,s_state
,i_color
,i_current_price
,i_manager_id
,i_units
,i_size
,sum(ss_sales_price) netpaid
from store_sales
,store_returns
,store
,item
,customer
,customer_address
where ss_ticket_number = sr_ticket_number
and ss_item_sk = sr_item_sk
and ss_customer_sk = c_customer_sk
and ss_item_sk = i_item_sk
and ss_store_sk = s_store_sk
and c_birth_country = upper(ca_country)
and s_zip = ca_zip
and s_market_id=7
group by c_last_name
,c_first_name
,s_store_name
,ca_state
,s_state
,i_color
,i_current_price
,i_manager_id
,i_units
,i_size);
```

1. The original plan of this statement is as follows and the statement execution takes 110s:

```
 id |                                    operation                                    |        A-time          |  A-rows   |  E-rows   |
----+-------------------------------------------------------------------------------------+------------------------+-----------+-----------+-
  1 | ->  Row Adapter                                                                 | 110324.107             |         1 |         1 |
  2 |   ->  Vector Aggregate                                                          | 110324.093             |         1 |         1 |
  3 |     ->  Vector Streaming (type: GATHER)                                         | 110323.958             |        24 |        24 |
  4 |       ->  Vector Aggregate                                                      | [110179.302,110309.653] |        24 |        24 |
  5 |         ->  Vector Hash Aggregate                                               | [110178.388,110308.515] |    647824 |     16656 |
  6 |           ->  Vector Streaming(type: REDISTRIBUTE)                              | [77616.177,96478.771]  | 666834733 |     16664 |
  7 |             ->  Vector Hash Join (8,22)                                         | [81727.257,84728.519]  | 666834733 |     16664 |
  8 |               ->  Vector Streaming(type: REDISTRIBUTE)                          | [78770.520,82021.087]  | 666834733 |     16664 |
  9 |                 ->  Vector Hash Join (10,21)                                    | [88066.755,90701.860]  | 666834733 |     16664 |
 10 |                   ->  Vector Streaming(type: BROADCAST)                         | [7940.962,21430.725]   | 591882336 |     51360 |
 11 |                     ->  Vector Hash Join (12,20)                                | [2419.995,5319.606]    |  24661764 |      2140 |
 12 |                       ->  Vector Streaming(type: REDISTRIBUTE)                  | [1750.448,4659.581]    |  25258268 |      2241 |
 13 |                         ->  Vector Hash Join (14,18)                            | [15240.666,17159.616]  |  25258268 |      2241 |
 14 |                           ->  Vector Hash Join (15,17)                          | [12112.913,13563.366]  | 252564412 | 472070592 |
 15 |                             ->  Vector Partition Iterator                       | [11148.731,12473.230]  | 2879987999 | 2879987999 |
 16 |                                ->  Partitioned CStore Scan on public.store_sales | [11097.921,12412.596]  | 2879987999 | 2879987999 |
 17 |                             ->  CStore Scan on public.store                     | [0.447,0.689]          |      2064 |      2064 |
 18 |                           ->  Vector Partition Iterator                         | [296.805,319.014]      | 287999764 | 287999764 |
 19 |                             ->  Partitioned CStore Scan on public.store_returns | [292.938,314.787]      | 287999764 | 287999764 |
 20 |                       ->  CStore Scan on public.customer                        | [114.358,144.462]      |  12000000 |  12000000 |
 21 |                   ->  CStore Scan on public.customer_address                    | [38.426,56.753]        |   6000000 |   6000000 |
 22 |               ->  CStore Scan on public.item                                    | [3.160,5.026]          |    300000 |    300000 |
(22 rows)
```

In this plan, the performance of the layer-10 **broadcast** is poor because the estimation result generated at layer 11 is 2140 rows, much less than the actual

number of rows. The inaccurate estimation is mainly caused by the underestimated number of rows in layer-13 hash join. In this layer, **store_sales** and **store_returns** are joined (based on the **ss_ticket_number** and **ss_item_sk** columns in **store_sales** and the **sr_ticket_number** and **sr_item_sk** columns in **store_returns**) but the multi-column correlation is not considered.

2. After the **rows** hint is used for optimization, the plan is as follows and the statement execution takes 318s:

```
select avg(netpaid) from
(select /*+rows(store_sales store_returns * 11270)*/ c_last_name ...
```

```
 id |                                operation                                 |        A-time         |  A-rows   |  E-rows
----+--------------------------------------------------------------------------+-----------------------+-----------+-----------+
  1 | ->  Row Adapter                                                          | 318585.246            |         1 |         1 |
  2 |    ->  Vector Aggregate                                                  | 318585.232            |         1 |         1 |
  3 |       ->  Vector Streaming (type: GATHER)                                | 318585.082            |        24 |        24 |
  4 |          ->  Vector Aggregate                                            | [318323.324,318499.290] |        24 |        24 |
  5 |             ->  Vector Hash Aggregate                                    | [318320.813,318497.054] |    647824 |  187770504 |
  6 |                ->  Vector Streaming(type: REDISTRIBUTE)                  | [288074.860,305601.698] |  666834733 |  187770507 |
  7 |                   ->  Vector Hash Join (8,22)                            | [253642.468,315808.664] |  666834733 |  187770507 |
  8 |                      ->  Vector Hash Join (9,18)                         | [250904.317,315684.018] |  666834733 |  187770507 |
  9 |                         ->  Vector Streaming(type: REDISTRIBUTE)         | [4552.500,310602.307] |  275042158 |  147106999 |
 10 |                            ->  Vector Hash Join (11,17)                  | [7658.951,14053.823]  |  275042158 |  147106999 |
 11 |                               ->  Vector Streaming(type: REDISTRIBUTE)   | [3953.255,10264.943]  |  287999764 |  154060900 |
 12 |                                  ->  Vector Hash Join (13,15)            | [28196.188,32838.794] |  287999764 |  154060900 |
 13 |                                     ->  Vector Partition Iterator        | [11477.673,12324.583] | 2879987999 | 2879987999 |
 14 |                                        ->  Partitioned CStore Scan on public.store_sales | [11411.382,12250.209] | 2879987999 | 2879987999 |
 15 |                                     ->  Vector Partition Iterator        | [304.188,403.205]     |  287999764 |  287999764 |
 16 |                                        ->  Partitioned CStore Scan on public.store_returns | [299.838,398.255] |  287999764 |  287999764 |
 17 |                               ->  CStore Scan on public.customer         | [122.246,170.128]     |   12000000 |   12000000 |
 18 |                         ->  Vector Streaming(type: REDISTRIBUTE)         | [57.558,117.461]      |     492915 |     146467 |
 19 |                            ->  Vector Hash Join (20,21)                  | [45.554,96.238]       |     492915 |     146467 |
 20 |                               ->  CStore Scan on public.customer_address | [39.738,89.412]       |    6000000 |    6000000 |
 21 |                               ->  CStore Scan on public.store            | [0.361,1.095]         |       2064 |       2064 |
 22 |                      ->  Vector Streaming(type: BROADCAST)               | [48.986,91.170]       |    7200000 |    7200000 |
 23 |                         ->  CStore Scan on public.item                   | [4.506,6.602]         |     300000 |     300000 |
(23 rows)
```

The execution takes a longer time because layer-9 **redistribute** is slow. Considering that data skew does not occur at layer-9 **redistribute**, the slow redistribution is caused by the slow layer-8 **hashjoin** due to data skew at layer-18 **redistribute**.

3. Data skew occurs at layer-18 **redistribute** because **customer_address** has a few different values in its two join keys. Therefore, plan **customer_address** as the last one to be joined. After the hint is used for optimization, the plan is as follows and the statement execution takes 116s:

```
select avg(netpaid) from
(select /*+rows(store_sales store_returns *11270)
leading((store_sales store_returns store item customer) customer_address)*/
c_last_name ...
```

```
 id |                                operation                                 |        A-time         |  A-rows   |  E-rows
----+--------------------------------------------------------------------------+-----------------------+-----------+-----------+
  1 | ->  Row Adapter                                                          | 116326.597            |         1 |         1 |
  2 |    ->  Vector Aggregate                                                  | 116326.590            |         1 |         1 |
  3 |       ->  Vector Streaming (type: GATHER)                                | 116326.473            |        24 |        24 |
  4 |          ->  Vector Aggregate                                            | [116157.161,116236.494] |        24 |        24 |
  5 |             ->  Vector Hash Aggregate                                    | [116155.328,116233.946] |    647824 |  187770504 |
  6 |                ->  Vector Streaming(type: REDISTRIBUTE)                  | [84103.951,102052.326] |  666834733 |  187770507 |
  7 |                   ->  Vector Hash Join (8,10)                            | [23229.469,47484.697] |  666834733 |  187770507 |
  8 |                      ->  Vector Streaming(type: REDISTRIBUTE)            | [38.367,74.930]       |    6000000 |    6000000 |
  9 |                         ->  CStore Scan on public.customer_address       | [69.877,121.460]      |    6000000 |    6000000 |
 10 |                      ->  Vector Streaming(type: REDISTRIBUTE)            | [17404.744,17567.550] |   24661764 |   24112909 |
 11 |                         ->  Vector Hash Join (12,22)                     | [16123.627,16397.246] |   24661764 |   24112909 |
 12 |                            ->  Vector Streaming(type: REDISTRIBUTE)      | [15320.663,15741.646] |   25258268 |   25252751 |
 13 |                               ->  Vector Hash Join (14,21)               | [14962.342,16375.458] |   25258268 |   25252751 |
 14 |                                  ->  Vector Hash Join (15,19)            | [14449.031,15825.949] |   25258268 |   25252751 |
 15 |                                     ->  Vector Hash Join (16,18)         | [11439.959,12510.065] |  252564412 |  472070592 |
 16 |                                        ->  Vector Partition Iterator     | [10531.986,11536.213] | 2879987999 | 2879987999 |
 17 |                                           ->  Partitioned CStore Scan on public.store_sales | [10483.634,11474.944] | 2879987999 | 2879987999 |
 18 |                                        ->  CStore Scan on public.store   | [0.347,0.463]         |       2064 |       2064 |
 19 |                                     ->  Vector Partition Iterator        | [293.977,365.021]     |  287999764 |  287999764 |
 20 |                                        ->  Partitioned CStore Scan on public.store_returns | [289.936,360.808] |  287999764 |  287999764 |
 21 |                                  ->  CStore Scan on public.item          | [3.109,5.245]         |     300000 |     300000 |
 22 |                               ->  CStore Scan on public.customer         | [113.871,141.791]     |   12000000 |   12000000 |
(22 rows)
```

Most of the time is spent on layer-6 **redistribute**. The plan needs to be further optimized.

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4. Most of the time is spent on layer-6 **redistribute** because of data skew. To avoid the data skew, plan the **item** table as the last one to be joined because the number of rows is not reduced after **item** is joined. After the hint is used for optimization, the plan is as follows and the statement execution takes 120s:

```
select avg(netpaid) from
(select /*+rows(store_sales store_returns *11270)
leading((customer_address (store_sales store_returns store customer) item))
c_last_name ...
```

```
 id |                                                operation                                                |        A-time         |  A-rows   |  E-rows
----+---------------------------------------------------------------------------------------------------------+-----------------------+-----------+-----------
  1 | ->  Row Adapter                                                                                         | 120377.258            |         1 |         1
  2 |    ->  Vector Aggregate                                                                                 | 120377.245            |         1 |         1
  3 |       ->  Vector Streaming (type: GATHER)                                                               | 120377.091            |        24 |        24
  4 |          ->  Vector Aggregate                                                                           | [120184.884,120301.704] |        24 |        24
  5 |             ->  Vector Hash Aggregate                                                                   | [120183.119,120297.845] |    647824 |  187770504
  6 |                ->  Vector Streaming(type: REDISTRIBUTE)                                                 | [87775.682,106070.878]  |  666834733 |  187770507
  7 |                   ->  Vector Hash Join (8,22)                                                           | [22323.764,49878.523]   |  666834733 |  187770507
  8 |                      ->  Vector Hash Join (9,11)                                                        | [21129.236,45208.255]   |  666834733 |  187770507
  9 |                         ->  Vector Streaming(type: REDISTRIBUTE)                                        | [37.859,75.412]         |    6000000 |    6000000
 10 |                            ->  CStore Scan on public.customer_address                                   | [74.798,114.449]        |    6000000 |    6000000
 11 |                         ->  Vector Streaming(type: REDISTRIBUTE)                                        | [15714.458,15824.928]   |   24661764 |   24112909
 12 |                            ->  Vector Hash Join (13,21)                                                 | [14637.516,14955.464]   |   24661764 |   24112909
 13 |                               ->  Vector Streaming(type: REDISTRIBUTE)                                  | [13898.593,14333.200]   |   25258268 |   25252751
 14 |                                  ->  Vector Hash Join (15,19)                                           | [14166.917,15378.244]   |   25258268 |   25252751
 15 |                                     ->  Vector Hash Join (16,18)                                        | [11272.239,12052.532]   |  252564412 |  472070592
 16 |                                        ->  Vector Partition Iterator                                    | [10409.566,11127.981]   | 2879987999 | 2879987999
 17 |                                           ->  Partitioned CStore Scan on public.store_sales             | [10365.838,11077.601]   | 2879987999 | 2879987999
 18 |                                        ->  CStore Scan on public.store                                  | [0.431,0.609]           |       2064 |       2064
 19 |                                     ->  Vector Partition Iterator                                       | [343.780,408.254]       |  287999764 |  287999764
 20 |                                        ->  Partitioned CStore Scan on public.store_returns              | [339.844,403.923]       |  287999764 |  287999764
 21 |                                  ->  CStore Scan on public.customer                                     | [117.234,163.598]       |   12000000 |   12000000
 22 |                      ->  Vector Streaming(type: BROADCAST)                                              | [44.571,130.129]        |    7200000 |    7200000
 23 |                         ->  CStore Scan on public.item                                                  | [4.169,6.347]           |     300000 |     300000
(23 rows)
```

Data skew occurs after the join of **item** and **customer_address** because **item** is broadcast at layer-22. As a result, layer-6 **redistribute** is still slow.

5. Add a hint to disable **broadcast** for **item** or add a **redistribute** hint for the join result of **item** and **customer_address**. After the hint is used for optimization, the plan is as follows and the statement execution takes 105s:

```
select avg(netpaid) from
(select /*+rows(store_sales store_returns *11270)
leading((customer_address (store_sales store_returns store customer) item))
no broadcast(item)*/
c_last_name ...
```

```
 id |                                                operation                                                |        A-time         |  A-rows   |  E-rows
----+---------------------------------------------------------------------------------------------------------+-----------------------+-----------+-----------
  1 | ->  Row Adapter                                                                                         | 105854.957            |         1 |         1
  2 |    ->  Vector Aggregate                                                                                 | 105854.948            |         1 |         1
  3 |       ->  Vector Streaming (type: GATHER)                                                               | 105854.825            |        24 |        24
  4 |          ->  Vector Aggregate                                                                           | [105706.709,105776.135] |        24 |        24
  5 |             ->  Vector Hash Aggregate                                                                   | [105705.061,105773.013] |    647824 |  187770504
  6 |                ->  Vector Streaming(type: REDISTRIBUTE)                                                 | [70701.966,89973.672]   |  666834733 |  187770507
  7 |                   ->  Vector Hash Join (8,23)                                                           | [71759.500,79018.433]   |  666834733 |  187770507
  8 |                      ->  Vector Streaming(type: REDISTRIBUTE)                                           | [69794.307,77269.178]   |  666834733 |  187770507
  9 |                         ->  Vector Hash Join (10,12)                                                    | [21443.307,46714.378]   |  666834733 |  187770507
 10 |                            ->  Vector Streaming(type: REDISTRIBUTE)                                     | [41.295,83.419]         |    6000000 |    6000000
 11 |                               ->  CStore Scan on public.customer_address                                | [70.405,166.072]        |    6000000 |    6000000
 12 |                            ->  Vector Streaming(type: REDISTRIBUTE)                                     | [15689.053,15788.475]   |   24661764 |   24112909
 13 |                               ->  Vector Hash Join (14,22)                                              | [14517.847,14712.929]   |   24661764 |   24112909
 14 |                                  ->  Vector Streaming(type: REDISTRIBUTE)                               | [13806.733,14089.770]   |   25258268 |   25252751
 15 |                                     ->  Vector Hash Join (16,20)                                        | [13709.384,15095.449]   |   25258268 |   25252751
 16 |                                        ->  Vector Hash Join (17,19)                                     | [10944.796,11827.285]   |  252564412 |  472070592
 17 |                                           ->  Vector Partition Iterator                                 | [10070.316,10884.728]   | 2879987999 | 2879987999
 18 |                                              ->  Partitioned CStore Scan on public.store_sales          | [10018.966,10828.990]   | 2879987999 | 2879987999
 19 |                                           ->  CStore Scan on public.store                               | [0.447,0.568]           |       2064 |       2064
 20 |                                        ->  Vector Partition Iterator                                    | [293.042,329.056]       |  287999764 |  287999764
 21 |                                           ->  Partitioned CStore Scan on public.store_returns           | [288.631,324.782]       |  287999764 |  287999764
 22 |                                     ->  CStore Scan on public.customer                                  | [113.735,138.235]       |   12000000 |   12000000
 23 |                               ->  CStore Scan on public.item                                            | [3.127,5.357]           |     300000 |     300000
(23 rows)
```

6. The last layer uses single-layer **Agg** and the number of rows is greatly reduced. Set **best_agg_plan** to **3** and change the single-layer **Agg** to a double-layer **Agg**. The plan is as follows and the statement execution takes 94s. The optimization ends.

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```
 id |                                                                operation                                                                |          A-time          | A-rows  | E-rows
----+-----------------------------------------------------------------------------------------------------------------------------------------+--------------------------+---------+---------
  1 | ->  Row Adapter                                                                                                                         | 94004.670                |       1 |       1
  2 |    ->  Vector Aggregate                                                                                                                 | 94004.655                |       1 |       1
  3 |       ->  Vector Streaming (type: GATHER)                                                                                               | 94004.504                |      24 |      24
  4 |          ->  Vector Aggregate                                                                                                           | [93833.832,93928.052]    |      24 |      24
  5 |             ->  Vector Hash Aggregate                                                                                                   | [93832.460,93926.412]    |  647824 | 187770507
  6 |                ->  Vector Streaming(type: REDISTRIBUTE)                                                                                 | [93640.866,93787.939]    |  647824 | 183912384
  7 |                   ->  Vector Hash Aggregate                                                                                             | [93687.544,93791.242]    |  647824 | 183912384
  8 |                      ->  Vector Hash Join (9,24)                                                                                        | [70025.469,72773.161]    |  666834733 | 187770507
  9 |                         ->  Vector Streaming(type: REDISTRIBUTE)                                                                        | [68242.223,71275.972]    |  666834733 | 187770507
 10 |                            ->  Vector Hash Join (11,13)                                                                                 | [21421.136,44830.306]    |  666834733 | 187770507
 11 |                               ->  Vector Streaming(type: REDISTRIBUTE)                                                                  | [35.444,71.328]          |    6000000 |    6000000
 12 |                                  ->  CStore Scan on public.customer_address                                                             | [67.246,119.224]         |    6000000 |    6000000
 13 |                               ->  Vector Streaming(type: REDISTRIBUTE)                                                                  | [16089.853,16212.570]    |   24661764 |   24112909
 14 |                                  ->  Vector Hash Join (15,23)                                                                           | [14822.972,15188.942]    |   24661764 |   24112909
 15 |                                     ->  Vector Streaming(type: REDISTRIBUTE)                                                            | [14061.867,14604.162]    |   25258268 |   25252751
 16 |                                        ->  Vector Hash Join (17,21)                                                                     | [13949.756,15492.311]    |   25258268 |   25252751
 17 |                                           ->  Vector Hash Join (18,20)                                                                  | [10935.742,12160.719]    |  252564412 |  472070592
 18 |                                              ->  Vector Partition Iterator                                                              | [10052.958,11194.962]    | 2879987999 | 2879987999
 19 |                                                 ->  Partitioned CStore Scan on public.store_sales                                       | [10008.415,11143.984]    | 2879987999 | 2879987999
 20 |                                              ->  CStore Scan on public.store                                                            | [0.452,0.839]            |       2064 |       2064
 21 |                                           ->  Vector Partition Iterator                                                                 | [298.235,332.736]        |  287999764 |  287999764
 22 |                                              ->  Partitioned CStore Scan on public.store_returns                                        | [294.067,327.629]        |  287999764 |  287999764
 23 |                                     ->  CStore Scan on public.customer                                                                  | [114.377,145.156]        |   12000000 |   12000000
 24 |                         ->  CStore Scan on public.item                                                                                  | [3.150,3.530]            |     300000 |     300000
(24 rows)
```

If the query performance deteriorates due to statistics changes, you can use hints to optimize the query plan. Take TPCH-Q17 as an example. The query performance deteriorates after the value of **default_statistics_target** is changed from the default one to **–2** for statistics collection.

1. If **default_statistics_target** is set to the default value **100**, the plan is as follows:

```
 id |                                                                operation                                                                |          A-time
----+-----------------------------------------------------------------------------------------------------------------------------------------+--------------------------
  1 | ->  Row Adapter                                                                                                                         | 265006.779
  2 |    ->  Vector Aggregate                                                                                                                 | 265006.764
  3 |       ->  Vector Streaming (type: GATHER)                                                                                               | 265006.071
  4 |          ->  Vector Aggregate                                                                                                           | [263699.512,264503.084]
  5 |             ->  Vector Hash Join (6,17)                                                                                                 | [263676.665,264477.932]
  6 |                ->  Vector Streaming(type: LOCAL GATHER dop: 1/4)                                                                        | [1.998,7.594]
  7 |                   ->  Vector Hash Aggregate                                                                                             | [201775.393,202432.672]
  8 |                      ->  Vector Streaming(type: SPLIT REDISTRIBUTE dop: 4/4)                                                            | [201567.130,202231.524]
  9 |                         ->  Vector Hash Join (10,12)                                                                                    | [170675.231,199908.410]
 10 |                            ->  Vector Partition Iterator                                                                                | [34847.797,51968.266]
 11 |                               ->  Partitioned CStore Scan on tpch10wx_col.lineitem                                                      | [33805.013,51137.657]
 12 |                            ->  Vector Hash Aggregate                                                                                    | [23283.387,25359.493]
 13 |                               ->  Vector Streaming(type: SPLIT BROADCAST dop: 4/4)                                                      | [12850.624,14608.515]
 14 |                                  ->  Vector Hash Aggregate                                                                              | [2690.439,3616.623]
 15 |                                     ->  Vector Partition Iterator                                                                       | [2659.700,3579.390]
 16 |                                        ->  Partitioned CStore Scan on tpch10wx_col.part                                                 | [2642.213,3559.093]
 17 |                   ->  Vector Streaming(type: REDISTRIBUTE dop: 1/4)                                                                     | [262300.732,262961.078]
 18 |                      ->  Vector Hash Join (19,21)                                                                                       | [225749.727,260990.322]
 19 |                         ->  Vector Partition Iterator                                                                                   | [40046.078,56220.694]
 20 |                            ->  Partitioned CStore Scan on tpch10wx_col.lineitem                                                         | [39204.414,55328.448]
 21 |                         ->  Vector Streaming(type: SPLIT BROADCAST dop: 4/4)                                                            | [55748.177,61987.136]
 22 |                            ->  Vector Partition Iterator                                                                                | [3042.864,3873.942]
 23 |                               ->  Partitioned CStore Scan on tpch10wx_col.part                                                          | [3027.023,3848.159]
(23 rows)
```

2. If **default_statistics_target** is set to **–2**, the plan is as follows:

```
 id |                                                                operation                                                                |          A-time
----+-----------------------------------------------------------------------------------------------------------------------------------------+--------------------------
  1 | ->  Row Adapter                                                                                                                         | 1440492.994
  2 |    ->  Vector Aggregate                                                                                                                 | 1440492.982
  3 |       ->  Vector Streaming (type: GATHER)                                                                                               | 1440491.021
  4 |          ->  Vector Streaming(type: LOCAL GATHER dop: 1/6)                                                                              | [1439737.284,1440008.568]
  5 |             ->  Vector Aggregate                                                                                                        | [1439008.369,1439854.148]
  6 |                ->  Vector Hash Join (7,18)                                                                                              | [1439006.016,1439851.619]
  7 |                   ->  Vector Streaming(type: LOCAL BROADCAST dop: 6/6)                                                                  | [2.932,139.405]
  8 |                      ->  Vector Hash Aggregate                                                                                          | [190452.312,195910.748]
  9 |                         ->  Vector Streaming(type: SPLIT REDISTRIBUTE dop: 6/6)                                                         | [190171.929,195653.119]
 10 |                            ->  Vector Hash Join (11,13)                                                                                 | [161076.195,178831.123]
 11 |                               ->  Vector Partition Iterator                                                                             | [27306.318,45564.565]
 12 |                                  ->  Partitioned CStore Scan on tpch10wx_col.lineitem                                                   | [26752.444,44912.020]
 13 |                               ->  Vector Hash Aggregate                                                                                 | [35601.624,39812.058]
 14 |                                  ->  Vector Streaming(type: SPLIT BROADCAST dop: 6/6)                                                   | [23096.460,27057.137]
 15 |                                     ->  Vector Hash Aggregate                                                                           | [2372.587,3052.445]
 16 |                                        ->  Vector Partition Iterator                                                                    | [2345.381,3012.732]
 17 |                                           ->  Partitioned CStore Scan on tpch10wx_col.part                                              | [2329.874,2989.393]
 18 |                   ->  Vector Hash Join (19,22)                                                                                          | [1437388.414,1438470.781]
 19 |                      ->  Vector Streaming(type: SPLIT REDISTRIBUTE dop: 6/6)                                                            | [1392693.529,1408571.859]
 20 |                         ->  Vector Partition Iterator                                                                                   | [29065.204,41264.514]
 21 |                            ->  Partitioned CStore Scan on tpch10wx_col.lineitem                                                         | [28212.219,40133.491]
 22 |                      ->  Vector Streaming(type: LOCAL REDISTRIBUTE dop: 6/6)                                                            | [2570.841,3438.567]
 23 |                         ->  Vector Partition Iterator                                                                                   | [2447.569,3276.369]
 24 |                            ->  Partitioned CStore Scan on tpch10wx_col.part                                                             | [2432.124,3263.641]
(24 rows)
```

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3. After the analysis, the cause is that the stream type is changed from **Broadcast** to **Redistribute** during the join of the **lineitem** and **part** tables. You can use a hint to change the stream type back to **BroadCast**. For example:

```
select /*+ no redistribute(part lineitem) */
    sum(l_extendedprice) / 7.0 as avg_yearly
from
    lineitem,
    part
where
    p_partkey = l_partkey
    and p_brand = 'Brand#23'
    and p_container = 'MED BOX'
    and l_quantity < (
        select
            0.2 * avg(l_quantity)
        from
            lineitem
        where
            l_partkey = p_partkey
    );
```

## 10.3.9.12 Optimizer GUC Parameter Hints

### Function

These hints set GUC parameters related to query optimization that take effect during the query execution. For details about the application scenarios of hints, see the description of each GUC parameter.

### Syntax

```
set(param value)
```

### Parameter Description

- **param** indicates the parameter name.
- **value** indicates the value of a parameter.
- Currently, the following parameters can be set and take effect by using hints:
  - Boolean

    enable_bitmapscan, enable_hashagg, enable_hashjoin, enable_indexscan, enable_indexonlyscan, enable_material, enable_mergejoin, enable_nestloop, enable_index_nestloop, enable_seqscan, enable_sort, enable_tidscan, enable_stream_operator, enable_stream_recursive, enable_broadcast, enable_fast_query_shipping, enable_trigger_shipping, enable_remotejoin, enable_remotegroup, enable_remotelimit, and enable_remotesort
  - Integer

    best_agg_plan and query_dop
  - Floating point

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cost_weight_index, default_limit_rows, seq_page_cost, random_page_cost, cpu_tuple_cost, cpu_index_tuple_cost, cpu_operator_cost, and effective_cache_size

- Enumerated type

  try_vector_engine_strategy

- Character string

  node_name

  By setting **node_name**, you can deliver the current SQL statement to the DN corresponding to **node_name** for execution.

  Example:

  ```
  select /*+ set(node_name datanode1) */ from table_name;
  ```

  In the preceding command, **datanode1** indicates the name of the DN queried from the **pgxc_node** system catalog (without quotation marks), and **table_name** indicates the table name. This query is directly performed on **datanode1**.

**NOTICE**

- **node_name** can be set only by using the SELECT statement. If it is set by using other statements, it does not take effect.
- **node_name** can only be set to the name of a DN and cannot be set to the name of a CN.
- **node_name** cannot be modified by using the SET statement and can only be used in plan hints.
- **node_name** cannot be modified by using **gs_guc**.
- **node_name** supports only simple query statements and does not support complex query statements (such as UNION and UNION ALL), subqueries, and multi-table associations.
- This operation can be performed by common users.
- This operation cannot be performed together with row-level access control. If they are performed together, an error will be reported.

**NOTE**

- If you set a parameter that is not in the whitelist and the parameter value is invalid or the hint syntax is incorrect, the query execution is not affected. Run **explain(verbose on)**. An error message is displayed, indicating that hint parsing fails.
- The GUC parameter hint takes effect only in the outermost query. That is, the GUC parameter hint in the subquery does not take effect.
- The GUC parameter hint in the view definition does not take effect.
- CREATE TABLE ... AS ... The GUC parameter hint in the outermost query takes effect.

## 10.3.9.13 Hints for Selecting the Custom Plan or Generic Plan

## Function

For query statements and DML statements executed in PBE mode, the optimizer generates a custom plan or generic plan based on factors such as rules, costs, and

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parameters. You can use the hint of **use_cplan** or **use_gplan** to specify the plan to execute.

## Syntax

- To select the custom plan, run the following statement:
  ```
  use_cplan
  ```
- To select the generic plan, run the following statement:
  ```
  use_gplan
  ```

  NOTE

  - For SQL statements that are executed in non-PBE mode, setting this hint does not affect the execution mode.
  - This hint has a higher priority than cost-based selection and the **plan_cache_mode** parameter. That is, this hint does not take effect for statements for which **plan_cache_mode** cannot be forcibly set to specify an execution mode.

## Example

Forcibly use the custom plan.

```
set enable_fast_query_shipping = off;
create table t (a int, b int, c int);
prepare p as select /*+ use_cplan */ * from t where a = $1;
explain execute p(1);
```

In the following plan, the filtering condition is the actual value of the input parameter, that is, the plan is a custom plan.

```
                              QUERY PLAN
-----------------------------------------------------------------
 Streaming (type: GATHER)  (cost=0.06..13.26 rows=1 width=12)
   Node/s: datanode1
   ->  Seq Scan on t  (cost=0.00..13.16 rows=1 width=12)
         Filter: (a = 1)
(4 rows)
```

Forcibly use the generic plan.

```
deallocate p;
prepare p as select /*+ use_gplan */ * from t where a = $1;
explain execute p(1);
```

In the following plan, the filtering condition is the input parameter to be added, that is, the plan is a generic plan.

```
                              QUERY PLAN
-----------------------------------------------------------------
 Streaming (type: GATHER)  (cost=0.06..13.26 rows=1 width=12)
   Node/s: All datanodes
   ->  Seq Scan on t  (cost=0.00..13.16 rows=1 width=12)
         Filter: (a = $1)
(4 rows)
```

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## 10.3.9.14 Hints Specifying Not to Expand Subqueries

### Function

When the database optimizes the query logic, some subqueries can be promoted to the upper layer to avoid nested execution. However, for some subqueries that have a low selection rate and can use indexes to filter access pages, nested execution does not cause too much performance deterioration, while after the promotion, the query search scope is expanded, which may cause performance deterioration. In this case, you can use the **no_expand** hint for debugging. This hint is not recommended in most cases.

### Syntax

```
no_expand
```

### Example

Normal query execution:

```
explain select * from t1 where t1.a in (select t2.a from t2);
```

Plan:

```
                              QUERY PLAN
-----------------------------------------------------------------------
 Streaming (type: GATHER)  (cost=0.06..2.13 rows=2 width=12)
   Node/s: All datanodes
   ->  Nested Loop Semi Join  (cost=0.00..2.03 rows=2 width=12)
         Join Filter: (t1.a = t2.a)
         ->  Seq Scan on t1  (cost=0.00..1.01 rows=1 width=12)
         ->  Seq Scan on t2  (cost=0.00..1.01 rows=1 width=4)
(6 rows)
```

After **no_expand** is added:

```
explain select * from t1 where t1.a in (select /*+ no_expand*/ t2.a from t2);
```

Plan:

```
                                    QUERY PLAN
-------------------------------------------------------------------------------
 Streaming (type: GATHER)  (cost=1.09..2.13 rows=1 width=12)
   Node/s: All datanodes
   ->  Seq Scan on t1  (cost=1.02..2.04 rows=1 width=12)
         Filter: (hashed SubPlan 1)
         SubPlan 1
           ->  Materialize  (cost=0.00..1.02 rows=4 width=4)
                 ->  Streaming(type: BROADCAST)  (cost=0.00..1.01 rows=2 width=4)
                       Spawn on: All datanodes
                       ->  Seq Scan on t2  (cost=0.00..1.01 rows=1 width=4)
(9 rows)
```

## 10.3.9.15 Hints Specifying Not to Use Global Plan Cache

### Function

When global plan cache is enabled, you can use the **no_gpc** hint to force a single query statement not to share the plan cache globally. Only the plan cache within the current session lifecycle is retained.

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The current feature is a lab feature. Contact Huawei technical support before using it.

## Syntax

```
no_gpc
```

NOTE

This parameter takes effect only for statements executed by PBE when **enable_global_plancache** is set to **on**.

## Example

```
openGauss=# deallocate all;
DEALLOCATE ALL
openGauss=# prepare insert_nogpc as insert /*+ no_gpc */ into t1 select c1, c2 from t2 where c1 = $1;
PREPARE
openGauss=# execute insert_nogpc(1);
INSERT 0 1
openGauss=# select * from dbe_perf.global_plancache_status where schema_name = 'schema_hint_iud' order by 1,2;
 nodename | query | refcount | valid | databaseid | schema_name | params_num | func_id
----------+-------+----------+-------+------------+-------------+------------+---------
(0 rows)
```

No result exists in the **dbe_perf.global_plancache_status** view, that is, no plan is cached globally.

## 10.3.9.16 Hint of Parameterized Paths at the Same Level

## Function

The **predpush_same_level** hint is used to specify the generation of parameterized paths between tables or materialized views at the same level.

For details about cross-layer parameterized path hints, see **10.3.9.9 Parameterized Path Hint**.

## Syntax

```
predpush_same_level(src, dest)
predpush_same_level(src1 src2 ..., dest)
```

NOTE

This parameter takes effect only when the **predpushforce** option in **rewrite_rule** is enabled.

## Examples

Prepare parameters, tables, and indexes.

```
openGauss=# set rewrite_rule = 'predpushforce';
SET
openGauss=# create table t1(a int, b int) distribute by hash(a);
CREATE TABLE
openGauss=# create table t2(a int, b int) distribute by hash(a);
CREATE TABLE
openGauss=# create index idx1 on t1(a);
CREATE INDEX
openGauss=# create index idx2 on t2(a);
CREATE INDEX
```

Run the following statement to view the plan:

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```
openGauss=# explain select * from t1, t2 where t1.a = t2.a;
                           QUERY PLAN
--------------------------------------------------------------------------
 Streaming (type: GATHER)  (cost=18.25..77.00 rows=1000 width=16)
   Node/s: All datanodes
   ->  Hash Join  (cost=14.25..30.12 rows=1000 width=16)
         Hash Cond: (t1.a = t2.a)
         ->  Seq Scan on t1  (cost=0.00..9.00 rows=1000 width=8)
         ->  Hash  (cost=8.00..8.00 rows=1000 width=8)
               ->  Seq Scan on t2  (cost=0.00..8.00 rows=1000 width=8)
(7 rows)
```

The filter condition **t1.a = t2.a** is displayed on **Join**. In this case, **predpush_same_level(t1, t2)** can be used to push the condition down to the scan operator of t2.

```
openGauss=# explain select /*+predpush_same_level(t1, t2)*/ * from t1, t2 where t1.a = t2.a;
                           QUERY PLAN
--------------------------------------------------------------------------------
 Streaming (type: GATHER)  (cost=4.00..263.88 rows=1000 width=16)
   Node/s: All datanodes
   ->  Nested Loop  (cost=0.00..217.00 rows=1000 width=16)
         ->  Seq Scan on t1  (cost=0.00..9.00 rows=1000 width=8)
         ->  Index Scan using idx2 on t2  (cost=0.00..0.41 rows=1 width=8)
               Index Cond: (a = t1.a)
(6 rows)
```

**NOTICE**

- **predpush_same_level** can specify multiple **src** parameters in the same condition.
- If the specified **src** and **dest** conditions do not exist or do not meet the parameterized path requirements, this hint does not take effect.
- If a stream operator exists on the **dest** scanning operator, this hint does not take effect.

## 10.3.10 Checking the Implicit Conversion Performance

In some scenarios, implicit data type conversion may cause performance problems. For example:

```
SET enable_fast_query_shipping = off;
CREATE TABLE t1(c1 VARCHAR, c2 VARCHAR);
CREATE INDEX on t1(c1);
EXPLAIN verbose SELECT * FROM t1 WHERE c1 = 10;
```

The execution plan of the preceding query is as follows:

```
                            QUERY PLAN
------------------------------------------------------------------
 Streaming (type: GATHER)  (cost=0.06..13.29 rows=1 width=64)
   Output: c1, c2
   Node/s: All datanodes
   ->  Seq Scan on public.t1  (cost=0.00..13.20 rows=1 width=64)
         Output: c1, c2
         Distribute Key: c1
         Filter: ((t1.c1)::bigint = 10)
(7 rows)
```

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The data type of **c1** is **varchar**. When the filter criterion is **c1 = 10**, the optimizer implicitly converts the data type of **c1** to **bigint** by default. As a result, the following two consequences occur:

- DN tailoring is not allowed. The plan is delivered to all DNs for execution.
- The Index Scan mode cannot be used to scan data in the plan.

These may cause performance problems.

After knowing the causes, you can rewrite the SQL statements. In the preceding scenario, you only need to convert the constant display in the filter criteria to the **varchar** type. The result is as follows:

```
EXPLAIN verbose SELECT * FROM t1 WHERE c1 = 10::varchar;
```

```
                                    QUERY PLAN
-----------------------------------------------------------------------------------
 Streaming (type: GATHER)  (cost=0.06..8.36 rows=1 width=64)
   Output: c1, c2
   Node/s: datanode2
   ->  Index Scan using t1_c1_idx on public.t1  (cost=0.00..8.27 rows=1 width=64)
         Output: c1, c2
         Distribute Key: c1
         Index Cond: ((t1.c1)::text = '10'::text)
(7 rows)
```

To identify the performance impact of implicit type conversion in advance, you can use the GUC parameter **check_implicit_conversions**. After this parameter is enabled, the system checks the index columns that are implicitly converted in the query in the path generation phase. If no candidate index scan path is generated for the index columns, an error message is displayed. For example:

```
SET check_implicit_conversions = on;
SELECT * FROM t1 WHERE c1 = 10;
ERROR:  There is no optional index path for index column: "t1"."c1".
Please check for potential performance problem.
```

**NOTE**

- The **check_implicit_conversions** parameter is used only to check for potential performance problems caused by implicit type conversion. In the formal production environment, set this parameter to **off** (default value) to disable it.
- When enabling **check_implicit_conversions**, you must disable **enable_fast_query_shipping**. Otherwise, you cannot view the result of restoring the implicit type conversion.
- A candidate path of a table may include multiple possible data scan modes such as sequential scanning and index scanning. A table scan mode used in the final execution plan is determined by the cost of the execution plan. Therefore, even if a candidate path for index scan is generated, other scan modes may also be used in the final execution plan.

## 10.3.11 Using the Vectorized Executor for Tuning

The GaussDB database supports row executors and vectorized executors for processing row-store tables and column-store tables, respectively. Column-store tables and vectorized executors have the following advantages:

- More data is read in one batch at a time, saving I/O resources.
- There are a large number of records in a batch, and the CPU cache hit rate increases.

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- The number of function calls is small in pipeline mode.
- A batch of data is processed at a time, which is efficient.

GaussDB achieves better query performance in complex analytical queries. However, column-store tables do not perform well in data insertion and update. Therefore, column-store tables cannot be used for services with frequent data insertion and update.

To improve the query performance of row-store tables in complex analytical queries, GaussDB provides vectorized executors for processing row-store tables. You can set **try_vector_engine_strategy** to convert query statements containing row-store tables into vectorized execution plans for execution.

The conversion is not applicable to all query scenarios. If a query statement contains operations such as expression calculation, multi-table join, and aggregation, the performance can be improved by converting the statement to a vectorized execution plan. Theoretically, converting a row-store table to a vectorized execution plan causes conversion overheads and performance deterioration. After the foregoing expression calculation, join operation, and aggregation operations are converted into vectorized execution plans, performance can be improved. The performance improvement must be higher than the overheads generated by the conversion. This determines whether the conversion is required.

Take TPCH Q1 as an example. When a row executor is used, the execution time of the scan operators is 405210 ms, and the execution time of the aggregation operation is 2618964 ms. After a vectorized executor is used, the execution time of the scan operators (SeqScan and VectorAdapter) is 470840 ms, and the execution time of the aggregation operation is 212384 ms. As such, the query performance is improved.

Execution plan of the TPCH Q1 row executor:

```
                                                
```

```
      ->  Vector Sonic Hash Aggregate  (cost=43825807.98..43825808.08 rows=6 width=298) (actual
time=683224.837..683224.837 rows=4 loops=1)
            Group By Key: l_returnflag, l_linestatus
            ->  Vector Adapter(type: BATCH MODE)  (cost=19966853.54..19966853.54 rows=596473861
width=66) (actual time=0.982..470840.274 rows=596140342 loops=1)
                  Filter: (l_shipdate <= '1998-10-01 00:00:00'::timestamp without time zone)
                  Rows Removed by Filter: 3897560
                  ->  Seq Scan on lineitem  (cost=0.00..19966853.54 rows=596473861 width=66) (actual
time=0.364..199301.737 rows=600037902 loops=1)
 Total runtime: 683225.564 ms
(11 rows)
```

# 10.4 Optimization Cases

## 10.4.1 Case: Selecting an Appropriate Distribution Key

### Symptom

Tables are defined as follows:

```
CREATE TABLE t1 (a int, b int);
CREATE TABLE t2 (a int, b int);
```

The following query is executed:

```
SELECT * FROM t1, t2 WHERE t1.a = t2.b;
```

### Optimization Analysis

If **a** is the distribution key of **t1** and **t2**:

```
CREATE TABLE t1 (a int, b int) DISTRIBUTE BY HASH (a);
CREATE TABLE t2 (a int, b int) DISTRIBUTE BY HASH (a);
```

Then **Streaming** exists in the execution plan and the data volume is heavy among DNs, as shown in **Figure 10-11**.

**Figure 10-11** Selecting an appropriate distribution key (1)

```
openGauss => explain select * from t1, t2 where t1.a = t2.b;
                                  QUERY PLAN
-------------------------------------------------------------------------------
 Streaming (type: GATHER)  (cost=245.40..582.15 rows=240 width=16)
   Node/s: All datanodes
   ->  Hash Join  (cost=10.22..24.26 rows=10 width=16)
         Hash Cond: (t1.a = t2.b)
         ->  Seq Scan on t1  (cost=0.00..10.10 rows=10 width=8)
         ->  Hash  (cost=3.79..3.79 rows=10 width=8)
               ->  Streaming(type: REDISTRIBUTE)  (cost=0.00..3.79 rows=10 width=8)
                     Spawn on: All datanodes
                     ->  Seq Scan on t2  (cost=0.00..10.10 rows=10 width=8)
(9 rows)
```

If **a** is the distribution key of **t1** and **b** is the distribution key of **t2**:

```
CREATE TABLE t1 (a int, b int) DISTRIBUTE BY HASH (a);
CREATE TABLE t2 (a int, b int) DISTRIBUTE BY HASH (b);
```

Then **Streaming** does not exist in the execution plan, and the data volume among DNs is decreasing and the query performance is increasing, as shown in **Figure 10-12**.

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**Figure 10-12** Selecting an appropriate distribution key (2)

```
openGauss=> explain select * from t1, t2 where t1.a = t2.b;
                                  QUERY PLAN
------------------------------------------------------------------------------
 Streaming (type: GATHER)  (cost=245.40..491.10 rows=240 width=16)
   Node/s: All datanodes
   ->  Hash Join  (cost=10.22..20.46 rows=10 width=16)
         Hash Cond: (t1.a = t2.b)
         ->  Seq Scan on t1  (cost=0.00..10.10 rows=10 width=8)
         ->  Hash  (cost=10.10..10.10 rows=10 width=8)
               ->  Seq Scan on t2  (cost=0.00..10.10 rows=10 width=8)
(7 rows)
```

## 10.4.2 Case: Creating an Appropriate Index

### Symptom

Query the information about all personnel in the sales department.

```
SELECT staff_id,first_name,last_name,employment_id,state_name,city
FROM staffs,sections,states,places
WHERE sections.section_name='Sales'
AND staffs.section_id = sections.section_id
AND sections.place_id = places.place_id
AND places.state_id = states.state_id
ORDER BY staff_id;
```

### Optimization Analysis

The original execution plan is as follows before creating the **places.place_id** and **states.state_id** indexes:

```
 id |                           operation                           |     A-time      | A-rows | E-rows | Peak Memory  | E-memory | A-width | E-width | E-costs
----+---------------------------------------------------------------+-----------------+--------+--------+--------------+----------+---------+---------+---------
  1 | ->  Streaming (type: GATHER)                                  | 69.801          |     34 |      2 |212KB         |          |         |     354 | 53.67
  2 |    ->  Sort                                                   | [21.508,23.283] |     34 |      2 |[30KB, 36KB]  | 16MB     | [380,380] |     354 | 53.32
  3 |       ->  Hash Join (4,5)                                     | [21.483,23.153] |     34 |      2 |[7KB, 7KB]    | 1MB      |         |     354 | 53.31
  4 |          ->  Seq Scan on hr.states                            | [0.007,0.022]   |     17 |     20 |[12KB, 12KB]  | 1MB      |         |     110 | 13.13
  5 |          ->  Hash                                             | [21.026,22.663] |     34 |      2 |[262KB, 294KB]| 16MB     | [284,284] |     268 | 40.08
  6 |             ->  Streaming(type: REDISTRIBUTE)                 | [21.024,22.458] |     34 |      2 |[85KB, 86KB]  | 1MB      |         |     268 | 40.08
  7 |                ->  Hash Join (8,9)                            | [13.814,14.827] |     34 |      2 |[8KB, 8KB]    | 1MB      |         |     268 | 39.80
  8 |                   ->  Seq Scan on hr.staffs                   | [0.035,0.043]   |    107 |     20 |[19KB, 19KB]  | 1MB      |         |     190 | 13.13
  9 |                   ->  Hash                                    | [13.361,14.348] |      2 |      4 |[292KB, 292KB]| 16MB     | [124,124] |     102 | 26.57
 10 |                      ->  Streaming(type: BROADCAST)           | [13.291,14.279] |      2 |      4 |[85KB, 85KB]  | 1MB      |         |     102 | 26.57
 11 |                         ->  Hash Join (12,13)                 | [6.359,7.446]   |      1 |      2 |[6KB, 6KB]    | 1MB      |         |     102 | 26.48
 12 |                            ->  Seq Scan on hr.places          | [0.008,0.018]   |     15 |     20 |[14KB, 14KB]  | 1MB      |         |     102 | 13.13
 13 |                            ->  Hash                           | [5.999,7.077]   |      1 |      1 |[259KB, 291KB]| 16MB     | [32,32] |      24 | 13.28
 14 |                               ->  Streaming(type: REDISTRIBUTE) | [5.999,6.958]   |      1 |      1 |[84KB, 85KB]  | 1MB      |         |      24 | 13.28
 15 |                                  ->  Seq Scan on hr.sections  | [0.021,0.022]   |      1 |      1 |[14KB, 14KB]  | 1MB      |         |      24 | 13.16
(15 rows)

         Predicate Information (identified by plan id)
-------------------------------------------------------------
  3 --Hash Join (4,5)
       Hash Cond: (states.state_id = places.state_id)
  7 --Hash Join (8,9)
       Hash Cond: (staffs.section_id = sections.section_id)
 11 --Hash Join (12,13)
       Hash Cond: (places.place_id = sections.place_id)
 15 --Seq Scan on hr.sections
       Filter: ((sections.section_name)::text = 'Sales'::text)
       Rows Removed by Filter: 26
(9 rows)
```

The optimized execution plan is as follows (two indexes have been created on the **places.place_id** and **states.state_id** columns):

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```
 id |                           operation                           |     A-time      | A-rows | E-rows | Peak Memory  | E-memory | A-width | E-width | E-costs
----+---------------------------------------------------------------+-----------------+--------+--------+--------------+----------+---------+---------+---------
  1 | ->  Streaming (type: GATHER)                                  | 50.411          |     34 |      2 | 212KB        |          |         |     354 | 46.84
  2 |    ->  Sort                                                   | [20.889,22.621] |     34 |      2 | [30KB, 36KB] | 16MB     | [380,380] |     354 | 46.49
  3 |       ->  Nested Loop (4,13)                                  | [20.870,22.490] |     34 |      2 | [5KB, 5KB]   | 1MB      |         |     354 | 46.48
  4 |          ->  Streaming(type: REDISTRIBUTE)                    | [20.869,21.852] |     34 |      2 | [85KB, 86KB] | 1MB      |         |     268 | 35.46
  5 |             ->  Nested Loop (6,7)                             | [13.433,14.452] |     34 |      2 | [6KB, 6KB]   | 1MB      |         |     268 | 35.18
  6 |                ->  Seq Scan on hr.staffs                      | [0.027,0.032]   |    107 |     20 | [19KB, 19KB] | 1MB      |         |     190 | 13.13
  7 |                ->  Materialize                                | [13.237,14.230] |    109 |      4 | [10KB, 10KB] | 16MB     | [124,124] |     102 | 21.66
  8 |                   ->  Streaming(type: BROADCAST)              | [13.150,14.137] |      2 |      4 | [85KB, 85KB] | 1MB      |         |     102 | 21.65
  9 |                      ->  Nested Loop (10,12)                  | [5.784,6.822]   |      1 |      2 | [3KB, 3KB]   | 1MB      |         |     102 | 21.56
 10 |                         ->  Streaming(type: REDISTRIBUTE)     | [5.782,6.675]   |      1 |      1 | [84KB, 85KB] | 1MB      |         |      24 | 13.28
 11 |                            ->  Seq Scan on hr.sections        | [0.019,0.020]   |      1 |      1 | [14KB, 14KB] | 1MB      |         |      24 | 13.16
 12 |                         ->  Index Scan using loc_id_pk on hr.places | [0.091,0.091]   |      1 |      2 | [24KB, 24KB] | 1MB      |         |     102 | 8.27
 13 |          ->  Index Scan using state_c_id_pk on hr.states      | [0.352,0.352]   |     34 |      2 | [23KB, 23KB] | 1MB      |         |     110 | 5.50
(13 rows)

          Predicate Information (identified by plan id)
-----------------------------------------------------------------
   5 --Nested Loop (6,7)
         Join Filter: (sections.section_id = staffs.section_id)
         Rows Removed by Join Filter: 73
  11 --Seq Scan on hr.sections
         Filter: ((sections.section_name)::text = 'Sales'::text)
         Rows Removed by Filter: 26
  12 --Index Scan using loc_id_pk on hr.places
         Index Cond: (places.place_id = sections.place_id)
  13 --Index Scan using state_c_id_pk on hr.states
         Index Cond: (states.state_id = places.state_id)
(10 rows)
```

# 10.4.3 Case: Adding NOT NULL for JOIN Columns

## Symptom

```
SELECT
 *
FROM
( ( SELECT
  STARTTIME STTIME,
  SUM(NVL(PAGE_DELAY_MSEL,0)) PAGE_DELAY_MSEL,
  SUM(NVL(PAGE_SUCCEED_TIMES,0)) PAGE_SUCCEED_TIMES,
  SUM(NVL(FST_PAGE_REQ_NUM,0)) FST_PAGE_REQ_NUM,
  SUM(NVL(PAGE_AVG_SIZE,0)) PAGE_AVG_SIZE,
  SUM(NVL(FST_PAGE_ACK_NUM,0)) FST_PAGE_ACK_NUM,
  SUM(NVL(DATATRANS_DW_DURATION,0)) DATATRANS_DW_DURATION,
  SUM(NVL(PAGE_SR_DELAY_MSEL,0)) PAGE_SR_DELAY_MSEL
 FROM
  PS.SDR_WEB_BSCRNC_1DAY SDR
  INNER JOIN (SELECT
      BSCRNC_ID,
      BSCRNC_NAME,
      ACCESS_TYPE,
      ACCESS_TYPE_ID
     FROM
      nethouse.DIM_LOC_BSCRNC
     GROUP BY
      BSCRNC_ID,
      BSCRNC_NAME,
      ACCESS_TYPE,
      ACCESS_TYPE_ID) DIM
  ON SDR.BSCRNC_ID = DIM.BSCRNC_ID
  AND DIM.ACCESS_TYPE_ID IN (0,1,2)
  INNER JOIN nethouse.DIM_RAT_MAPPING RAT
  ON (RAT.RAT = SDR.RAT)
 WHERE
  ( (STARTTIME >= 1461340800
  AND STARTTIME < 1461427200) )
  AND RAT.ACCESS_TYPE_ID IN (0,1,2)
  --and SDR.BSCRNC_ID is not null
 GROUP BY
  STTIME ) ) ;
```

**Figure 10-13** shows the execution plan.

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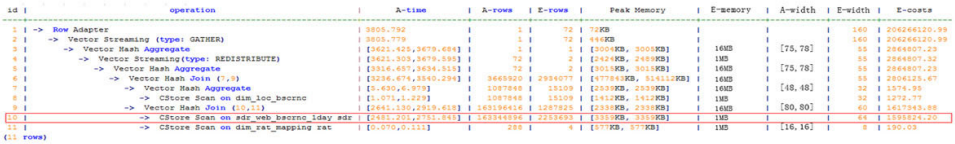
**Figure 10-13** Adding NOT NULL for JOIN columns (1)



## Optimization Analysis

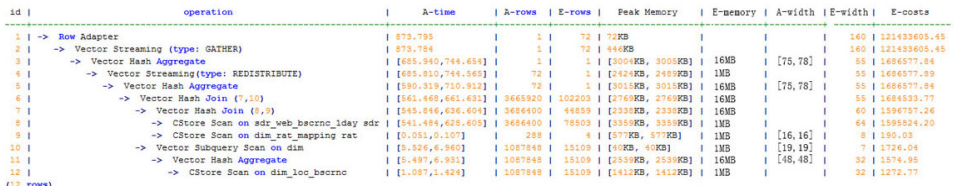
1. As shown in **Figure 10-13**, the sequential scan phase is time consuming.
2. The JOIN performance is poor because a large number of null values exist in the JOIN column **BSCRNC_ID** of the **PS.SDR_WEB_BSCRNC_1DAY** table.

   Therefore, you are advised to manually add **NOT NULL** for **JOIN** columns in the statement, as shown below:

```
SELECT
 *
FROM
( ( SELECT
  STARTTIME STTIME,
  SUM(NVL(PAGE_DELAY_MSEL,0)) PAGE_DELAY_MSEL,
  SUM(NVL(PAGE_SUCCEED_TIMES,0)) PAGE_SUCCEED_TIMES,
  SUM(NVL(FST_PAGE_REQ_NUM,0)) FST_PAGE_REQ_NUM,
  SUM(NVL(PAGE_AVG_SIZE,0)) PAGE_AVG_SIZE,
  SUM(NVL(FST_PAGE_ACK_NUM,0)) FST_PAGE_ACK_NUM,
  SUM(NVL(DATATRANS_DW_DURATION,0)) DATATRANS_DW_DURATION,
  SUM(NVL(PAGE_SR_DELAY_MSEL,0)) PAGE_SR_DELAY_MSEL
 FROM
  PS.SDR_WEB_BSCRNC_1DAY SDR
  INNER JOIN (SELECT
      BSCRNC_ID,
      BSCRNC_NAME,
      ACCESS_TYPE,
      ACCESS_TYPE_ID
     FROM
      nethouse.DIM_LOC_BSCRNC
     GROUP BY
      BSCRNC_ID,
      BSCRNC_NAME,
      ACCESS_TYPE,
      ACCESS_TYPE_ID) DIM
  ON SDR.BSCRNC_ID = DIM.BSCRNC_ID
  AND DIM.ACCESS_TYPE_ID IN (0,1,2)
  INNER JOIN nethouse.DIM_RAT_MAPPING RAT
  ON (RAT.RAT = SDR.RAT)
 WHERE
  ( (STARTTIME >= 1461340800
  AND STARTTIME < 1461427200) )
  AND RAT.ACCESS_TYPE_ID IN (0,1,2)
  and SDR.BSCRNC_ID is not null
 GROUP BY
  STTIME ) ) A;
```

**Figure 10-14** shows the execution plan.

**Figure 10-14** Adding NOT NULL for JOIN columns (2)



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# 10.4.4 Case: Pushing Down Sort Operations to DNs

## Symptom

In an execution plan, more than 95% of the execution time is spent on **window agg** performed on the CN. In this case, **sum** is performed for the two columns separately, and then another **sum** is performed for the separate sum results of the two columns. After this, **trunc** and **sort** are performed in sequence.

The table structure is as follows:

```
CREATE TABLE public.test(imsi int,L4_DW_THROUGHPUT int,L4_UL_THROUGHPUT int)
with (orientation = column) DISTRIBUTE BY hash(imsi);
```

The query statements are as follows:

```
SELECT COUNT(1) over() AS DATACNT,
IMSI AS IMSI_IMSI,
CAST(TRUNC(((SUM(L4_UL_THROUGHPUT) + SUM(L4_DW_THROUGHPUT))), 0) AS
DECIMAL(20)) AS TOTAL_VOLOME_KPIID
FROM public.test AS test
GROUP BY IMSI
order by TOTAL_VOLOME_KPIID DESC;
```

The execution plan is as follows:

```
Row Adapter  (cost=10.70..10.70 rows=10 width=12)
  ->  Vector Sort  (cost=10.68..10.70 rows=10 width=12)
        Sort Key: ((trunc((((sum(l4_ul_throughput)) + (sum(l4_dw_throughput))))::numeric,
0))::numeric(20,0))
        ->  Vector WindowAgg  (cost=10.09..10.51 rows=10 width=12)
              ->  Vector Streaming (type: GATHER)  (cost=242.04..246.84 rows=240 width=12)
                    Node/s: All datanodes
                    ->  Vector Hash Aggregate  (cost=10.09..10.29 rows=10 width=12)
                          Group By Key: imsi
                          ->  CStore Scan on test  (cost=0.00..10.01 rows=10 width=12)
```

As we can see, both **window agg** and **sort** are performed on the CN, which is time consuming.

## Optimization Analysis

Modify the statement to a subquery statement, as shown below:

```
SELECT COUNT(1) over() AS DATACNT, IMSI_IMSI, TOTAL_VOLOME_KPIID
FROM (SELECT IMSI AS IMSI_IMSI,
CAST(TRUNC(((SUM(L4_UL_THROUGHPUT) + SUM(L4_DW_THROUGHPUT))),
0) AS DECIMAL(20)) AS TOTAL_VOLOME_KPIID
FROM public.test AS test
GROUP BY IMSI
ORDER BY TOTAL_VOLOME_KPIID DESC);
```

Perform **sum** on the **trunc** results of the two columns, take it as a subquery, and then perform **window agg** for the subquery to push down the sorting operation to DNs, as shown below:

```
Row Adapter  (cost=10.70..10.70 rows=10 width=24)
  ->  Vector WindowAgg  (cost=10.45..10.70 rows=10 width=24)
        ->  Vector Streaming (type: GATHER)  (cost=250.83..253.83 rows=240 width=24)
              Node/s: All datanodes
              ->  Vector Sort  (cost=10.45..10.48 rows=10 width=12)
                    Sort Key: ((trunc(((sum(test.l4_ul_throughput) + sum(test.l4_dw_throughput)))::numeric,
0))::numeric(20,0))
                    ->  Vector Hash Aggregate  (cost=10.09..10.29 rows=10 width=12)
```

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```
                Group By Key: test.imsi
                ->  CStore Scan on test  (cost=0.00..10.01 rows=10 width=12)
```

The optimized SQL statement greatly improves the performance by reducing the execution time from 120s to 7s.

## 10.4.5 Case: Setting cost_param and Optimizing Query Performance

### Symptom 1

If **bit0** of **cost_param** is set to **1** (**set cost_param=1**), an improved mechanism is used for estimating the selection rate of non-equi-joins. This method is more accurate for estimating the selection rate of joins between two identical tables. The following example describes the optimization scenario when **bit0** of **cost_param** is set to **1**. At present, if **cost_param & 1** is set to a value other than 0, the path is not used. That is, an optimized formula is selected for calculation.

**Note**: The selection rate indicates the percentage for which the number of rows meeting the join conditions account of the **JOIN** results when the **JOIN** relationship is established between two tables.

The table structure is as follows:

```
CREATE TABLE LINEITEM
(
L_ORDERKEY BIGINT NOT NULL
, L_PARTKEY BIGINT NOT NULL
, L_SUPPKEY BIGINT NOT NULL
, L_LINENUMBER BIGINT NOT NULL
, L_QUANTITY DECIMAL(15,2) NOT NULL
, L_EXTENDEDPRICE DECIMAL(15,2) NOT NULL
, L_DISCOUNT DECIMAL(15,2) NOT NULL
, L_TAX DECIMAL(15,2) NOT NULL
, L_RETURNFLAG CHAR(1) NOT NULL
, L_LINESTATUS CHAR(1) NOT NULL
, L_SHIPDATE DATE NOT NULL
, L_COMMITDATE DATE NOT NULL
, L_RECEIPTDATE DATE NOT NULL
, L_SHIPINSTRUCT CHAR(25) NOT NULL
, L_SHIPMODE CHAR(10) NOT NULL
, L_COMMENT VARCHAR(44) NOT NULL
) with (orientation = column, COMPRESSION = MIDDLE) distribute by hash(L_ORDERKEY);

CREATE TABLE ORDERS
(
O_ORDERKEY BIGINT NOT NULL
, O_CUSTKEY BIGINT NOT NULL
, O_ORDERSTATUS CHAR(1) NOT NULL
, O_TOTALPRICE DECIMAL(15,2) NOT NULL
, O_ORDERDATE DATE NOT NULL
, O_ORDERPRIORITY CHAR(15) NOT NULL
, O_CLERK CHAR(15) NOT NULL
, O_SHIPPRIORITY BIGINT NOT NULL
, O_COMMENT VARCHAR(79) NOT NULL
)with (orientation = column, COMPRESSION = MIDDLE) distribute by hash(O_ORDERKEY);
```

The query statements are as follows:

```
explain verbose select
count(*) as numwait
from
lineitem l1,
orders
```

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```
where
o_orderkey = l1.l_orderkey
and o_orderstatus = 'F'
and l1.l_receiptdate > l1.l_commitdate
and not exists (
select
*
from
lineitem l3
where
l3.l_orderkey = l1.l_orderkey
and l3.l_suppkey <> l1.l_suppkey
and l3.l_receiptdate > l3.l_commitdate
)
order by
numwait desc;
```

The following figure shows the execution plan. (When **verbose** is used, **distinct** is added for column selection which is controlled by **cost off/on**. The hash join rows show the estimated number of **distinct** values and the other rows do not.)

```
 id |                        operation                          | E-rows | E-distinct | E-width | E-costs
----+-----------------------------------------------------------+--------+------------+---------+---------
  1 | ->  Row Adapter                                           |      1 |            |       8 | 39.36
  2 |    ->  Vector Sort                                        |      1 |            |       8 | 39.36
  3 |       ->  Vector Aggregate                                |      1 |            |       8 | 39.34
  4 |          ->  Vector Streaming (type: GATHER)              |      2 |            |       8 | 39.34
  5 |             ->  Vector Aggregate                          |      2 |            |       8 | 39.25
  6 |                ->  Vector Hash Anti Join (7, 10)          |      2 | 4, 5       |       0 | 39.24
  7 |                   ->  Vector Hash Join (8,9)              |      2 | 200, 1     |      16 | 26.12
  8 |                      ->  CStore Scan on public.lineitem l1 |      7 |            |      16 | 13.05
  9 |                      ->  CStore Scan on public.orders      |      1 |            |       8 | 13.05
 10 |                   ->  CStore Scan on public.lineitem l3    |      7 |            |      16 | 13.05
(10 rows)
```

## Optimization Analysis 1

These queries are from Anti Join connected in the **lineitem** table. When **bit0** of **cost_param** is set to **1**, the estimated number of Anti Join rows greatly differ from that of the actual number of rows so that the query performance deteriorates. You can estimate the number of Anti Join rows more accurately by setting **bit0** of **cost_param** to **1** to improve the query performance. The optimized execution plan is as follows:

```
 id |                    operation                          |   E-rows   | E-memory  | E-width  |  E-costs
----+-----------------------------------------------------------+------------+-----------+---------+---------
  1 |  -> Row Adapter                                       |          1 |           |    0     | 9104892.37 9
  2 |    -> Vector Sort                                     |          1 |           |    0     | 9104892.37 9
  3 |      -> Vector Aggregate                              |          1 |           |    0     | 9104892.35 8
  4 |        -> Vector Streaming (type: GATHER)             |         48 |           |    0     | 9104892.35 8
  5 |          -> Vector Aggregate                          |         48 | 1MB       |    0     | 9104890.82 5
  6 |            -> Vector Hash Join (7.12)                 | 2526630903 | 929MB     |    0     | 8973295.45 4
  7 |              -> Vector Hash Anti Join (8. 10)         | 1999996587 | 3178MB    |    8     | 7198231.14
  8 |                -> Vector Partition Iterator           | 1999996587 | 1MB       |   16     | 3000158.25
  9 |                  -> Partitioned CStore Scan on public.lineitem 11 | 1999996587 | 1MB       |   16     | 3000158.25 1
 10 |                -> Vector Partition Iterator           | 1999996587 | 1MB       |   16     | 3000158.25
 11 |                  -> Partitioned CStore Scan on public.lineitem 13 | 1999996587 | 1MB       |   16     | 3000158.25
 12 |              -> Vector Partition Iterator             |  730839014 | 1MB       |    8     | 589611.00
 13 |                -> Partitioned CStore Scan on public.orders | 730839014 | 1MB       |    8     | 589611.00
(13 rows)
```

## Symptom 2

If **bit1** of **cost_param** is set to **1** (**set cost_param=2**), the selection rate is estimated based on multiple filter criteria. The lowest selection rate among all

filter criteria, but not the product of the selection rates for two tables under a specific filter criterion, is used as the total selection rate. This method is more accurate when a close correlation exists between the columns to be filtered. The following example describes the optimization scenario when **bit1** of **cost_param** is set to **1**.

The table structure is as follows:

```
CREATE TABLE NATION
(
  N_NATIONKEY INT NOT NULL
, N_NAME      CHAR(25) NOT NULL
, N_REGIONKEY INT NOT NULL
, N_COMMENT   VARCHAR(152)
) distribute by replication;
CREATE TABLE SUPPLIER
(
  S_SUPPKEY   BIGINT NOT NULL
, S_NAME      CHAR(25) NOT NULL
, S_ADDRESS   VARCHAR(40) NOT NULL
, S_NATIONKEY INT NOT NULL
, S_PHONE     CHAR(15) NOT NULL
, S_ACCTBAL   DECIMAL(15,2) NOT NULL
, S_COMMENT   VARCHAR(101) NOT NULL
) distribute by hash(S_SUPPKEY);
CREATE TABLE PARTSUPP
(
  PS_PARTKEY    BIGINT NOT NULL
, PS_SUPPKEY    BIGINT NOT NULL
, PS_AVAILQTY   BIGINT NOT NULL
, PS_SUPPLYCOST DECIMAL(15,2)NOT NULL
, PS_COMMENT    VARCHAR(199) NOT NULL
)distribute by hash(PS_PARTKEY);
```

The query statements are as follows:

```
set cost_param=2;
explain verbose select
nation,
sum(amount) as sum_profit
from
(
select
n_name as nation,
l_extendedprice * (1 - l_discount) - ps_supplycost * l_quantity as amount
from
supplier,
lineitem,
partsupp,
nation
where
s_suppkey = l_suppkey
and ps_suppkey = l_suppkey
and ps_partkey = l_partkey
and s_nationkey = n_nationkey
) as profit
group by nation
order by nation;
```

When **bit1** of **cost_param** is set to **0**, the execution plan is shown as follows:

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```
 id |                           operation                           | E-rows | E-distinct | E-width | E-costs
----+---------------------------------------------------------------+--------+------------+---------+---------
  1 | ->  Sort                                                      |      1 |            |     208 | 61.52
  2 |    ->  HashAggregate                                          |      1 |            |     208 | 61.51
  3 |       ->  Streaming (type: GATHER)                            |      2 |            |     208 | 61.51
  4 |          ->  HashAggregate                                    |      2 |            |     208 | 61.36
  5 |             ->  Hash Join (6,7)                               |      2 | 20, 15     |     176 | 61.33
  6 |                ->  Seq Scan on public.nation                  |     40 |            |     108 | 20.20
  7 |                ->  Hash                                       |      2 |            |      76 | 41.04
  8 |                   ->  Hash Join (9,16)                        |      2 | 10, 13     |      76 | 41.04
  9 |                      ->  Streaming(type: REDISTRIBUTE)        |      2 |            |      88 | 27.73
 10 |                         ->  Hash Join (11,14)                 |      2 | 10, 13     |      88 | 27.62
 11 |                            ->  Streaming(type: REDISTRIBUTE)  |     20 |            |      70 | 14.19
 12 |                               ->  Row Adapter                 |     21 |            |      70 | 13.01
 13 |                                  ->  CStore Scan on public.lineitem |     20 |            |      70 | 13.01
 14 |                            ->  Hash                           |     21 |            |      34 | 13.13
 15 |                               ->  Seq Scan on public.partsupp |     20 |            |      34 | 13.13
 16 |                      ->  Hash                                 |     21 |            |      12 | 13.13
 17 |                         ->  Seq Scan on public.supplier       |     20 |            |      12 | 13.13
(17 rows)
```

## Optimization Analysis 2

In the preceding queries, the hash join criteria of the **supplier**, **lineitem**, and **partsupp** tables are setting **lineitem.l_suppkey** to **supplier.s_suppkey** and **lineitem.l_partkey** to **partsupp.ps_partkey**. Two filter criteria exist in the hash join conditions. **lineitem.l_suppkey** in the first filter criterion and **lineitem.l_partkey** in the second filter criterion are two columns with strong relationship of the **lineitem** table. In this situation, when you estimate the rate of the hash join conditions, if **bit1** of **cost_param** is set to **0**, the selection rate is estimated based on multiple filter criteria. The lowest selection rate among all filter criteria, but not the product of the selection rates for two tables under a specific filter criterion, is used as the total selection rate. Therefore, you need to set **bit1** of **cost_param** to **2** and select the lowest selection rate as the total selection rate to optimize the query performance. The optimized query plan is shown as follows:

```
 id |                           operation                           | E-rows | E-distinct | E-width | E-costs
----+---------------------------------------------------------------+--------+------------+---------+---------
  1 | ->  Sort                                                      |     10 |            |     208 | 64.42
  2 |    ->  HashAggregate                                          |     10 |            |     208 | 64.23
  3 |       ->  Streaming (type: GATHER)                            |     20 |            |     208 | 64.23
  4 |          ->  HashAggregate                                    |     20 |            |     208 | 62.71
  5 |             ->  Hash Join (6,7)                               |     20 | 20, 10     |     176 | 62.46
  6 |                ->  Seq Scan on public.nation                  |     40 |            |     108 | 20.20
  7 |                ->  Hash                                       |     20 |            |      76 | 41.97
  8 |                   ->  Hash Join (9,16)                        |     20 | 10, 13     |      76 | 41.97
  9 |                      ->  Streaming(type: REDISTRIBUTE)        |     20 |            |      82 | 28.54
 10 |                         ->  Hash Join (11,14)                 |     20 | 10, 13     |      82 | 27.63
 11 |                            ->  Streaming(type: REDISTRIBUTE)  |     20 |            |      70 | 14.19
 12 |                               ->  Row Adapter                 |     21 |            |      70 | 13.01
 13 |                                  ->  CStore Scan on public.lineitem |     20 |            |      70 | 13.01
 14 |                            ->  Hash                           |     21 |            |      12 | 13.13
 15 |                               ->  Seq Scan on public.supplier |     20 |            |      12 | 13.13
 16 |                      ->  Hash                                 |     21 |            |      34 | 13.13
 17 |                         ->  Seq Scan on public.partsupp       |     20 |            |      34 | 13.13
(17 rows)
```

# 10.4.6 Case: Adjusting Distribution Keys

## Symptom

During a site test, the information is displayed after **EXPLAIN ANALYZE** is run:

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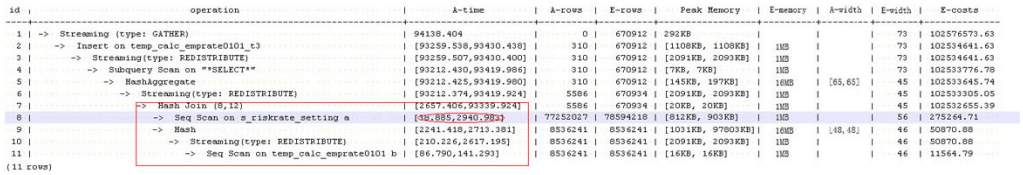

| id | operation | A-time | A-rows | E-rows | Peak Memory | E-memory | A-width | E-width | E-costs |
|---|---|---|---|---|---|---|---|---|---|
| 1 | -> Streaming (type: GATHER) | 94138.404 | 0 | 670912 | 292KB | | | 73 | 102576573.63 |
| 2 | -> Insert on temp_calc_emprate0101_t3 | [93259.538,93430.438] | 310 | 670912 | [1108KB, 1108KB] | 1MB | | 73 | 102534641.63 |
| 3 | -> Streaming(type: REDISTRIBUTE) | [93259.507,93430.400] | 310 | 670912 | [2091KB, 2093KB] | 1MB | | 73 | 102534641.63 |
| 4 | -> Subquery Scan on "*SELECT*" | [93212.430,93419.986] | 310 | 670912 | [7KB, 7KB] | 1MB | | 73 | 102533776.78 |
| 5 | -> HashAggregate | [93212.425,93419.980] | 310 | 670912 | [145KB, 197KB] | 16MB | [65,65] | 45 | 102533645.74 |
| 6 | -> Streaming(type: REDISTRIBUTE) | [93212.374,93419.924] | 5586 | 670934 | [2091KB, 2093KB] | 1MB | | 45 | 102533305.05 |
| 7 | -> Hash Join (8,12) | [2657.406,93339.924] | 5586 | 670934 | [20KB, 20KB] | 1MB | | 45 | 102532655.39 |
| 8 | -> Seq Scan on s_riskrate_setting a | [38.885,2940.983] | 77252027 | 78594218 | [812KB, 903KB] | 1MB | | 56 | 275264.71 |
| 9 | -> Hash | [2241.418,2713.381] | 8536241 | 8536241 | [1031KB, 97803KB] | 16MB | [48,48] | 46 | 50870.88 |
| 10 | -> Streaming(type: REDISTRIBUTE) | [210.226,2617.195] | 8536241 | 8536241 | [2091KB, 2093KB] | 1MB | | 46 | 50870.88 |
| 11 | -> Seq Scan on temp_calc_emprate0101 b | [86.790,141.293] | 8536241 | 8536241 | [16KB, 16KB] | 1MB | | 46 | 11564.79 |

(11 rows)

According to the execution information, Hash Join becomes the performance bottleneck of the whole plan. Based on the execution time of Hash Join **[2657.406,93339.924]** (for details about the value, see **10.3.2.2 Description**), it can be seen that severe skew occurs on different DNs during the Hash Join operation.

In the memory information (as shown in the following figure), it can be seen that the data skew occurs in the memory usage of each node.

```
Memory Information (identified by plan id)
--------------------------------------------------------------------------------
Coordinator:
  Query Peak Memory: 4MB
Datanode:
  Max Query Peak Memory: 118MB
  Min Query Peak Memory: 24MB
 12 --Hash
        Max Buckets: 131072  Max Batches: 1  Max Memory Usage: 91857kB
        Min Buckets: 131072  Min Batches: 1  Min Memory Usage: 0kB
(8 rows)
```

## Optimization Analysis

The preceding two features indicate that this SQL statement has extremely serious computing unbalance. The further lower-layer analysis on the Hash Join operator shows that serious computing skew **[38.885,2940.983]** occurs in **Seq Scan on s_riskrate_setting**. Based on the description of the Scan, we can infer that the performance problems of this plan lie in data skew occurred in the **s_riskrate_setting** table. Later, it is proved that serious data skew occurred in the **s_riskrate_setting** table. After performance optimization, the execution time is reduced from 94s to 50s.

# 10.4.7 Case: Adjusting Partial Clustering Keys

## Symptom

Information on the **EXPLAIN PERFORMANCE** at a site is as follows: As shown in the red boxes, two performance bottlenecks are scan operations in a table.

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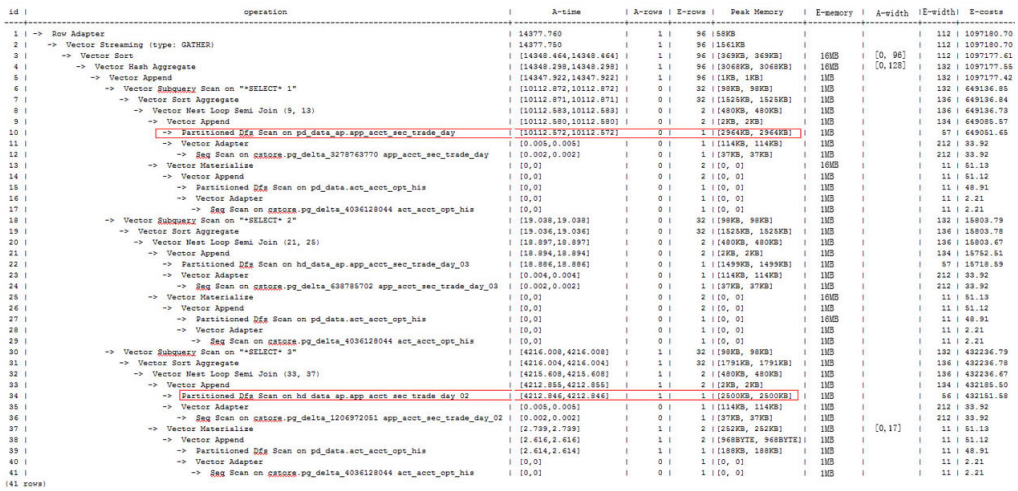
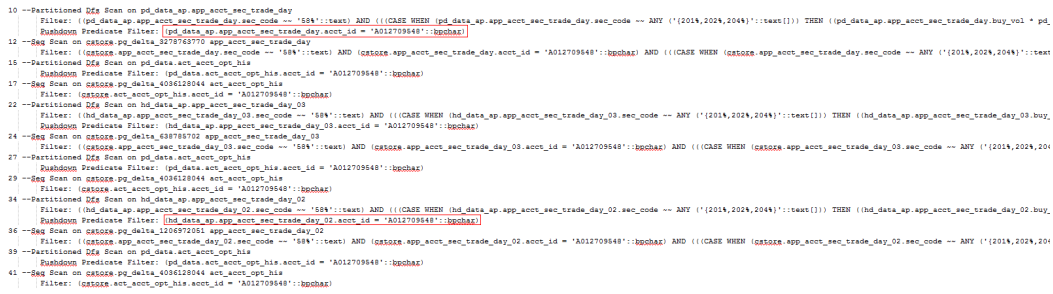


## Optimization Analysis

Based on further analysis, the filter condition **acct_id = 'A012709548'::bpchar** exists in **Scan** of two tables.



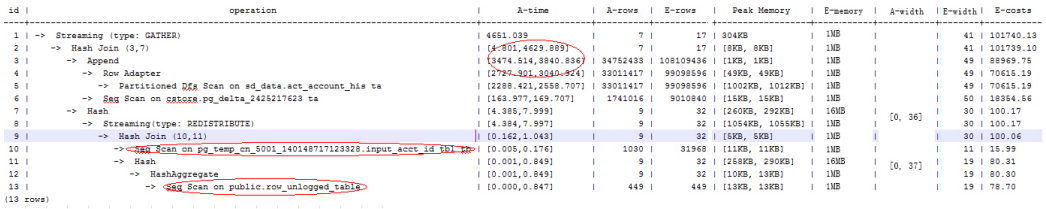
Try to add the partial clustering key in the **acct_id** column of the two tables, and run the **VACUUM FULL** statement to make the local clustering take effect. The table performance is improved.

# 10.4.8 Case: Adjusting the Table Storage Model in a Medium Table

## Symptom

In the GaussDB database, row-store tables use row execution engine, and column-store tables use column execution engine. If both row-store tables and column-store tables exist in a SQL statement, the system will automatically select the row execution engine. The performance of a column execution engine (except for the index scan related operators) is much better than that of a row execution engine. Therefore, a column-store table is recommended. This is important for some intermediate result set dumping tables, and you need to select a proper table storage model.

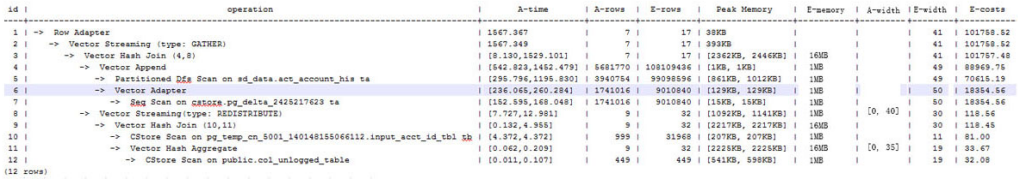
During the test at a site, if the following execution plan is performed, the customer expects that the performance can be improved and the result can be returned within 3s.



## Optimization Analysis

It is found that the row execution engine is used after analysis, because both the temporary plan table **input_acct_id_tbl** and the intermediate result dumping table **row_unlogged_table** use row storage.

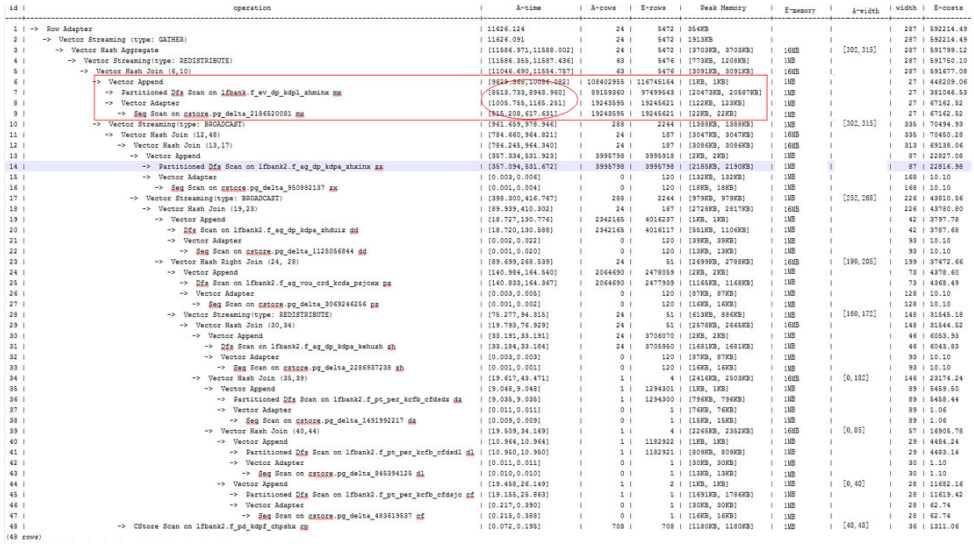
After the two tables are changed into column-store tables, the system performance is improved and the result is returned by 1.6s.



# 10.4.9 Case: Adjusting Partial Clustering Keys

## Symptom

During the test at a site, if the following execution plan is performed, the customer expects that the performance can be improved and the result can be returned within 3s.



## Optimization Analysis

The analysis shows that the performance bottleneck of this plan is the scan operation on the **lfbank.f_ev_dp_kdpl_zhminx** table. The scan condition of this table is as follows:

```
                                Predicate Information (identified by plan id)
-------------------------------------------------------------------------------------------------------------------------------------------------------
  5 --Vector Hash Join (6,10)
      Hash Cond: (((mx.zhanghao)::text = (dd.zhanghao)::text) AND ((mx.farendma)::text = (cf.farendma)::text))
  7 --Partitioned Dfs Scan on lfbank.f_ev_dp_kdpl_zhminx mx
      Pushdown Predicate Filter: ((mx.yezdminc)::text = 'DPLDGBAL'::text)
  9 --Seq Scan on cstore.pg_delta_21865ZUU81 mx
      Filter: ((mx.yezdminc)::text = 'DPLDGBAL'::text)
      Rows Removed by Filter: 489
```

Try to change the **lfbank.f_ev_dp_kdpl_zhminx** table to a column-store table. Then, create the PCK (local clustering) in the **yezdminc** column, and set **PARTIAL_CLUSTER_ROWS** to **100000000**. The execution plan after optimization is as follows:

```
id |                                operation                                |          A-time          | A-rows |  E-rows   |  Peak Memory   | E-memory | A-width | E-width | E-costs
---+-------------------------------------------------------------------------+--------------------------+--------+-----------+----------------+----------+---------+---------+---------
  1 | ->  Row Adapter                                                         | [2633.864]               |     24 |      5496 | [354KB]        |          |         |     287 | 745338.94
  2 |   ->  Vector Streaming (type: GATHER)                                   | [2633.847]               |     24 |      5496 | [191KB]        |          |         |     287 | 745338.94
  3 |     ->  Vector Hash Aggregate                                           | [2597.766,2599.012]      |     24 |      5496 | [3703KB, 3708KB] | 16MB     | [302,316] |     287 | 744921.75
  4 |       ->  Vector Streaming(type: REDISTRIBUTE)                          | [2597.346,2598.631]      |     63 |      5491 | [775KB, 1208KB] | 1MB      |         |     287 | 744872.52
  5 |         ->  Vector Hash Join (6,7)                                      | [2317.650,2579.801]      |     63 |      5491 | [3003KB, 3003KB] | 16MB     |         |     287 | 744799.18
  6 |           ->  CStore Scan on lfbank.f_ev_dp_kdpl_zhminx_column mx        | [1144.465,1345.452]      | 116702564 | 117088649 | [1681KB, 1802KB] | 1MB      |         |      28 | 590396.39
  7 |           ->  Vector Streaming(type: BROADCAST)                         | [715.439,725.474]        |    288 |      2244 | [1388KB, 1388KB] | 1MB      | [419,423] |     337 | 81233.75
  8 |             ->  Vector Hash Join (9,42)                                 | [610.787,723.121]        |     24 |       187 | [3047KB, 3047KB] | 16MB     |         |     337 | 81189.11
  9 |               ->  Vector Hash Join (10,11)                              | [610.191,722.453]        |     24 |       187 | [2997KB, 2997KB] | 16MB     |         |     315 | 79876.88
 10 |                 ->  CStore Scan on lfbank.f_sg_dp_kdps_zhninx zx        | [146.165,248.865]        |   3995798 |   3995798 | [3800KB, 3915KB] | 1MB      |         |      89 | 33565.98
 11 |                 ->  Vector Streaming(type: BROADCAST)                   | [443.942,448.609]        |    288 |      2244 | [979KB, 979KB] | 1MB      | [252,268] |     226 | 43810.56
 12 |                   ->  Vector Hash Join (13,17)                          | [90.644,440.831]         |     24 |       187 | [2728KB, 2817KB] | 16MB     |         |     226 | 43780.80
 13 |                     ->  Vector Append                                   | [20.159,146.517]         |   2342165 |   4016237 | [1KB, 1KB]     | 1MB      |         |      42 | 8797.78
 14 |                       ->  Dfs Scan on lfbank2.f_sg_dp_kdps_shduix dd    | [20.151,146.356]         |   2342165 |   4016117 | [581KB, 1106KB] | 1MB      |         |      42 | 8787.68
 15 |                       ->  Vector Adapter                                | [0.002,0.005]            |      0 |       120 | [39KB, 39KB]   | 1MB      |         |      93 | 10.10
 16 |                         ->  Seq Scan on cstore.pg_delta_1125056844 dd    | [0.001,0.002]            |      0 |       120 | [13KB, 13KB]   | 1MB      |         |      93 | 10.10
 17 |                     ->  Vector Hash Right Join (18, 22)                 | [90.411,291.664]         |     24 |        51 | [2699KB, 2768KB] | 16MB     | [190,205] |     199 | 37472.66
 18 |                       ->  Vector Append                                 | [148.194,187.045]        |   2044690 |   2478059 | [2KB, 2KB]     | 1MB      |         |      73 | 4378.40
 19 |                         ->  Dfs Scan on lfbank2.f_sg_vou_crd_kcds_psjcxx px | [148.049,186.900]        |   2044690 |   2477939 | [1165KB, 1168KB] | 1MB      |         |      73 | 4368.49
 20 |                         ->  Vector Adapter                              | [0.003,0.018]            |      0 |       120 | [87KB, 87KB]   | 1MB      |         |     128 | 10.10
 21 |                           ->  Seq Scan on cstore.pg_delta_3069246256 px  | [0.001,0.003]            |      0 |       120 | [14KB, 14KB]   | 1MB      |         |     128 | 10.10
 22 |                       ->  Vector Streaming(type: REDISTRIBUTE)          | [90.054,94.358]          |     24 |        51 | [613KB, 886KB] | 1MB      | [160,172] |     148 | 31545.18
 23 |                         ->  Vector Hash Join (24,28)                    | [19.529,80.468]          |     24 |        51 | [2578KB, 2665KB] | 16MB     |         |     148 | 31544.82
 24 |                           ->  Vector Append                             | [35.109,35.109]          |     24 |   3706070 | [2KB, 2KB]     | 1MB      |         |      46 | 6053.93
 25 |                             ->  Dfs Scan on lfbank2.f_sg_dp_kdps_kehuzh zh | [35.102,35.102]          |     24 |   3705950 | [1681KB, 1681KB] | 1MB      |         |      46 | 6043.83
 26 |                             ->  Vector Adapter                          | [0.003,0.003]            |      0 |       120 | [87KB, 87KB]   | 1MB      |         |      93 | 10.10
 27 |                               ->  Seq Scan on cstore.pg_delta_2286937238 zh | [0.002,0.002]            |      0 |       120 | [14KB, 14KB]   | 1MB      |         |      93 | 10.10
 28 |                           ->  Vector Hash Join (29,33)                  | [19.374,45.091]          |      1 |         4 | [241KB, 2503KB] | 16MB     | [0,182] |     146 | 23174.24
 29 |                             ->  Vector Append                           | [8.778,8.778]            |      1 |   1294301 | [1KB, 1KB]     | 1MB      |         |      89 | 5459.50
 30 |                               ->  Partitioned Dfs Scan on lfbank2.f_pt_per_kcfb_cfdsds ds | [8.768,8.768]            |      1 |   1294300 | [796KB, 796KB] | 1MB      |         |      89 | 5458.44
 31 |                               ->  Vector Adapter                        | [0.009,0.009]            |      0 |         1 | [74KB, 74KB]   | 1MB      |         |      89 | 1.06
 32 |                                 ->  Seq Scan on cstore.pg_delta_1491992217 ds | [0.008,0.008]            |      0 |         1 | [13KB, 13KB]   | 1MB      |         |      89 | 1.06
 33 |                             ->  Vector Hash Join (34,38)                | [19.310,36.096]          |      1 |         4 | [226KB, 2352KB] | 16MB     | [0,85]  |      57 | 16905.78
 34 |                               ->  Vector Append                         | [11.000,11.000]          |      1 |   1182922 | [1KB, 1KB]     | 1MB      |         |      29 | 4484.24
 35 |                                 ->  Partitioned Dfs Scan on lfbank2.f_pt_per_kcfb_cfdsdl dl | [10.988,10.988]          |      1 |   1182921 | [809KB, 809KB] | 1MB      |         |      29 | 4483.14
 36 |                                 ->  Vector Adapter                      | [0.009,0.009]            |      0 |         1 | [30KB, 30KB]   | 1MB      |         |      30 | 1.10
 37 |                                   ->  Seq Scan on cstore.pg_delta_845394125 dl | [0.008,0.008]            |      0 |         1 | [13KB, 13KB]   | 1MB      |         |      30 | 1.10
 38 |                               ->  Vector Append                         | [19.255,28.756]          |      1 |         2 | [1KB, 1KB]     | 1MB      | [0,40]  |      28 | 11682.16
 39 |                                 ->  Partitioned Dfs Scan on lfbank2.f_pt_per_kcfb_cfdsjc cf | [19.003,28.284]          |      1 |         1 | [1681KB, 1756KB] | 1MB      |         |      28 | 11619.42
 40 |                                 ->  Vector Adapter                      | [0.250,0.539]            |      0 |         1 | [30KB, 30KB]   | 1MB      |         |      28 | 62.74
 41 |                                   ->  Seq Scan on cstore.pg_delta_483619537 cf | [0.247,0.536]            |      0 |         1 | [16KB, 16KB]   | 1MB      |         |      28 | 62.74
 42 |                   ->  CStore Scan on lfbank2.f_pd_kdpf_chpshx cp        | [0.135,0.338]            |    708 |       708 | [1180KB, 1180KB] | 1MB      | [48,48] |      96 | 1311.06
(42 rows)
```

**NOTE**

- This method actually sacrifices the performance during data import to improve the query performance.
- The number of local sorting tuples is increased, and you need to increase the value of **psort_work_mem** to improve the sorting efficiency.

# 10.4.10 Case: Modifying a Partitioned Table

## Symptom

In the following simple SQL statements, the performance bottlenecks exist in the scan operation of the **dwcjk** table.

```
openGauss=#    explain performance select zqdh, count(1) from dwcjk where cjrq = '2015-05-02 00:00:00' group by zqdh;
 id |                  operation                  |        A-time         | A-rows  | E-rows  |    Peak Memory    | E-memory | A-width | E-width | E-costs
----+---------------------------------------------+-----------------------+---------+---------+-------------------+----------+---------+---------+---------
  1 | ->  Row Adapter                             | 1599.794              |      58 |      12 | 19KB              |          |         |       7 | 771106.83
  2 |   ->  Vector Streaming (type: GATHER)       | 1599.781              |      58 |      12 | 210KB             |          |         |       7 | 771106.83
  3 |     ->  Vector Hash Aggregate               | [1445.092,1446.332]   |      58 |       2 | [2315KB, 2315KB]  | 16MB     | [16,16] |       7 | 128517.80
  4 |       ->  Vector Streaming(type: REDISTRIBUTE) | [1444.996,1446.259]   |     340 |      12 | [247KB, 247KB]    | 1MB      |         |       7 | 128518.09
  5 |         ->  Vector Hash Aggregate           | [573.150,1261.354]    |     340 |      12 | [2297KB, 2297KB]  | 16MB     | [16,16] |       7 | 128517.80
  6 |           ->  CStore Scan on public.dwcjk   | [330.178,1021.695]    | 10000000 | 1623137 | [786KB, 786KB]    | 1MB      |         |       7 | 120402.00
(6 rows)
```

## Optimization Analysis

Obviously, there are date features in the **cjrq** column of table data in the service layer, and this meet the features of a partitioned table. Replan the table definition of the **dwcjk** table. Set the **cjrq** column as a partition key, and day as an interval unit. Define the partitioned table **dwcjk_part**. The modified result is as follows, and the performance is nearly doubled.

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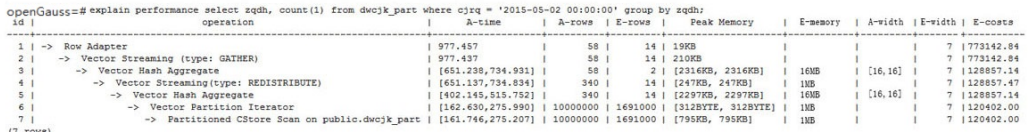

```
openGauss=# explain performance select zqdh, count(1) from dwcjk_part where cjrq = '2015-05-02 00:00:00' group by zqdh;
 id |                          operation                          |      A-time       |  A-rows  | E-rows  |    Peak Memory     |  E-memory  | A-width  | E-width | E-costs
----+-------------------------------------------------------------+-------------------+----------+---------+--------------------+------------+----------+---------+----------
  1 | ->  Row Adapter                                             | 977.457           |       58 |      14 | 19KB               |            |          |      7 | 773142.84
  2 |    ->  Vector Streaming (type: GATHER)                      | 977.437           |       58 |      14 | 210KB              |            |          |      7 | 773142.84
  3 |       ->  Vector Hash Aggregate                             | [651.238,734.931] |       58 |       2 | [2316KB, 2316KB]   |  16MB      | [16,16]  |      7 | 128857.14
  4 |          ->  Vector Streaming(type: REDISTRIBUTE)           | [651.137,734.834] |      340 |      14 | [247KB, 247KB]     |  1MB       |          |      7 | 128857.47
  5 |             ->  Vector Hash Aggregate                       | [402.145,515.752] |      340 |      14 | [2297KB, 2297KB]   |  16MB      | [16,16]  |      7 | 128857.14
  6 |                ->  Vector Partition Iterator                | [162.630,275.990] | 10000000 | 1691000 | [312BYTE, 312BYTE] |  1MB       |          |      7 | 120402.00
  7 |                   ->  Partitioned CStore Scan on public.dwcjk_part | [161.746,275.207] | 10000000 | 1691000 | [795KB, 795KB]     |  1MB       |          |      7 | 120402.00
(7 rows)
```

# 10.4.11 Case: Adjusting the GUC Parameter best_agg_plan

## Symptom

The **t1** table is defined as follows:

```
create table t1(a int, b int, c int) distribute by hash(a);
```

Assume that the distribution key of the result set provided by the agg lower-layer operator is **setA**, and the **group by** column of the agg operation is **setB**, the agg operations can be performed in two scenarios in the Stream framework.

1. **setA** is a subset of **setB**.

   In this scenario, the aggregation result of the lower-layer is correct and can be directly used by upper-level operators. Example:

```
openGauss=# explain select a, count(1) from t1 group by a;
 id |          operation            | E-rows | E-width | E-costs
----+-------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER) |     30 |       4 | 15.56
  2 |    ->  HashAggregate          |     30 |       4 | 14.31
  3 |       ->  Seq Scan on t1      |     30 |       4 | 14.14
(3 rows)
```

2. **setA** is not a subset of **setB**.

   In this scenario, the Stream execution framework is classified into the following three plans:

   hashagg+gather(redistribute)+hashagg

   redistribute+hashagg(+gather)

   hashagg+redistribute+hashagg(+gather)

   GaussDB provides the GUC parameter **best_agg_plan** to intervene the execution plan, and forces the plan to generate the corresponding execution plan. This parameter can be set to **0**, **1**, **2**, **3**.

   – When the parameter is set to **1**, the first plan is forcibly generated.
   – When the parameter is set to **2** and if the **group by** column can be redistributed, the second plan is forcibly generated. Otherwise, the first plan is generated.
   – When the parameter is set to **3** and if the **group by** column can be redistributed, the third plan is generated. Otherwise, the first plan is generated.
   – When the parameter is set to **0**, the query optimizer chooses the most optimal plan by the three preceding plans' evaluation cost.

   For details, see the following figure.

```
openGauss=# set best_agg_plan to 1;
SET
openGauss=# explain select b,count(1) from t1 group by b;
 id |            operation            | E-rows | E-width | E-costs
----+---------------------------------+--------+---------+---------
  1 | ->  HashAggregate               |      8 |       4 | 15.83
  2 |    ->  Streaming (type: GATHER) |     25 |       4 | 15.83
```

```
 3 |       ->  HashAggregate        |     25 |       4 | 14.33
 4 |         ->  Seq Scan on t1     |     30 |       4 | 14.14
(4 rows)
openGauss=# set best_agg_plan to 2;
SET
openGauss=# explain select b,count(1) from t1 group by b;
 id |              operation               | E-rows | E-width | E-costs
----+--------------------------------------+--------+---------+---------
 1 | ->  Streaming (type: GATHER)         |     30 |       4 | 15.85
 2 |    ->  HashAggregate                 |     30 |       4 | 14.60
 3 |       ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 14.45
 4 |         ->  Seq Scan on t1           |     30 |       4 | 14.14
(4 rows)
openGauss=# set best_agg_plan to 3;
SET
openGauss=# explain select b,count(1) from t1 group by b;
 id |              operation               | E-rows | E-width | E-costs
----+--------------------------------------+--------+---------+---------
 1 | ->  Streaming (type: GATHER)         |     30 |       4 | 15.84
 2 |    ->  HashAggregate                 |     30 |       4 | 14.59
 3 |       ->  Streaming(type: REDISTRIBUTE) |     25 |       4 | 14.59
 4 |         ->  HashAggregate            |     25 |       4 | 14.33
 5 |           ->  Seq Scan on t1         |     30 |       4 | 14.14
(5 rows)
```

## Optimization

Generally, the optimizer chooses an optimal execution plan, but the cost estimation, especially that of the intermediate result set, has large deviations, which may result in large deviations in agg calculation. In this case, you need to use **best_agg_plan** to adjust the agg calculation model.

When the aggregation convergence ratio is very small, that is, the number of result sets does not become small obviously after the agg operation (5 times is a critical point), you can select the redistribute+hashagg or hashagg+redistribute +hashagg execution mode.

# 10.4.12 Case: Rewriting SQL and Deleting Subqueries (1)

## Symptom

```
select
   1,
   (select count(*) from customer_address_001 a4 where a4.ca_address_sk = a.ca_address_sk) as GZCS
from customer_address_001 a;
```

This SQL performance is poor. SubPlan exists in the execution plan as follows:

```
openGauss=# explain select 1,(select count(*)
openGauss(#           from customer_address_001 a4
openGauss(#          where a4.ca_address_sk = a.ca_address_sk
openGauss(#         ) as GZCS from customer_address_001 a;
 id |                          operation                          | E-rows | E-width | E-costs
----+-------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                |    320 |       4 | 4529.27
  2 |    ->  Seq Scan on customer_address_001 a                   |    320 |       4 | 4496.27
  3 |       ->  Aggregate  [2, SubPlan 1]                         |     32 |       4 | 139.50
  4 |          ->  Result                                         |  10240 |       4 | 138.69
  5 |             ->  Materialize                                 |  10240 |       4 | 138.69
  6 |                ->  Streaming(type: BROADCAST)               |  10240 |       4 | 137.09
  7 |                   ->  Seq Scan on customer_address_001 a4   |    320 |       4 | 32.32
(7 rows)
```

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## Optimization

The core of this optimization is to eliminate subqueries. Based on the service scenario analysis, **a.ca_address_sk** is not null. In terms of SQL syntax, you can rewrite the SQL statement as follows:

```
select
count(*)
from customer_address_001 a4, customer_address_001 a
where a4.ca_address_sk = a.ca_address_sk
group by  a.ca_address_sk;
```

NOTE

To ensure that the modified statements have the same functions, **not null** is added to **customer_address_001. ca_address_sk**.

# 10.4.13 Case: Rewriting SQL and Deleting Subqueries (2)

## Symptom

On a site, the customer gave the feedback saying that the execution time of the following SQL statements lasted over one day and did not end:

```
UPDATE calc_empfyc_c_cusr1 t1
SET ln_rec_count =
 (
   SELECT CASE WHEN current_date - ln_process_date + 1 <= 12 THEN 0 ELSE t2.ln_rec_count END
   FROM calc_empfyc_c1_policysend_tmp t2
   WHERE t1.ln_branch = t2.ln_branch AND t1.ls_policyno_cusr1 = t2.ls_policyno_cusr1
)
WHERE dsign = '1'
AND flag = '1'
AND EXISTS
   (SELECT 1
   FROM calc_empfyc_c1_policysend_tmp t2
   WHERE t1.ln_branch = t2.ln_branch AND t1.ls_policyno_cusr1 = t2.ls_policyno_cusr1
   );
```

The corresponding execution plan is as follows:

```
Streaming (type: GATHER)  (cost=44693.26..19548819558.34 rows=4058158 width=1061)
  Node/s: All datanodes
  ->  Update on channel.calc_empfyc_c_cusr1 t1  (cost=44689.26..19546717163.01 rows=4058158 width=1061)
        ->  Hash Join  (cost=44689.26..19546717163.01 rows=4058158 width=1061)
              Hash Cond: (((t1.ln_branch)::text = ((t2.ln_branch)::text)) AND ((t1.ls_policyno_cusr1)::text = ((t2.ls_policyno_cusr1)::text)))
              ->  Seq Scan on channel.calc_empfyc_c_cusr1 t1  (cost=0.00..28692.39 rows=7105667 width=1055)
                    Filter: ((t1.dsign = '1'::bpchar) AND (t1.flag = '1'::bpchar))
              ->  Hash  (cost=2112.16..2112.16 rows=108998016 width=37)
                    ->  Unique  (cost=2112.06..2112.16 rows=108998016 width=37)
                          ->  Sort  (cost=2112.06..2112.09 rows=775 width=37)
                                Sort Key: ((t2.ln_branch)::text), ((t2.ls_policyno_cusr1)::text)
                                ->  Streaming(type: BROADCAST)  (cost=2109.81..2111.85 rows=775 width=37)
                                      Spawn on: All datanodes
                                      ->  HashAggregate  (cost=2109.81..2109.82 rows=12 width=37)
                                            Group By Key: (t2.ln_branch)::text, (t2.ls_policyno_cusr1)::text
                                            ->  Seq Scan on channel.calc_empfyc_c1_policysend_tmp t2  (cost=0.00..1406.87 rows=1703094 width=37)
              SubPlan 1
                ->  Result  (cost=0.00..308262.89 rows=108998016 width=44)
                      Filter: (((t1.ln_branch)::text = (t2.ln_branch)::text) AND ((t1.ls_policyno_cusr1)::text = (t2.ls_policyno_cusr1)::text))
                      ->  Materialize  (cost=0.00..295489.68 rows=108998016 width=44)
                            ->  Streaming(type: BROADCAST)  (cost=0.00..286974.21 rows=108998016 width=44)
                                  Spawn on: All datanodes
                                  ->  Seq Scan on channel.calc_empfyc_c1_policysend_tmp t2  (cost=0.00..1406.87 rows=1703094 width=44)
```

## Optimization

SubPlan exists in the execution plan, and the calculation accounts for a large proportion in the SubPlan query. That is, SubPlan is a performance bottleneck.

Based on the SQL syntax, you can rewrite the SQL statements and delete SubPlan as follows:

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```
UPDATE calc_empfyc_c_cusr1 t1
SET ln_rec_count = CASE WHEN current_date - ln_process_date + 1 <= 12 THEN 0 ELSE t2.ln_rec_count END
FROM calc_empfyc_c1_policysend_tmp t2
WHERE
t1.dsign = '1' AND t1.flag = '1'
AND t1.ln_branch = t2.ln_branch AND t1.ls_policyno_cusr1 = t2.ls_policyno_cusr1;
```

After the rewriting, the execution of this SQL statement is complete within 50s.

# 10.4.14 Case: Rewriting SQL Statements to Eliminate Pruning Interference

## Symptom

In a test at a site, **ddw_f10_op_cust_asset_mon** is a partitioned table and the partitioning key is **year_mth** whose value is a combined string of month and year values.

The following figure shows the tested SQL statements:

```
select
    count(1)
from t_ddw_f10_op_cust_asset_mon b1
where b1.year_mth between to_char(add_months(to_date(''20170222'','yyyymmdd'), -11),'yyyymm') and
substr(''20170222'',1 ,6 );
```

The test result shows the Scan operation on the tables in the SQL statement takes 135s. This may be the performance bottleneck.

NOTE

**add_months** is a local adaptation function.

```
CREATE OR REPLACE FUNCTION ADD_MONTHS(date, integer) RETURNS date
   AS $$
   SELECT
   CASE
   WHEN (EXTRACT(day FROM $1) = EXTRACT(day FROM (date_trunc('month', $1) + INTERVAL '1
month - 1 day'))) THEN
       date_trunc('month', $1) + CAST($2 + 1 || ' month - 1 day' as interval)
   ELSE
       $1 + CAST($2 || ' month' as interval)
   END
   $$
   LANGUAGE SQL
   IMMUTABLE;
```

## Optimization

According to the statement execution plan, the base table filter is displayed as follows:

```
Filter: (((year_mth)::text <= '201702'::text) AND ((year_mth)::text >=
to_char(add_months(to_date('20170222'::text, 'YYYYMMDD'::text), (-11)), 'YYYYMM'::text)))
```

The query condition expression to_char(add_months(to_date(''20170222'','yyyymmdd'),-11),'yyyymm') exists in the filter condition, and this non-constant expression cannot be used for pruning. Therefore, all data of query statements in the partitioned tables is scanned.

**to_date** and **to_char** are stable functions as queried in **pg_proc**. According to the function behavior described in PostgreSQL, this type of functions cannot be

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converted to Const values in the preprocessing phase, which is the root cause why partition pruning cannot be performed.

Based on the preceding analysis, the optimization expression can be used for partition pruning, which is the key to performance optimization. The original SQL statements can be written to as follows:

```
select
   count(1)
from t_ddw_f10_op_cust_asset_mon b1
where b1.year_mth between(substr(ADD_MONTHS('20170222'::date, -11), 1, 4)||
substr(ADD_MONTHS('20170222'::date, -11), 6, 2)) and substr(''20170222'',1 ,6 );
```

The execution time of modified SQL statements is reduced from 135s to 18s.

# 10.4.15 Case: Rewriting SQL Statements and Deleting in-clause

## Symptom

in-clause/any-clause is a common SQL statement constraint. Sometimes, the clause following **in** or **any** is a constant. For example:

```
select
count(1)
from calc_empfyc_c1_result_tmp_t1
where ls_pid_cusr1 in ('20120405', '20130405')
```

or

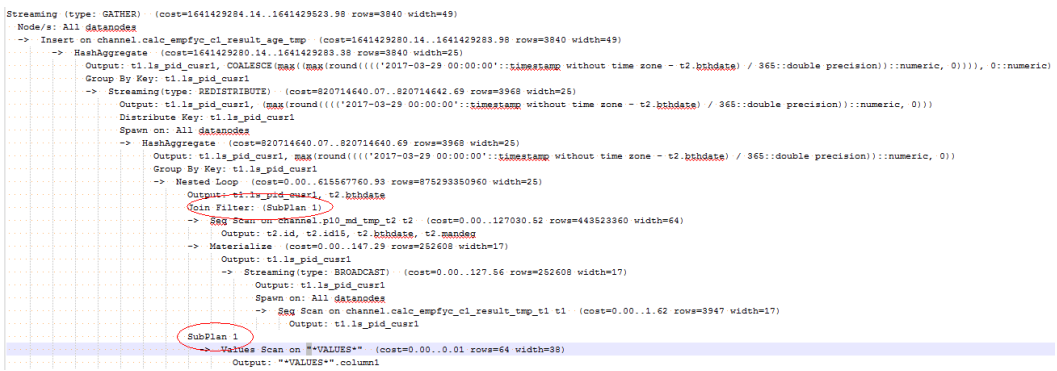
```
select
count(1)
from calc_empfyc_c1_result_tmp_t1
where ls_pid_cusr1 in any('20120405', '20130405');
```

Sometimes, the **in** or **any** clause is used as follows:

```
SELECT
ls_pid_cusr1,COALESCE(max(round((current_date-bthdate)/365)),0)
FROM calc_empfyc_c1_result_tmp_t1 t1,p10_md_tmp_t2 t2
WHERE t1.ls_pid_cusr1 = any(values(id),(id15))
GROUP BY ls_pid_cusr1;
```

**id** and **id15** are columns in **p10_md_tmp_t2**, and **t1.ls_pid_cusr1 = any(values(id),(id15))** is equivalent to **t1.ls_pid_cusr1 = id or t1.ls_pid_cusr1 = id15**.

Therefore, join-condition is essentially an inequality, and nestloop must be used for this join operation. The execution plan is as follows:

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## Optimization

The test result shows that both result sets are too large. As a result, nestloop is time-consuming with more than one hour to return results. Therefore, the key to performance optimization is to eliminate nestloop, using more efficient hash join. From the perspective of semantic equivalence, the SQL statements can be written as follows:

```
select
ls_pid_cusr1,COALESCE(max(round(ym/365)),0)
from
(
        (
                SELECT
                        ls_pid_cusr1,(current_date-bthdate) as ym
                FROM calc_empfyc_c1_result_tmp_t1 t1,p10_md_tmp_t2 t2
                WHERE t1.ls_pid_cusr1 = t2.id and t1.ls_pid_cusr1 != t2.id15
        )
        union all
        (
                SELECT
                        ls_pid_cusr1,(current_date-bthdate) as ym
                FROM calc_empfyc_c1_result_tmp_t1 t1,p10_md_tmp_t2 t2
                WHERE t1.ls_pid_cusr1 = id15
        )
)
GROUP BY ls_pid_cusr1;
```

The optimized SQL query consists of two equivalent join subqueries, and each subquery can be used for hash join in this scenario. The optimized execution plan is as follows:

```
 id |                                  operation                                  |       A-time        |  A-rows   |  E-rows   |   Peak Memory    |  E-memory  |  A-width
----+-----------------------------------------------------------------------------+---------------------+-----------+-----------+------------------+------------+----------
  1 | ->  Streaming (type: GATHER)                                                | 6737.281            |         0 |       192 | 292KB            |            |
  2 |    ->  Insert on channel.calc_empfyc_c1_result_age_tmp                      | [4665.024,4990.666] |         0 |       192 | [1108KB, 1108KB] |  1MB       |
  3 |       ->  HashAggregate                                                     | [4664.996,4990.641] |         0 |       192 | [12KB, 12KB]     |  16MB      |
  4 |          ->  Streaming(type: REDISTRIBUTE)                                  | [4664.991,4990.637] |         0 |      3392 | [2090KB, 2090KB] |  1MB       |
  5 |             ->  HashAggregate                                               | [3416.939,4958.348] |         0 |      3392 | [14KB, 14KB]     |  16MB      |
  6 |                ->  Append                                                   | [3416.936,4958.340] |         0 |      4011 | [1KB, 1KB]       |  1MB       |
  7 |                   ->  Hash Join (8,9)                                       | [2011.226,3080.697] |         0 |      3947 | [6KB, 6KB]       |  1MB       |
  8 |                      ->  Seq Scan on channel.p10_md_tmp_t2 t2               | [803.782,1238.984]  | 443525717 | 443523360 | [12KB, 12KB]     |  1MB       |
  9 |                      ->  Hash                                               | [4.357,328.979]     |    252608 |    252608 | [482KB, 482KB]   |  16MB      |  [35,39]
 10 |                         ->  Streaming(type: BROADCAST)                      | [2.345,326.320]     |    252608 |    252608 | [2090KB, 2090KB] |  1MB       |
 11 |                            ->  Seq Scan on channel.calc_empfyc_c1_result_tmp_t1 t1 | [0.011,0.030]       |      3947 |      3947 | [11KB, 11KB]     |  1MB       |
 12 |                   ->  Hash Join (13,14)                                     | [1376.258,2066.110] |         0 |        64 | [5KB, 5KB]       |  1MB       |
 13 |                      ->  Seq Scan on channel.p10_md_tmp_t2 t2               | [777.552,1388.499]  | 443525717 | 443523360 | [12KB, 12KB]     |  1MB       |
 14 |                      ->  Hash                                               | [2.812,4.217]       |    252608 |    252608 | [482KB, 482KB]   |  16MB      |  [23,27]
 15 |                         ->  Streaming(type: BROADCAST)                      | [1.276,1.868]       |    252608 |    252608 | [2090KB, 2090KB] |  1MB       |
 16 |                            ->  Seq Scan on channel.calc_empfyc_c1_result_tmp_t1 t1 | [0.010,0.033]       |      3947 |      3947 | [11KB, 11KB]     |  1MB       |
(16 rows)
```

Before the optimization, no result is returned for more than 1 hour. After the optimization, the result is returned within 7s.

# 10.4.16 Case: Setting Partial Cluster Keys

You can add **PARTIAL CLUSTER KEY**(*column_name*[,...]) to the definition of a column-store table to set one or more columns of this table as PCKs. In this way, every 70 CUs (4.2 million rows) will be sorted based on the cluster keys by default during data import and the value range is narrowed down for each of the new 70 CUs. If the **where** condition in the query statement contains these columns, the filtering performance will be improved.

1. Use PCKs.

```
CREATE TABLE lineitem
(
  L_ORDERKEY    BIGINT NOT NULL
, L_PARTKEY     BIGINT NOT NULL
, L_SUPPKEY     BIGINT NOT NULL
, L_LINENUMBER  BIGINT NOT NULL
, L_QUANTITY    DECIMAL(15,2) NOT NULL
, L_EXTENDEDPRICE  DECIMAL(15,2) NOT NULL
```

```
, L_DISCOUNT    DECIMAL(15,2) NOT NULL
, L_TAX         DECIMAL(15,2) NOT NULL
, L_RETURNFLAG  CHAR(1) NOT NULL
, L_LINESTATUS  CHAR(1) NOT NULL
, L_SHIPDATE    DATE NOT NULL
, L_COMMITDATE  DATE NOT NULL
, L_RECEIPTDATE DATE NOT NULL
, L_SHIPINSTRUCT CHAR(25) NOT NULL
, L_SHIPMODE     CHAR(10) NOT NULL
, L_COMMENT      VARCHAR(44) NOT NULL
)
with (orientation = column)
distribute by hash(L_ORDERKEY);

select
sum(l_extendedprice * l_discount) as revenue
from
lineitem
where
l_shipdate >= '1994-01-01'::date
and l_shipdate < '1994-01-01'::date + interval '1 year'
and l_discount between 0.06 - 0.01 and 0.06 + 0.01
and l_quantity < 24;
```

In the **where** condition, both the **l_shipdate** and **l_quantity** columns have a few distinct values, and their values can be used for **min**/**max** filtering. Therefore, modify the table definition as follows:

```
CREATE TABLE lineitem
(
  L_ORDERKEY    BIGINT NOT NULL
, L_PARTKEY     BIGINT NOT NULL
, L_SUPPKEY     BIGINT NOT NULL
, L_LINENUMBER  BIGINT NOT NULL
, L_QUANTITY    DECIMAL(15,2) NOT NULL
, L_EXTENDEDPRICE  DECIMAL(15,2) NOT NULL
, L_DISCOUNT    DECIMAL(15,2) NOT NULL
, L_TAX         DECIMAL(15,2) NOT NULL
, L_RETURNFLAG  CHAR(1) NOT NULL
, L_LINESTATUS  CHAR(1) NOT NULL
, L_SHIPDATE    DATE NOT NULL
, L_COMMITDATE  DATE NOT NULL
, L_RECEIPTDATE DATE NOT NULL
, L_SHIPINSTRUCT CHAR(25) NOT NULL
, L_SHIPMODE     CHAR(10) NOT NULL
, L_COMMENT      VARCHAR(44) NOT NULL
, partial cluster key(l_shipdate, l_quantity)
)
with (orientation = column)
distribute by hash(L_ORDERKEY);
```

Import the data again and run the query statement. Then, compare the execution time before and after PCKs are used.

**Figure 10-15** PCKs not used

```
 id |                 operation                 |       A-time       | A-rows | E-rows |  Peak Memory   | A-width | E-width |  E-costs
----+-------------------------------------------+--------------------+--------+--------+----------------+---------+---------+----------
  1 | ->  Row Adapter                           | 1653.156           |      1 |      1 | 12KB           |         |      44 | 205803.90
  2 |    ->  Vector Aggregate                   | 1653.146           |      1 |      1 | 184KB          |         |      44 | 205803.90
  3 |       ->  Vector Streaming (type: GATHER) | 1653.070           |      1 |      1 | 174KB          |         |      44 | 205803.90
  4 |          ->  Vector Aggregate             | [1481.497,1481.497] |      1 |      1 | [225KB, 225KB] |         |      44 | 205803.84
  5 |             ->  CStore Scan on public.lineitem | [1405.004,1405.004] | 114160 | 111485 | [792KB, 792KB] |         |      12 | 205246.40
(5 rows)
```

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**Figure 10-16** CU loading without PCKs

```
 5 --CStore Scan on public.lineitem
       datanode1 (actual time=40.623..1405.004 rows=114160 loops=1)
       datanode1 (RoughCheck CU: CUNone: 0, CUSome: 101)
       datanode1 (LLVM Optimized)
       datanode1 (Buffers: shared hit=18385 read=23)
       datanode1 (CPU: ex c/r=31917, ex cyc=3643646206, inc cyc=3643646206)
```

**Figure 10-17** PCKs used

```
id |                operation                |      A-time       | A-rows | E-rows |  Peak Memory   | A-width | E-width |  E-costs
---+-----------------------------------------+-------------------+--------+--------+----------------+---------+---------+----------
 1 | ->  Row Adapter                         | 459.539           |      1 |      1 | 12KB           |         |      44 | 205693.85
 2 |    ->  Vector Aggregate                 | 459.528           |      1 |      1 | 184KB          |         |      44 | 205693.85
 3 |       ->  Vector Streaming (type: GATHER) | 459.452         |      1 |      1 | 174KB          |         |      44 | 205693.85
 4 |          ->  Vector Aggregate           | [285.177,285.177] |      1 |      1 | [225KB, 225KB] |         |      44 | 205693.79
 5 |             ->  CStore Scan on public.lineitem | [249.757,249.757] | 114160 |  89475 | [792KB, 792KB] |         |      12 | 205246.40
(5 rows)
```

**Figure 10-18** CU loading with PCKs

```
 5 --CStore Scan on public.lineitem
       datanode1 (actual time=23.017..249.757 rows=114160 loops=1)
       datanode1 (RoughCheck CU: CUNone: 84, CUSome: 17)
       datanode1 (LLVM Optimized)
       datanode1 (Buffers: shared hit=2853 read=23)
       datanode1 (CPU: ex c/r=5673, ex cyc=647656146, inc cyc=647656146)
```

After PCKs are used, the execution time of **5 --CStore Scan on public.lineitem** decreases by 1.2s because 84 CUs are filtered out.

2. Select PCKs.
   - The following data types support cluster keys: character varying(n), varchar(n), character(n), char(n), text, nvarchar2, timestamp with time zone, timestamp without time zone, date, time without time zone, and time with time zone.
   - Smaller number of distinct values in a PCK generates higher filtering performance.
   - Columns that can filter out larger amount of data is preferentially selected as PCKs.
   - If multiple columns are selected as PCKs, the columns are used in sequence to sort data. You are advised to select a maximum of three columns.
3. Modify parameters to reduce the impact of PCKs on the import performance.

   After PCKs are used, data will be sorted when they are imported, affecting the import performance. If all the data can be sorted in the memory, the keys have little impact on import. If some data cannot be sorted in the memory and is written into a temporary file for collation, the import performance will be greatly affected.

   The memory used for sorting is specified by the GUC parameter **psort_work_mem**. You can set it to a larger value so that the collation has less impact on the import performance.

   The volume of data to be sorted is specified by the **PARTIAL_CLUSTER_ROWS** parameter of the table. Decreasing the value of this parameter reduces the amount of data to be sorted at a time. **PARTIAL_CLUSTER_ROWS** is usually used along with the **MAX_BATCHROW** parameter. The value of **PARTIAL_CLUSTER_ROWS** must be an integer multiple of the

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**MAX_BATCHROW** value. **MAX_BATCHROW** specifies the maximum number of rows in a CU.

# 10.4.17 Case: Modifying the GUC Parameter rewrite_rule

**rewrite_rule** contains multiple query rewriting rules: magicset, partialpush, uniquecheck, disablerep, intargetlist, and predpush. The following describes the application scenarios of some important rules:

## partialpush: Partial Pushdown

Queries are pushed down to DNs for distributed execution, greatly accelerating queries. If a query statement contains a factor that cannot be pushed down, the entire statement cannot be pushed down. As a result, a stream plan cannot be generated and executed on DNs for the distributed execution, and the performance is poor.

The following is an example:

```
yshen=# set rewrite_rule='none';
SET
yshen=# explain (verbose on, costs off)  select two_sum(tt.c1, tt.c2) from (select t1.c1,t2.c2 from t1,t2
where t1.c1=t2.c2) tt(c1,c2);
                          QUERY PLAN
------------------------------------------------------------------------
 Hash Join
   Output: two_sum(t1.c1, t2.c2)
   Hash Cond: (t1.c1 = t2.c2)
   ->  Data Node Scan on t1 "_REMOTE_TABLE_QUERY_"
         Output: t1.c1
         Node/s: All datanodes
         Remote query: SELECT c1 FROM ONLY public.t1 WHERE true
   ->  Hash
         Output: t2.c2
         ->  Data Node Scan on t2 "_REMOTE_TABLE_QUERY_"
               Output: t2.c2
               Node/s: All datanodes
               Remote query: SELECT c2 FROM ONLY public.t2 WHERE true
(13 rows)
```

The **two_sum()** function cannot be pushed down. As a result, the remote query plan is executed:

1. Deliver the **select c1 from t1 where true** statement to DNs to read all data in the **t1** table.
2. Deliver the **select c2 from t2 where true** statement to DNs to read all data in the **t2** table.
3. Perform HASH JOIN on the CN.
4. Perform the two_sum calculation and return the final result.

This plan is slow because a large amount of data is transmitted over the network and then HASH JOIN is executed on the CN. As a result, cluster resources cannot be fully used.

**partialpush** is added to push the preceding 1, 2, and 3 operations down to DNs for distributed execution, greatly improving statement performance.

```
yshen=# set rewrite_rule='partialpush';
SET
yshen=# explain (verbose on, costs off) select two_sum(tt.c1, tt.c2) from (select t1.c1,t2.c2 from t1,t2 where
t1.c1=t2.c2) tt(c1,c2);
```

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```
                    QUERY PLAN
------------------------------------------------------------
 Subquery Scan on tt
   Output: two_sum(tt.c1, tt.c2)
   ->  Streaming (type: GATHER) --The Gather plan is executed on DNs in a distributed manner:
         Output: t1.c1, t2.c2
         Node/s: All datanodes
         ->  Nested Loop
               Output: t1.c1, t2.c2
               Join Filter: (t1.c1 = t2.c2)
               ->  Seq Scan on public.t1
                     Output: t1.c1, t1.c2, t1.c3
                     Distribute Key: t1.c1
               ->  Materialize
                     Output: t2.c2
                     ->  Streaming(type: REDISTRIBUTE)
                           Output: t2.c2
                           Distribute Key: t2.c2
                           Spawn on: All datanodes
                           Consumer Nodes: All datanodes
                           ->  Seq Scan on public.t2
                                 Output: t2.c2
                                 Distribute Key: t2.c1
(21 rows)
```

## intargetlist: Target Column Subquery Performance Improvement

The query performance can be greatly improved by converting the subquery in the target column to JOIN. The following is an example:

```
yshen=# set rewrite_rule='none';
SET
yshen=# explain (verbose on, costs off) select c1,(select avg(c2) from t2 where t2.c2=t1.c2) from t1 where
t1.c1<100 order by t1.c2;
                          QUERY PLAN
------------------------------------------------------------------------------
 Streaming (type: GATHER)
   Output: t1.c1, ((SubPlan 1)), t1.c2
   Merge Sort Key: t1.c2
   Node/s: All datanodes
   ->  Sort
         Output: t1.c1, ((SubPlan 1)), t1.c2
         Sort Key: t1.c2
         ->  Seq Scan on public.t1
               Output: t1.c1, (SubPlan 1), t1.c2
               Distribute Key: t1.c1
               Filter: (t1.c1 < 100)
               SubPlan 1
                 ->  Aggregate
                       Output: avg(t2.c2)
                       ->  Result
                             Output: t2.c2
                             Filter: (t2.c2 = t1.c2)
                             ->  Materialize
                                   Output: t2.c2
                                   ->  Streaming(type: BROADCAST)
                                         Output: t2.c2
                                         Spawn on: All datanodes
                                         Consumer Nodes: All datanodes
                                         ->  Seq Scan on public.t2
                                               Output: t2.c2
                                               Distribute Key: t2.c1
(26 rows)
```

Because the subquery **(select avg(c2) from t2 where t2.c2=t1.c2)** in the target column cannot be pulled up, execution of the subquery is triggered each time a row of data of **t1** is scanned, and the query efficiency is low. If the **intargetlist**

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parameter is enabled, the subquery is converted to JOIN to improve the query performance.

```
yshen=# set rewrite_rule='intargetlist';
SET
yshen=# explain (verbose on, costs off) select c1,(select avg(c2) from t2 where t2.c2=t1.c2) from t1 where
t1.c1<100 order by t1.c2;
                        QUERY PLAN
------------------------------------------------------------------
 Streaming (type: GATHER)
   Output: t1.c1, (avg(t2.c2)), t1.c2
   Merge Sort Key: t1.c2
   Node/s: All datanodes
   ->  Sort
         Output: t1.c1, (avg(t2.c2)), t1.c2
         Sort Key: t1.c2
         ->  Hash Right Join
               Output: t1.c1, (avg(t2.c2)), t1.c2
               Hash Cond: (t2.c2 = t1.c2)
               ->  Streaming(type: BROADCAST)
                     Output: (avg(t2.c2)), t2.c2
                     Spawn on: All datanodes
                     Consumer Nodes: All datanodes
                     ->  HashAggregate
                           Output: avg(t2.c2), t2.c2
                           Group By Key: t2.c2
                           ->  Streaming(type: REDISTRIBUTE)
                                 Output: t2.c2
                                 Distribute Key: t2.c2
                                 Spawn on: All datanodes
                                 Consumer Nodes: All datanodes
                                 ->  Seq Scan on public.t2
                                       Output: t2.c2
                                       Distribute Key: t2.c1
               ->  Hash
                     Output: t1.c1, t1.c2
                     ->  Seq Scan on public.t1
                           Output: t1.c1, t1.c2
                           Distribute Key: t1.c1
                           Filter: (t1.c1 < 100)
(31 rows)
```

## uniquecheck: Performance Improvement of Subqueries Without Aggregate Functions

Ensure that each condition has only one line of output. The subqueries with aggregate functions can be automatically pulled up. For subqueries without aggregate functions, the following is an example:

select t1.c1 from t1 where t1.c1 = (select t2.c1 from t2 where t1.c1=t2.c2) ;

Rewrite as follows:

select t1.c1 from t1 join (select t2.c1 from t2 where t2.c1 is not null group by t2.c1(unique check)) tt(c1) on tt.c1=t1.c1;

To ensure semantic equivalence, the subquery **tt** must ensure that each **group by t2.c1** has only one line of output. Enable the **uniquecheck** query rewriting parameter to ensure that the query can be pulled up and equivalent. If more than one row of data is output at run time, an error is reported.

```
yshen=# set rewrite_rule='uniquecheck';
SET
yshen=# explain verbose select t1.c1 from t1 where t1.c1 = (select t2.c1 from t2 where t1.c1=t2.c1) ;
                          QUERY PLAN
```

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```
--------------------------------------------------------------------------------
 Streaming (type: GATHER)
   Output: t1.c1
   Node/s: All datanodes
   ->  Nested Loop
         Output: t1.c1
         Join Filter: (t1.c1 = subquery."?column?")
         ->  Seq Scan on public.t1
               Output: t1.c1, t1.c2, t1.c3
               Distribute Key: t1.c1
         ->  Materialize
               Output: subquery."?column?", subquery.c1
               ->  Subquery Scan on subquery
                     Output: subquery."?column?", subquery.c1
                     ->  HashAggregate
                           Output: t2.c1, t2.c1
                           Group By Key: t2.c1
                           Filter: (t2.c1 IS NOT NULL)
                           Unique Check Required -- If more than one row of data is output during running, an
error is reported.
                           ->  Index Only Scan using t2idx on public.t2
                                 Output: t2.c1
                                 Distribute Key: t2.c1
(21 rows)
```

Note: Because **group by t2.c1 unique check** occurs before the filter condition **tt.c1=t1.c1**, an error may be reported after the query that does not report an error is rewritten. An example is as follows:

There are tables **t1** and **t2**. The data in the tables is as follows:

```
yshen=# select * from t1 order by c2;
 c1 | c2 | c3
----+----+----
  1 |  1 |  1
  2 |  2 |  2
  3 |  3 |  3
  4 |  4 |  4
  5 |  5 |  5
  6 |  6 |  6
  7 |  7 |  7
  8 |  8 |  8
  9 |  9 |  9
 10 | 10 | 10
(10 rows)

yshen=# select * from t2 order by c1;
 c1 | c2 | c3
----+----+----
  1 |  1 |  1
  2 |  2 |  2
  3 |  3 |  3
  4 |  4 |  4
  5 |  5 |  5
  6 |  6 |  6
  7 |  7 |  7
  8 |  8 |  8
  9 |  9 |  9
 10 | 10 | 10
 11 | 11 | 11
 11 | 11 | 11
 12 | 12 | 12
 12 | 12 | 12
 13 | 13 | 13
 13 | 13 | 13
 14 | 14 | 14
 14 | 14 | 14
 15 | 15 | 15
 15 | 15 | 15
```

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```
 16 | 16 | 16
 16 | 16 | 16
 17 | 17 | 17
 17 | 17 | 17
 18 | 18 | 18
 18 | 18 | 18
 19 | 19 | 19
 19 | 19 | 19
 20 | 20 | 20
 20 | 20 | 20
(30 rows)
```

Disable and enable the **uniquecheck** parameter for comparison. After the parameter is enabled, an error is reported.

```
yshen=#  select t1.c1 from t1 where t1.c1 = (select t2.c1 from t2 where t1.c1=t2.c2) ;
 c1
----
  6
  7
  3
  1
  2
  4
  5
  8
  9
 10
(10 rows)

yshen=# set rewrite_rule='uniquecheck';
SET
yshen=#  select t1.c1 from t1 where t1.c1 = (select t2.c1 from t2 where t1.c1=t2.c2) ;
ERROR:  more than one row returned by a subquery used as an expression
```

## predpush, predpushnormal, and predpushforce: Condition Pushdown to Subqueries

Generally, the optimizer performs optimization by query block, and different query blocks are independently optimized. If a predicate condition involving cross-query blocks exists, it is difficult to consider the location of a predicate application from a global perspective. The predpush may push down the predicate to the subquery block, so that performance can be improved in a scenario in which the data volume in the parent query block is relatively small and an index can be used in the subquery. There are three rewriting rules related to predpush:

- predpushnormal: attempts to push predicates down to subqueries. The STREAM operators, such as BROADCAST, are used to implement distributed plans.
- predpushforce: attempts to push down predicates to subqueries and uses the index of the parameterized path for scanning as much as possible.
- predpush: selects an optimal distributed plan from predpushnormal and predpushforce at a cost, but increases optimization time.

The following is an example of a plan for disabling and enabling the query rewriting rule:

```
openGauss=# show rewrite_rule;
 rewrite_rule
--------------
 magicset
(1 row)
```

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```
openGauss=# explain (costs off) select * from t1, (select sum(c2), c1 from t2 group by c1) st2 where st2.c1
= t1.c1;
            QUERY PLAN
--------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Nested Loop
         Join Filter: (t1.c1 = t2.c1)
         ->  HashAggregate
               Group By Key: t2.c1
               ->  Seq Scan on t2
         ->  Seq Scan on t1
(8 rows)


openGauss=# set rewrite_rule='predpushnormal';
SET
openGauss=# explain (costs off) select * from t1, (select sum(c2), c1 from t2 group by c1) st2 where st2.c1
= t1.c1;
                     QUERY PLAN
------------------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Nested Loop
         ->  Seq Scan on t1
         ->  GroupAggregate
               Group By Key: t2.c1
               ->  Result
                     Filter: (t1.c1 = t2.c1)
                     ->  Materialize
                           ->  Streaming(type: BROADCAST)
                                 Spawn on: All datanodes
                                 ->  Seq Scan on t2
(12 rows)


openGauss=# set rewrite_rule='predpushforce';
SET

openGauss=# explain (costs off) select * from t1, (select sum(c2), c1 from t2 group by c1) st2 where st2.c1
= t1.c1;
                   QUERY PLAN
-----------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Nested Loop
         ->  Seq Scan on t1
         ->  HashAggregate
               Group By Key: t2.c1
               ->  Index Scan using t2_c1_idx on t2
                     Index Cond: (t1.c1 = c1)
(8 rows)



openGauss=# set rewrite_rule = 'predpush';
SET
openGauss=# explain (costs off) select * from t1, (select sum(c2), c1 from t2 group by c1) st2 where st2.c1
= t1.c1;
                     QUERY PLAN
------------------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Nested Loop
         ->  Seq Scan on t1
         ->  GroupAggregate
               Group By Key: t2.c1
               ->  Result
                     Filter: (t1.c1 = t2.c1)
```

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```
                ->  Materialize
                    ->  Streaming(type: BROADCAST)
                        Spawn on: All datanodes
                        ->  Seq Scan on t2
(12 rows)
```

# 10.4.18 Case: Using DN Gather to Reduce Stream Nodes in the Plan

The DN Gather is used to remove the stream nodes from the distribution plan and send data to a node for calculation. This reduces the cost of data redistribution during the execution of the distribution plan and improves the single query performance and the overall throughput capability of the system. However, DN Gather is oriented to small-data-volume scenarios of TP. For small-data-volume queries, performance can be improved because the cost of data redistribution is reduced and the computing power of a single node is sufficient. Multi-node parallel computing is more advantageous for large-data-volume computing. You need to enable and disable DN Gather to determine which one is faster. (The default value of **dngather_min_rows** is 500. The following uses the default value.) Some cases are provided as follows:

## Gather Join

To converge the join results to a single DN, the following conditions must be met:

- The number of data rows estimated by the optimizer before and after join is less than the threshold.
- The subnodes of Join are all stream nodes.

For example, the subnodes of Join are all stream nodes, and broadcast is disabled.

```
openGauss=# set enable_broadcast=false;
SET
openGauss=# set explain_perf_mode=pretty;
SET
openGauss=# set enable_dngather=false;
SET
openGauss=# explain select count(*) from t1, t2 where t1.b = t2.b;
 id |                    operation                    | E-rows | E-width | E-costs
----+-------------------------------------------------+--------+---------+---------
  1 | ->  Aggregate                                   |      1 |       8 | 31.46
  2 |    ->  Streaming (type: GATHER)                 |      3 |       8 | 31.46
  3 |       ->  Aggregate                             |      3 |       8 | 31.34
  4 |          ->  Hash Join (5,7)                    |     30 |       0 | 31.30
  5 |             ->  Streaming(type: REDISTRIBUTE)   |     30 |       4 | 15.49
  6 |                ->  Seq Scan on t1               |     30 |       4 | 14.14
  7 |             ->  Hash                            |     29 |       4 | 15.49
  8 |                ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 15.49
  9 |                   ->  Seq Scan on t2            |     30 |       4 | 14.14
(9 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   4 --Hash Join (5,7)
       Hash Cond: (t1.b = t2.b)
(2 rows)
openGauss=# set enable_dngather=true;
SET
openGauss=# explain select count(*) from t1, t2 where t1.b = t2.b;
 id |                          operation                          | E-rows | E-width | E-costs
----+-------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                |      1 |       8 | 32.53
```

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```
 2 |   ->  Aggregate                                          |      1 |       8 | 32.47
 3 |     ->  Hash Join (4,6)                                  |     30 |       0 | 32.38
 4 |       ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1)    |     30 |       4 | 15.69
 5 |         ->  Seq Scan on t1                               |     30 |       4 | 14.14
 6 |       ->  Hash                                           |     30 |       4 | 15.69
 7 |         ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1) |     30 |       4 | 15.69
 8 |           ->  Seq Scan on t2                             |     30 |       4 | 14.14
(8 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
  3 --Hash Join (4,6)
       Hash Cond: (t1.b = t2.b)
(2 rows)
openGauss=# set enable_dngather=false;
SET
openGauss=# explain select * from t1, t2, t3, t4 where t1.b = t2.b and t2.c = t3.c and t3.d = t4.d order by
t1.a;
 id |                      operation                       | E-rows | E-width | E-costs
----+------------------------------------------------------+--------+---------+---------
 1 | ->  Streaming (type: GATHER)                         |     30 |     144 | 66.46
 2 |   ->  Sort                                           |     30 |     144 | 66.05
 3 |     ->  Hash Join (4,16)                             |     30 |     144 | 64.86
 4 |       ->  Streaming(type: REDISTRIBUTE)              |     30 |     108 | 49.05
 5 |         ->  Hash Join (6,13)                         |     30 |     108 | 48.08
 6 |           ->  Streaming(type: REDISTRIBUTE)          |     30 |      72 | 32.27
 7 |             ->  Hash Join (8,10)                     |     30 |      72 | 31.30
 8 |               ->  Streaming(type: REDISTRIBUTE)      |     30 |      36 | 15.49
 9 |                 ->  Seq Scan on t1                   |     30 |      36 | 14.14
10 |               ->  Hash                               |     29 |      36 | 15.49
11 |                 ->  Streaming(type: REDISTRIBUTE)    |     30 |      36 | 15.49
12 |                   ->  Seq Scan on t2                 |     30 |      36 | 14.14
13 |           ->  Hash                                   |     29 |      36 | 15.49
14 |             ->  Streaming(type: REDISTRIBUTE)        |     30 |      36 | 15.49
15 |               ->  Seq Scan on t3                     |     30 |      36 | 14.14
16 |       ->  Hash                                       |     29 |      36 | 15.49
17 |         ->  Streaming(type: REDISTRIBUTE)            |     30 |      36 | 15.49
18 |           ->  Seq Scan on t4                         |     30 |      36 | 14.14
(18 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
  3 --Hash Join (4,16)
       Hash Cond: (t3.d = t4.d)
  5 --Hash Join (6,13)
       Hash Cond: (t2.c = t3.c)
  7 --Hash Join (8,10)
       Hash Cond: (t1.b = t2.b)
(6 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select * from t1, t2, t3, t4 where t1.b = t2.b and t2.c = t3.c and t3.d = t4.d order by
t1.a;
 id |                          operation                           | E-rows | E-width | E-costs
----+--------------------------------------------------------------+--------+---------+---------
 1 | ->  Streaming (type: GATHER)                                 |     30 |     144 | 68.47
 2 |   ->  Sort                                                   |     30 |     144 | 66.36
 3 |     ->  Hash Join (4,10)                                     |     30 |     144 | 65.55
 4 |       ->  Hash Join (5,7)                                    |     30 |      72 | 32.38
 5 |         ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode3)    |     30 |      36 | 15.69
 6 |           ->  Seq Scan on t1                                 |     30 |      36 | 14.14
 7 |         ->  Hash                                             |     30 |      36 | 15.69
 8 |           ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode3)  |     30 |      36 | 15.69
 9 |             ->  Seq Scan on t2                               |     30 |      36 | 14.14
10 |       ->  Hash                                               |     30 |      72 | 32.38
11 |         ->  Hash Join (12,14)                                |     30 |      72 | 32.38
12 |           ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode3)  |     30 |      36 | 15.69
13 |             ->  Seq Scan on t3                               |     30 |      36 | 14.14
```

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```
 14 |              ->  Hash                                              |     30 |      36 | 15.69
 15 |                ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode3) |     30 |      36 | 15.69
 16 |                  ->  Seq Scan on t4                                |     30 |      36 | 14.14
(16 rows)

 Predicate Information (identified by plan id)
------------------------------------------------
   3 --Hash Join (4,10)
         Hash Cond: (t2.c = t3.c)
   4 --Hash Join (5,7)
         Hash Cond: (t1.b = t2.b)
  11 --Hash Join (12,14)
         Hash Cond: (t3.d = t4.d)
(6 rows)
openGauss=# set enable_dngather=false;
SET
openGauss=# explain select count(*) from t1, t2, t3, t4 where t1.b = t2.b and t2.c = t3.c and t3.d = t4.d
group by t1.b order by t1.b;
 id |                       operation                        | E-rows | E-width | E-costs
----+--------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                           |     30 |      12 | 66.45
  2 |    ->  GroupAggregate                                  |     30 |      12 | 65.20
  3 |      ->  Sort                                          |     30 |       4 | 65.05
  4 |        ->  Hash Join (5,17)                            |     30 |       4 | 64.86
  5 |          ->  Streaming(type: REDISTRIBUTE)             |     30 |       4 | 49.05
  6 |            ->  Hash Join (7,14)                       |     30 |       4 | 48.08
  7 |              ->  Streaming(type: REDISTRIBUTE)         |     30 |       8 | 32.27
  8 |                ->  Hash Join (9,11)                    |     30 |       8 | 31.30
  9 |                  ->  Streaming(type: REDISTRIBUTE)     |     30 |       8 | 15.49
 10 |                    ->  Seq Scan on t2                  |     30 |       8 | 14.14
 11 |                  ->  Hash                              |     29 |       8 | 15.49
 12 |                    ->  Streaming(type: REDISTRIBUTE)   |     30 |       8 | 15.49
 13 |                      ->  Seq Scan on t3                |     30 |       8 | 14.14
 14 |              ->  Hash                                  |     29 |       4 | 15.49
 15 |                ->  Streaming(type: REDISTRIBUTE)       |     30 |       4 | 15.49
 16 |                  ->  Seq Scan on t4                    |     30 |       4 | 14.14
 17 |          ->  Hash                                      |     29 |       4 | 15.49
 18 |            ->  Streaming(type: REDISTRIBUTE)           |     30 |       4 | 15.49
 19 |              ->  Seq Scan on t1                        |     30 |       4 | 14.14
(19 rows)

 Predicate Information (identified by plan id)
------------------------------------------------
   4 --Hash Join (5,17)
         Hash Cond: (t2.b = t1.b)
   6 --Hash Join (7,14)
         Hash Cond: (t3.d = t4.d)
   8 --Hash Join (9,11)
         Hash Cond: (t2.c = t3.c)
(6 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select count(*) from t1, t2, t3, t4 where t1.b = t2.b and t2.c = t3.c and t3.d = t4.d
group by t1.b order by t1.b;
 id |                              operation                               | E-rows | E-width | E-costs
----+----------------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                         |     30 |      12 | 68.69
  2 |    ->  GroupAggregate                                                |     30 |      12 | 66.81
  3 |      ->  Sort                                                        |     30 |       4 | 66.36
  4 |        ->  Hash Join (5,11)                                          |     30 |       4 | 65.55
  5 |          ->  Hash Join (6,8)                                         |     30 |       8 | 32.38
  6 |            ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1)  |     30 |       4 | 15.69
  7 |              ->  Seq Scan on t1                                      |     30 |       4 | 14.14
  8 |            ->  Hash                                                  |     30 |       8 | 15.69
  9 |              ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1)  |     30 |       8 | 15.69
 10 |                ->  Seq Scan on t2                                    |     30 |       8 | 14.14
 11 |          ->  Hash                                                    |     30 |       4 | 32.38
 12 |            ->  Hash Join (13,15)                                     |     30 |       4 | 32.38
```

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```
 13 |                 ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1)    |     30 |       8 | 15.69
 14 |                   ->  Seq Scan on t3                                           |     30 |       8 | 14.14
 15 |                 ->  Hash                                                       |     30 |       4 | 15.69
 16 |                   ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1) |     30 |       4 | 15.69
 17 |                     ->  Seq Scan on t4                                         |     30 |       4 | 14.14
(17 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
  4 --Hash Join (5,11)
        Hash Cond: (t2.c = t3.c)
  5 --Hash Join (6,8)
        Hash Cond: (t1.b = t2.b)
 12 --Hash Join (13,15)
        Hash Cond: (t3.d = t4.d)
(6 rows)
```

## Gather Groupby/Agg

To converge the GroupBy/Agg results to a single DN, the following conditions must be met:

- The number of data rows estimated by the optimizer before and after GroupBy/Agg is less than the threshold.
- All agg subnodes are stream nodes.

```
openGauss=# set explain_perf_mode=pretty;
SET
openGauss=# set enable_dngather=false;
SET
openGauss=# explain select count(*) from t1 group by b;
 id |              operation               | E-rows | E-width | E-costs
----+--------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)         |     30 |      12 | 15.87
  2 |   ->  HashAggregate                  |     30 |      12 | 14.62
  3 |     ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 14.45
  4 |       ->  Seq Scan on t1             |     30 |       4 | 14.14
(4 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select count(*) from t1 group by b;
 id |                          operation                          | E-rows | E-width | E-costs
----+-------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                |     30 |      12 | 16.85
  2 |   ->  HashAggregate                                         |     30 |      12 | 14.97
  3 |     ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1) |     30 |       4 | 14.46
  4 |       ->  Seq Scan on t1                                    |     30 |       4 | 14.14
(4 rows)

openGauss=# set enable_dngather=false;
SET
openGauss=# explain select b from t1 group by b;
 id |              operation               | E-rows | E-width | E-costs
----+--------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)         |     30 |       4 | 15.84
  2 |   ->  HashAggregate                  |     30 |       4 | 14.59
  3 |     ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 14.45
  4 |       ->  Seq Scan on t1             |     30 |       4 | 14.14
(4 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select b from t1 group by b;
 id |                          operation                          | E-rows | E-width | E-costs
----+-------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                |     30 |       4 | 16.74
  2 |   ->  HashAggregate                                         |     30 |       4 | 14.87
```

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```
 3 |       ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1) |     30 |       4 | 14.46
 4 |         ->  Seq Scan on t1                                        |     30 |       4 | 14.14
(4 rows)
```

## Gather Window Function

To converge window function results to a single DN, the following conditions must be met:

- The number of data rows estimated by the optimizer before and after the window function is less than the threshold.
- All subnodes of the window function are stream nodes.

```
openGauss=# set explain_perf_mode=pretty;
SET
openGauss=# set enable_dngather=false;
SET
openGauss=# explain select count(*) over (partition by b) a from t1;
 id |               operation                | E-rows | E-width | E-costs
----+----------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)           |     29 |       4 | 16.71
  2 |    ->  WindowAgg                       |     29 |       4 | 14.96
  3 |      ->  Sort                          |     29 |       4 | 14.75
  4 |        ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 14.45
  5 |          ->  Seq Scan on t1            |     30 |       4 | 14.14
(5 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select count(*) over (partition by b) a from t1;
 id |                          operation                          | E-rows | E-width | E-costs
----+-------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                |     30 |       4 | 19.07
  2 |    ->  WindowAgg                                            |     30 |       4 | 16.38
  3 |      ->  Sort                                               |     30 |       4 | 15.73
  4 |        ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode3) |     30 |       4 | 14.46
  5 |          ->  Seq Scan on t1                                 |     30 |       4 | 14.14
(5 rows)

openGauss=# set enable_dngather=false;
SET
openGauss=# explain select sum(b) over (partition by b) a from t1 group by b;
 id |               operation                | E-rows | E-width | E-costs
----+----------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)           |     30 |       4 | 16.18
  2 |    ->  WindowAgg                       |     30 |       4 | 14.93
  3 |      ->  Sort                          |     30 |       4 | 14.78
  4 |        ->  HashAggregate               |     30 |       4 | 14.59
  5 |          ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 14.45
  6 |            ->  Seq Scan on t1          |     30 |       4 | 14.14
(6 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select sum(b) over (partition by b) a from t1 group by b;
 id |                          operation                          | E-rows | E-width | E-costs
----+-------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                |     30 |       4 | 18.00
  2 |    ->  WindowAgg                                            |     30 |       4 | 16.13
  3 |      ->  Sort                                               |     30 |       4 | 15.68
  4 |        ->  HashAggregate                                    |     30 |       4 | 14.87
  5 |          ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode3) |     30 |       4 | 14.46
  6 |            ->  Seq Scan on t1                               |     30 |       4 | 14.14
(6 rows)
```

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## Union/Union all

To converge union/union all results to a single DN, the following conditions must be met:

- Subnodes must meet conditions of at least one of the preceding three cases.

For example, all the subnodes of Join are stream nodes, and broadcast is disabled.

```
openGauss=# set explain_perf_mode=pretty;
SET
openGauss=# set enable_broadcast=false;
SET
openGauss=# set enable_dngather=false;
SET
openGauss=# explain select t1.a, t2.b from t1, t2 where t1.b = t2.b union all select t3.a, t3.b from t3, t4
where t3.b = t4.b;
 id |                  operation                   | E-rows | E-width | E-costs
----+----------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                 |     60 |       8 | 65.31
  2 |    ->  Result                                |     60 |       8 | 62.81
  3 |       ->  Append(4, 10)                      |     60 |       8 | 62.81
  4 |         ->  Hash Join (5,7)                  |     30 |       8 | 31.30
  5 |           ->  Streaming(type: REDISTRIBUTE)  |     30 |       8 | 15.49
  6 |             ->  Seq Scan on t1               |     30 |       8 | 14.14
  7 |           ->  Hash                           |     29 |       4 | 15.49
  8 |             ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 15.49
  9 |               ->  Seq Scan on t2             |     30 |       4 | 14.14
 10 |         ->  Hash Join (11,13)                |     30 |       8 | 31.30
 11 |           ->  Streaming(type: REDISTRIBUTE)  |     30 |       8 | 15.49
 12 |             ->  Seq Scan on t3               |     30 |       8 | 14.14
 13 |           ->  Hash                           |     29 |       4 | 15.49
 14 |             ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 15.49
 15 |               ->  Seq Scan on t4             |     30 |       4 | 14.14
(15 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   4 --Hash Join (5,7)
       Hash Cond: (t1.b = t2.b)
  10 --Hash Join (11,13)
       Hash Cond: (t3.b = t4.b)
(4 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select t1.a, t2.b from t1, t2 where t1.b = t2.b union all select t3.a, t3.b from t3, t4
where t3.b = t4.b;
 id |                                operation                                | E-rows | E-width | E-costs
----+-------------------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                            |     60 |       8 | 69.11
  2 |    ->  Append(3, 9)                                                     |     60 |       8 | 65.36
  3 |       ->  Hash Join (4,6)                                               |     30 |       8 | 32.38
  4 |         ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1)     |     30 |       8 | 15.69
  5 |           ->  Seq Scan on t1                                            |     30 |       8 | 14.14
  6 |         ->  Hash                                                        |     30 |       4 | 15.69
  7 |           ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1)  |     30 |       4 | 15.69
  8 |             ->  Seq Scan on t2                                          |     30 |       4 | 14.14
  9 |       ->  Hash Join (10,12)                                             |     30 |       8 | 32.38
 10 |         ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1)     |     30 |       8 | 15.69
 11 |           ->  Seq Scan on t3                                            |     30 |       8 | 14.14
 12 |         ->  Hash                                                        |     30 |       4 | 15.69
 13 |           ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode1)  |     30 |       4 | 15.69
 14 |             ->  Seq Scan on t4                                          |     30 |       4 | 14.14
(14 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   3 --Hash Join (4,6)
```

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```
       Hash Cond: (t1.b = t2.b)
  9 --Hash Join (10,12)
       Hash Cond: (t3.b = t4.b)
(4 rows)

openGauss=# set enable_dngather=false;
SET
openGauss=# explain select t1.a, t2.b from t1, t2 where t1.b = t2.b union select t3.a, t3.b from t3, t4 where
t3.b = t4.b order by a, b;
 id |                    operation                    | E-rows | E-width | E-costs
----+-------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                    |     60 |       8 | 66.09
  2 |    ->  Sort                                     |     60 |       8 | 63.59
  3 |      ->  HashAggregate                          |     60 |       8 | 63.11
  4 |         ->  Append(5, 11)                       |     60 |       8 | 62.81
  5 |           ->  Hash Join (6,8)                   |     30 |       8 | 31.30
  6 |             ->  Streaming(type: REDISTRIBUTE)   |     30 |       8 | 15.49
  7 |               ->  Seq Scan on t1                |     30 |       8 | 14.14
  8 |             ->  Hash                            |     29 |       4 | 15.49
  9 |               ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 15.49
 10 |                 ->  Seq Scan on t2              |     30 |       4 | 14.14
 11 |           ->  Hash Join (12,14)                 |     30 |       8 | 31.30
 12 |             ->  Streaming(type: REDISTRIBUTE)   |     30 |       8 | 15.49
 13 |               ->  Seq Scan on t3                |     30 |       8 | 14.14
 14 |             ->  Hash                            |     29 |       4 | 15.49
 15 |               ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 15.49
 16 |                 ->  Seq Scan on t4              |     30 |       4 | 14.14
(16 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   5 --Hash Join (6,8)
       Hash Cond: (t1.b = t2.b)
  11 --Hash Join (12,14)
       Hash Cond: (t3.b = t4.b)
(4 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select t1.a, t2.b from t1, t2 where t1.b = t2.b union select t3.a, t3.b from t3, t4 where
t3.b = t4.b order by a, b;
 id |                              operation                              | E-rows | E-width | E-costs
----+---------------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                        |     60 |       8 | 71.93
  2 |    ->  Sort                                                         |     60 |       8 | 68.18
  3 |      ->  HashAggregate                                              |     60 |       8 | 66.26
  4 |         ->  Append(5, 11)                                           |     60 |       8 | 65.36
  5 |           ->  Hash Join (6,8)                                       |     30 |       8 | 32.38
  6 |             ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode2)    |     30 |       8 | 15.69
  7 |               ->  Seq Scan on t1                                    |     30 |       8 | 14.14
  8 |             ->  Hash                                                |     30 |       4 | 15.69
  9 |               ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode2) |     30 |       4 | 15.69
 10 |                 ->  Seq Scan on t2                                  |     30 |       4 | 14.14
 11 |           ->  Hash Join (12,14)                                     |     30 |       8 | 32.38
 12 |             ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode2)    |     30 |       8 | 15.69
 13 |               ->  Seq Scan on t3                                    |     30 |       8 | 14.14
 14 |             ->  Hash                                                |     30 |       4 | 15.69
 15 |               ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode2) |     30 |       4 | 15.69
 16 |                 ->  Seq Scan on t4                                  |     30 |       4 | 14.14
(16 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   5 --Hash Join (6,8)
       Hash Cond: (t1.b = t2.b)
  11 --Hash Join (12,14)
       Hash Cond: (t3.b = t4.b)
(4 rows)
```

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```
openGauss=# set enable_dngather=false;
SET
openGauss=# explain select b, count(*) from t1 group by b union all select b, count(*) from t2 group by b
order by b;
 id |                 operation                  | E-rows | E-width | E-costs
----+--------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)               |     60 |      12 | 32.43
  2 |   ->  Sort                                 |     60 |      12 | 29.93
  3 |     ->  Result                             |     60 |      12 | 29.45
  4 |       ->  Append(5, 8)                     |     60 |      12 | 29.45
  5 |         ->  HashAggregate                  |     30 |      12 | 14.62
  6 |           ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 14.45
  7 |             ->  Seq Scan on t1             |     30 |       4 | 14.14
  8 |         ->  HashAggregate                  |     30 |      12 | 14.62
  9 |           ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 14.45
 10 |             ->  Seq Scan on t2             |     30 |       4 | 14.14
(10 rows)

openGauss=# set enable_dngather=true;
SET
openGauss=# explain select b, count(*) from t1 group by b union all select b, count(*) from t2 group by b
order by b;
 id |                              operation                               | E-rows | E-width | E-costs
----+----------------------------------------------------------------------+--------+---------+---------
  1 | ->  Streaming (type: GATHER)                                         |     60 |      12 | 36.22
  2 |   ->  Sort                                                           |     60 |      12 | 32.47
  3 |     ->  Append(4, 7)                                                 |     60 |      12 | 30.55
  4 |       ->  HashAggregate                                              |     30 |      12 | 14.97
  5 |         ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode2) |     30 |       4 | 14.46
  6 |           ->  Seq Scan on t1                                         |     30 |       4 | 14.14
  7 |       ->  HashAggregate                                              |     30 |      12 | 14.97
  8 |         ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode2) |     30 |       4 | 14.46
  9 |           ->  Seq Scan on t2                                         |     30 |       4 | 14.14
(9 rows)
openGauss=# set enable_dngather=false;
SET
openGauss=# explain select b, count(*) from t1 group by b union all select count(distinct a) a ,
count(distinct b)b from t2 order by b;
 id |                    operation                    | E-rows | E-width |    E-costs
----+-------------------------------------------------+--------+---------+----------------
  1 | ->  Streaming (type: GATHER)                    |     33 |      12 | 20000000045.02
  2 |   ->  Sort                                      |     33 |      12 | 20000000043.65
  3 |     ->  Append(4, 8)                            |     33 |      12 | 20000000043.43
  4 |       ->  Subquery Scan on "*SELECT* 1"         |     30 |      12 | 14.72
  5 |         ->  HashAggregate                       |     30 |      12 | 14.62
  6 |           ->  Streaming(type: REDISTRIBUTE)     |     30 |       4 | 14.45
  7 |             ->  Seq Scan on t1                  |     30 |       4 | 14.14
  8 |       ->  Subquery Scan on "*SELECT* 2"         |      1 |      16 | 20000000028.73
  9 |         ->  Nested Loop (10,14)                 |      3 |      16 | 20000000028.70
 10 |           ->  Aggregate                         |      3 |      12 | 10000000014.18
 11 |             ->  Streaming(type: BROADCAST)      |      9 |      12 | 10000000014.18
 12 |               ->  Aggregate                     |      3 |      12 | 14.19
 13 |                 ->  Seq Scan on t2              |     30 |       4 | 14.14
 14 |           ->  Materialize                       |      3 |       8 | 10000000014.49
 15 |             ->  Aggregate                       |      3 |      12 | 10000000014.48
 16 |               ->  Streaming(type: BROADCAST)    |      9 |      12 | 10000000014.48
 17 |                 ->  Aggregate                   |      3 |      12 | 14.48
 18 |                   ->  Streaming(type: REDISTRIBUTE) |     30 |       4 | 14.45
 19 |                     ->  Seq Scan on t2          |     30 |       4 | 14.14
(19 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   8 --Subquery Scan on "*SELECT* 2"
       Filter: (Hash By "*SELECT* 2".a)
(2 rows)

openGauss=# set enable_dngather=true;
```

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```
SET
openGauss=# explain select b, count(*) from t1 group by b union all select count(distinct a) a ,
count(distinct b)b from t2 order by b;
 id |                              operation                              | E-rows | E-width |    E-costs
----+---------------------------------------------------------------------+--------+---------+----------------
 1 | ->  Streaming (type: GATHER)                                        |     33 |      11 | 20000000046.96
 2 |   ->  Sort                                                          |     33 |      11 | 20000000044.90
 3 |     ->  Append(4, 8)                                                |     33 |      11 | 20000000043.99
 4 |       ->  Subquery Scan on "*SELECT* 1"                             |     30 |      12 | 15.27
 5 |         ->  HashAggregate                                           |     30 |      12 | 14.97
 6 |           ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode2) |     30 |       4 | 14.46
 7 |             ->  Seq Scan on t1                                      |     30 |       4 | 14.14
 8 |       ->  Streaming(type: REDISTRIBUTE ng: node_group->datanode2)    |      3 |      16 |
20000000028.83
 9 |         ->  Nested Loop (10,14)                                     |      3 |      16 | 20000000028.70
10 |           ->  Aggregate                                             |      3 |      12 | 10000000014.18
11 |             ->  Streaming(type: BROADCAST)                          |      9 |      12 | 10000000014.18
12 |               ->  Aggregate                                        |      3 |      12 | 14.19
13 |                 ->  Seq Scan on t2                                  |     30 |       4 | 14.14
14 |           ->  Materialize                                           |      3 |       8 | 10000000014.50
15 |             ->  Aggregate                                          |      3 |      12 | 10000000014.48
16 |               ->  Streaming(type: BROADCAST)                        |      9 |      12 | 10000000014.48
17 |                 ->  Aggregate                                      |      3 |      12 | 14.48
18 |                   ->  Streaming(type: REDISTRIBUTE)                 |     30 |       4 | 14.45
19 |                     ->  Seq Scan on t2                              |     30 |       4 | 14.14
(19 rows)
```

# 10.4.19 Case: Adjusting I/O Parameters to Reduce the Log Bloat Rate

- Parameter values before adjustment:
  - pagewriter_sleep=2000ms
  - bgwriter_delay=2000ms
  - max_io_capacity=500MB
- Parameter values after adjustment:
  - pagewriter_sleep=100ms
  - bgwriter_delay=1s
  - max_io_capacity=300MB

NOTE

- The **max_io_capacity** parameter is set to a small value because the I/O does not use the maximum value of the previous parameter. This parameter is used to limit the upper limit of the I/O usage of the backend write process.
- Log recycling is triggered only when the number of logs reaches a certain value. The formula for calculating the value is as follows: Value of **wal_keep_segments** + Value of **checkpoint_segments** x 2 + 1. If **checkpoint_segments** is set to **128** and **wal_keep_segments** is set to **128**, the number of logs is (128 + 128 x 2 + 1) x 16 MB = 6 GB.
- Before the parameters are adjusted, the Xlogs of different data volumes bloat in different degrees in the TPC-C data export phase. As a result, GB-level logs bloat. The main cause is that dirty pages are not flushed to disks, the recovery point cannot be pushed forward, and logs cannot be recycled in time. After the parameters are adjusted, the log bloat rate decreases significantly.
- Take the 2000 warehouses as an example. Before the parameter adjustment, the log size bloats by 10 GB in the data export phase. After the parameter adjustment, the log size remains within the range of the minimum xlog value calculated based on the parameter setting.

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# 11 Configuring Running Parameters

## 11.1 Viewing Parameter Values

GaussDB uses a set of default running parameters after it is installed. You can modify the parameters to better fit your application scenarios and data volume.

### Procedure

**Step 1** Connect to a database. For details, see **2.1 Connecting to a Database**.

**Step 2** View the parameter values in the database.

- Method 1: Run the **SHOW** command.
  - Run the following command to view the value of a certain parameter:
    ```
    openGauss=# SHOW server_version;
    ```
    *server_version* indicates the database version.
  - Run the following command to view values of all parameters:
    ```
    openGauss=# SHOW ALL;
    ```
- Method 2: Query the **pg_settings** view.
  - Run the following command to view the value of a certain parameter:
    ```
    openGauss=# SELECT * FROM pg_settings WHERE NAME='server_version';
    ```
  - Run the following command to view values of all parameters:
    ```
    openGauss=# SELECT * FROM pg_settings;
    ```

**----End**

### Example

View the server version.

```
openGauss=# SHOW server_version;
 server_version
----------------
 9.2.4
(1 row)
```

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# 11.2 Resetting Parameters

## Background

GaussDB provides multiple methods to set GUC parameters for databases, users, or sessions.

- Parameter names are case-insensitive.
- The parameter values can be integers, floating points, strings, Boolean values, or enumerated values.
  - The Boolean values can be **on**/**off**, **true**/**false**, **yes**/**no**, or **1**/**0**, and are case-insensitive.
  - The enumerated value range is specified in the **enumvals** column of the system catalog **pg_settings**.
- For parameters using units, specify their units during the setting. Otherwise, default units are used.
  - The default units are specified in the **unit** column of **pg_settings**.
  - The unit of memory can be KB, MB, or GB.
  - The unit of time can be ms, s, min, h, or d.
- You can set parameters about CNs and DNs at a time, but cannot do the same to other parameters.

For details about parameters in the hosts configuration template, see **19 GUC Parameters**.

## Setting GUC Parameters

GaussDB provides six types of GUC parameters. For details about parameter types and their setting methods, see **Table 11-1**.

**Table 11-1** GUC parameter types

| Parameter Type | Description | Setting Method |
| --- | --- | --- |
| INTERNAL | Fixed parameter. It is set during database creation and cannot be modified. Users can only view the parameter by running the **SHOW** command or in the **pg_settings** view. | None |
| POSTMASTER | Database server parameter. It can be set when the database is started or in the configuration file. | Method 1 in **Table 11-2**. |
| SIGHUP | Global database parameter. It can be set when the database is started or be modified later. | Method 1 or 2 in **Table 11-2**. |

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| Parameter Type | Description | Setting Method |
| --- | --- | --- |
| BACKEND | Session connection parameter. It is specified during session connection creation and cannot be modified after that. The parameter setting becomes invalid when the session is disconnected. This is an internal parameter and not recommended for users to set it. | Method 1 or 2 in **Table 11-2**.<br>**NOTE**<br>The parameter setting takes effect when the next session is created. |
| SUSET | Database administrator parameter. It can be set by common users when or after the database is started. It can also be set by database administrators using SQL statements. | Method 1 or 2 by a common user, or method 3 by a database administrator in **Table 11-2**. |
| USERSET | Common user parameter. It can be set by any user at any time. | Method 1, 2, or 3 in **Table 11-2**.<br>**NOTE**<br>When you set parameters of the USERSET type, the parameter value set using **ALTER DATABASE** takes precedence over that set using **gs_guc**. To make the parameter settings of **gs_guc** take effect, run the **alter database** *xxx* **reset** *xxx* command to reset the parameters. |

You can set GUC parameters in GaussDB using the methods listed in **Table 11-2**.

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**Table 11-2** Methods for setting GUC parameters

| No. | Setting Method |
| --- | --- |
| Method 1 | 1. Run the following command to set a parameter:<br>**gs_guc set -Z** *nodetype* **-D** *datadir* **-c** "*paraname=value*"<br>**NOTE**<br>If the parameter is a string variable, use **-c** *parameter*="'*value*'" or **-c** "*parameter* = '*value*'".<br>Run the following command to set a parameter for CNs and DNs at the same time:<br>**gs_guc set -Z coordinator -Z datanode -N *all* -I *all* -c "*paraname=value*"**<br>Run the following command to set a cm_agent parameter for CN and DN:<br>**gs_guc set -Z cmagent -N *all* -I *all* -c "paraname=value"**<br>**gs_guc set -Z cmagent -c "paraname=value"**<br>Run the following command to set a cm_server parameter for CN and DN:<br>**gs_guc set -Z cmserver -N *all* -I *all* -c "paraname=value"**<br>**gs_guc set -Z cmserver -c "paraname=value"**<br>2. Restart the database to make the setting take effect.<br>**NOTE**<br>Restarting the database cluster results in operation interruption. Properly plan the restart to avoid affecting users.<br>**gs_om -t stop gs_om -t start** |
| Method 2 | **gs_guc reload -Z** *nodetype* **-D** *datadir* **-c** *"paraname=value*"<br>**NOTE**<br>Run the following command to set a parameter for CNs and DNs at the same time:<br>**gs_guc reload -Z coordinator -Z datanode -N *all* -I *all* -c "*paraname=value*"**<br>Run the following command to set a cm_agent parameter for CN and DN:<br>**gs_guc reload -Z cmagent -N *all* -I *all* -c "paraname=value"**<br>**gs_guc reload -Z cmagent -c "paraname=value"**<br>Run the following command to set a cm_server parameter for CN and DN:<br>**gs_guc reload -Z cmserver -N *all* -I *all* -c "paraname=value"**<br>**gs_guc reload -Z cmserver -c "paraname=value"** |
| Method 3 | Modify a session-level parameter.<br>• Set a session-level parameter.<br>openGauss=# **SET** *paraname* **TO** *value;*<br>Parameter value in the current session is changed. After you exit the session, the setting becomes invalid. |

**CAUTION**

If you use method 1 or 2 to set a parameter that does not belong to the current environment, the database displays a message indicating that the parameter is not supported.

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# 12 SQL Reference

## 12.1 GaussDB SQL

### What Is SQL?

SQL is a standard computer language used to control the access to databases and manage data in databases.

SQL provides different statements to enable you to:

- Query data.
- Insert, update, and delete rows.
- Create, replace, modify, and delete objects.
- Control the access to a database and its objects.
- Maintain the consistency and integrity of a database.

SQL consists of commands and functions that are used to manage databases and database objects. SQL can also forcibly implement the rules for data types, expressions, and texts. Therefore, **12 SQL Reference** describes data types, expressions, functions, and operators in addition to SQL syntax.

### Development of SQL Standards

Released SQL standards are as follows:

- 1986: ANSI X3.135-1986, ISO/IEC 9075:1986, SQL-86
- 1989: ANSI X3.135-1989, ISO/IEC 9075:1989, SQL-89
- 1992: ANSI X3.135-1992, ISO/IEC 9075:1992, SQL-92 (SQL2)
- 1999: ISO/IEC 9075:1999, SQL:1999 (SQL3)
- 2003: ISO/IEC 9075:2003, SQL:2003 (SQL4)
- 2011: ISO/IEC 9075:200N, SQL:2011 (SQL5)

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### SQL Standards Supported by GaussDB

GaussDB is compatible with Postgres-XC and supports major SQL2, SQL3, and SQL4 features by default.

## 12.2 Keywords

The SQL contains reserved words and non-reserved words. Standards require that reserved keywords not be used as other identifiers. Non-reserved keywords have special meanings only in a specific environment and can be used as identifiers in other environments.

**Table 12-1** SQL keywords

| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| ABORT | Non-reserved | N/A | N/A |
| ABS | N/A | Non-reserved | N/A |
| ABSOLUTE | Non-reserved | Reserved | Reserved |
| ACCESS | Non-reserved | N/A | N/A |
| ACCOUNT | Non-reserved | N/A | N/A |
| ACTION | Non-reserved | Reserved | Reserved |
| ADA | N/A | Non-reserved | Non-reserved |
| ADD | Non-reserved | Reserved | Reserved |
| ADMIN | Non-reserved | Reserved | N/A |
| AFTER | Non-reserved | Reserved | N/A |
| AGGREGATE | Non-reserved | Reserved | N/A |
| ALGORITHM | Non-reserved | N/A | N/A |
| ALIAS | N/A | Reserved | N/A |
| ALL | Reserved | Reserved | Reserved |
| ALLOCATE | N/A | Reserved | Reserved |
| ALSO | Non-reserved | N/A | N/A |
| ALTER | Non-reserved | Reserved | Reserved |
| ALWAYS | Non-reserved | N/A | N/A |
| ANALYSE | Reserved | N/A | N/A |
| ANALYZE | Reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| AND | Reserved | Reserved | Reserved |
| ANY | Reserved | Reserved | Reserved |
| APP | Non-reserved | N/A | N/A |
| APPEND | Non-reserved | N/A | N/A |
| ARCHIVE | Non-reserved | N/A | N/A |
| ARE | N/A | Reserved | Reserved |
| ARRAY | Reserved | Reserved | N/A |
| AS | Reserved | Reserved | Reserved |
| ASC | Reserved | Reserved | Reserved |
| ASENSITIVE | N/A | Non-reserved | N/A |
| ASSERTION | Non-reserved | Reserved | Reserved |
| ASSIGNMENT | Non-reserved | Non-reserved | N/A |
| ASYMMETRIC | Reserved | Non-reserved | N/A |
| AT | Non-reserved | Reserved | Reserved |
| ATOMIC | N/A | Non-reserved | N/A |
| ATTRIBUTE | Non-reserved | N/A | N/A |
| AUDIT | Non-reserved | N/A | N/A |
| AUTHID | Reserved | N/A | N/A |
| AUTHORIZATION | Reserved (functions and types allowed) | Reserved | Reserved |
| AUTOEXTEND | Non-reserved | N/A | N/A |
| AUTOMAPPED | Non-reserved | N/A | N/A |
| AVG | N/A | Non-reserved | Reserved |
| BACKWARD | Non-reserved | N/A | N/A |
| BARRIER | Non-reserved | N/A | N/A |
| BEFORE | Non-reserved | Reserved | N/A |
| BEGIN | Non-reserved | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| BEGIN_NON_ANOYBLOCK | Non-reserved | N/A | N/A |
| BETWEEN | Non-reserved (excluding functions and types) | Non-reserved | Reserved |
| BIGINT | Non-reserved (excluding functions and types) | N/A | N/A |
| BINARY | Reserved (functions and types allowed) | Reserved | N/A |
| BINARY_DOUBLE | Non-reserved (excluding functions and types) | N/A | N/A |
| BINARY_INTEGER | Non-reserved (excluding functions and types) | N/A | N/A |
| BIT | Non-reserved (excluding functions and types) | Reserved | Reserved |
| BITVAR | N/A | Non-reserved | N/A |
| BIT_LENGTH | N/A | Non-reserved | Reserved |
| BLANKS | Non-reserved | N/A | N/A |
| BLOB | Non-reserved | Reserved | N/A |
| BLOCKCHAIN | Non-reserved | N/A | N/A |
| BODY | Non-reserved | N/A | N/A |
| BOOLEAN | Non-reserved (excluding functions and types) | Reserved | N/A |
| BOTH | Reserved | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| BUCKETCNT | Non-reserved (excluding functions and types) | N/A | N/A |
| BUCKETS | Reserved | N/A | N/A |
| BREADTH | N/A | Reserved | N/A |
| BY | Non-reserved | Reserved | Reserved |
| BYTEAWITHOUTORDER | Non-reserved (excluding functions and types) | N/A | N/A |
| BYTEAWITHOUTORDER-WITHEQUAL | Non-reserved (excluding functions and types) | N/A | N/A |
| C | N/A | Non-reserved | Non-reserved |
| CACHE | Non-reserved | N/A | N/A |
| CALL | Non-reserved | Reserved | N/A |
| CALLED | Non-reserved | Non-reserved | N/A |
| CANCELABLE | Non-reserved | N/A | N/A |
| CARDINALITY | N/A | Non-reserved | N/A |
| CASCADE | Non-reserved | Reserved | Reserved |
| CASCADED | Non-reserved | Reserved | Reserved |
| CASE | Reserved | Reserved | Reserved |
| CAST | Reserved | Reserved | Reserved |
| CATALOG | Non-reserved | Reserved | Reserved |
| CATALOG_NAME | N/A | Non-reserved | Non-reserved |
| CHAIN | Non-reserved | Non-reserved | N/A |
| CHAR | Non-reserved (excluding functions and types) | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| CHARACTER | Non-reserved (excluding functions and types) | Reserved | Reserved |
| CHARACTERISTICS | Non-reserved | N/A | N/A |
| CHARACTERSET | Non-reserved | N/A | N/A |
| CHARACTER_LENGTH | N/A | Non-reserved | Reserved |
| CHARACTER_SET_CATALOG | N/A | Non-reserved | Non-reserved |
| CHARACTER_SET_NAME | N/A | Non-reserved | Non-reserved |
| CHARACTER_SET_SCHEMA | N/A | Non-reserved | Non-reserved |
| CHAR_LENGTH | N/A | Non-reserved | Reserved |
| CHECK | Reserved | Reserved | Reserved |
| CHECKED | N/A | Non-reserved | N/A |
| CHECKPOINT | Non-reserved | N/A | N/A |
| CLASS | Non-reserved | Reserved | N/A |
| CLEAN | Non-reserved | N/A | N/A |
| CLASS_ORIGIN | N/A | Non-reserved | Non-reserved |
| CLIENT | Non-reserved | N/A | N/A |
| CLIENT_MASTER_KEY | Non-reserved | N/A | N/A |
| CLIENT_MASTER_KEYS | Non-reserved | N/A | N/A |
| CLOB | Non-reserved | Reserved | N/A |
| CLOSE | Non-reserved | Reserved | Reserved |
| CLUSTER | Non-reserved | N/A | N/A |
| COALESCE | Non-reserved (excluding functions and types) | Non-reserved | Reserved |
| COBOL | N/A | Non-reserved | Non-reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| COLLATE | Reserved | Reserved | Reserved |
| COLLATION | Reserved (functions and types allowed) | Reserved | Reserved |
| COLLATION_CATALOG | N/A | Non-reserved | Non-reserved |
| COLLATION_NAME | N/A | Non-reserved | Non-reserved |
| COLLATION_SCHEMA | N/A | Non-reserved | Non-reserved |
| COLUMN | Reserved | Reserved | Reserved |
| COLUMN_ENCRYPTION_KEY | Non-reserved | N/A | N/A |
| COLUMN_ENCRYPTION_KEYS | Non-reserved | N/A | N/A |
| COLUMN_NAME | N/A | Non-reserved | Non-reserved |
| COMMAND_FUNCTION | N/A | Non-reserved | Non-reserved |
| COMMAND_FUNCTION_CODE | N/A | Non-reserved | N/A |
| COMMENT | Non-reserved | N/A | N/A |
| COMMENTS | Non-reserved | N/A | N/A |
| COMMIT | Non-reserved | Reserved | Reserved |
| COMMITTED | Non-reserved | Non-reserved | Non-reserved |
| COMPACT | Non-reserved | N/A | N/A |
| COMPATIBLE_ILLEGAL_CHARS | Non-reserved | N/A | N/A |
| COMPLETE | Non-reserved | N/A | N/A |
| COMPRESS | Non-reserved | N/A | N/A |
| COMPLETION | N/A | Reserved | N/A |
| CONCURRENTLY | Reserved (functions and types allowed) | N/A | N/A |
| CONDITION | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| CONDITION_NUMBER | N/A | Non-reserved | Non-reserved |
| CONFIGURATION | Non-reserved | N/A | N/A |
| CONNECT | Reserved | Reserved | Reserved |
| CONNECTION | Non-reserved | Reserved | Reserved |
| CONSTANT | Non-reserved | N/A | N/A |
| CONNECTION_NAME | N/A | Non-reserved | Non-reserved |
| CONSTRAINT | Reserved | Reserved | Reserved |
| CONSTRAINTS | Non-reserved | Reserved | Reserved |
| CONSTRAINT_CATALOG | N/A | Non-reserved | Non-reserved |
| CONSTRAINT_NAME | N/A | Non-reserved | Non-reserved |
| CONSTRAINT_SCHEMA | N/A | Non-reserved | Non-reserved |
| CONSTRUCTOR | N/A | Reserved | N/A |
| CONTAINS | N/A | Non-reserved | N/A |
| CONTENT | Non-reserved | N/A | N/A |
| CONTINUE | Non-reserved | Reserved | Reserved |
| CONTVIEW | Non-reserved | N/A | N/A |
| CONVERSION | Non-reserved | N/A | N/A |
| CONVERT | N/A | Non-reserved | Reserved |
| COORDINATOR | Non-reserved | N/A | N/A |
| COORDINATORS | Non-reserved | N/A | N/A |
| COPY | Non-reserved | N/A | N/A |
| CORRESPONDING | N/A | Reserved | Reserved |
| COST | Non-reserved | N/A | N/A |
| COUNT | N/A | Non-reserved | Reserved |
| CREATE | Reserved | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| CROSS | Reserved (functions and types allowed) | Reserved | Reserved |
| CSN | Reserved (functions and types allowed) | N/A | N/A |
| CSV | Non-reserved | N/A | N/A |
| CUBE | Non-reserved | Reserved | N/A |
| CURRENT | Non-reserved | Reserved | Reserved |
| CURRENT_CATALOG | Reserved | N/A | N/A |
| CURRENT_DATE | Reserved | Reserved | Reserved |
| CURRENT_PATH | N/A | Reserved | N/A |
| CURRENT_ROLE | Reserved | Reserved | N/A |
| CURRENT_SCHEMA | Reserved (functions and types allowed) | N/A | N/A |
| CURRENT_TIME | Reserved | Reserved | Reserved |
| CURRENT_TIMESTAMP | Reserved | Reserved | Reserved |
| CURRENT_USER | Reserved | Reserved | Reserved |
| CURSOR | Non-reserved | Reserved | Reserved |
| CURSOR_NAME | N/A | Non-reserved | Non-reserved |
| CYCLE | Non-reserved | Reserved | N/A |
| DATA | Non-reserved | Reserved | Non-reserved |
| DATABASE | Non-reserved | N/A | N/A |
| DATAFILE | Non-reserved | N/A | N/A |
| DATANODE | Non-reserved | N/A | N/A |
| DATANODES | Non-reserved | N/A | N/A |
| DATATYPE_CL | Non-reserved | N/A | N/A |
| DATE | Non-reserved (excluding functions and types) | Reserved | Reserved |
| DATE_FORMAT | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| DATETIME_INTERVAL_CODE | N/A | Non-reserved | Non-reserved |
| DATETIME_INTERVAL_PRECISION | N/A | Non-reserved | Non-reserved |
| DAY | Non-reserved | Reserved | Reserved |
| DBCOMPATIBILITY | Non-reserved | N/A | N/A |
| DEALLOCATE | Non-reserved | Reserved | Reserved |
| DEC | Non-reserved (excluding functions and types) | Reserved | Reserved |
| DECIMAL | Non-reserved (excluding functions and types) | Reserved | Reserved |
| DECLARE | Non-reserved | Reserved | Reserved |
| DECODE | Non-reserved (excluding functions and types) | N/A | N/A |
| DEFAULT | Reserved | Reserved | Reserved |
| DEFAULTS | Non-reserved | N/A | N/A |
| DEFERRABLE | Reserved | Reserved | Reserved |
| DEFERRED | Non-reserved | Reserved | Reserved |
| DEFINED | N/A | Non-reserved | N/A |
| DEFINER | Non-reserved | Non-reserved | N/A |
| DELETE | Non-reserved | Reserved | Reserved |
| DELIMITER | Non-reserved | N/A | N/A |
| DELIMITERS | Non-reserved | N/A | N/A |
| DELTA | Non-reserved | N/A | N/A |
| DELTAMERGE | Reserved (functions and types allowed) | N/A | N/A |
| DEPTH | N/A | Reserved | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| DEREF | N/A | Reserved | N/A |
| DESC | Reserved | Reserved | Reserved |
| DESCRIBE | N/A | Reserved | Reserved |
| DESCRIPTOR | N/A | Reserved | Reserved |
| DESTROY | N/A | Reserved | N/A |
| DESTRUCTOR | N/A | Reserved | N/A |
| DETERMINISTIC | Non-reserved | Reserved | N/A |
| DIAGNOSTICS | N/A | Reserved | Reserved |
| DICTIONARY | Non-reserved | Reserved | N/A |
| DIRECT | Non-reserved | N/A | N/A |
| DIRECTORY | Non-reserved | N/A | N/A |
| DISABLE | Non-reserved | N/A | N/A |
| DISCARD | Non-reserved | N/A | N/A |
| DISCONNECT | Non-reserved | Reserved | Reserved |
| DISPATCH | N/A | Non-reserved | N/A |
| DISTINCT | Reserved | Reserved | Reserved |
| DISTRIBUTE | Non-reserved | N/A | N/A |
| DISTRIBUTION | Non-reserved | N/A | N/A |
| DO | Reserved | N/A | N/A |
| DOCUMENT | Non-reserved | N/A | N/A |
| DOMAIN | Non-reserved | Reserved | Reserved |
| DOUBLE | Non-reserved | Reserved | Reserved |
| DROP | Non-reserved | Reserved | Reserved |
| DUPLICATE | Non-reserved | N/A | N/A |
| DYNAMIC | N/A | Reserved | N/A |
| DYNAMIC_FUNCTION | N/A | Non-reserved | Non-reserved |
| DYNAMIC_FUNCTION_CODE | N/A | Non-reserved | N/A |
| EACH | Non-reserved | Reserved | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| ELASTIC | Non-reserved | N/A | N/A |
| ELSE | Reserved | Reserved | Reserved |
| ENABLE | Non-reserved | N/A | N/A |
| ENCLOSED | Non-reserved | N/A | N/A |
| ENCODING | Non-reserved | N/A | N/A |
| ENCRYPTED | Non-reserved | N/A | N/A |
| ENCRYPTED_VALUE | Non-reserved | N/A | N/A |
| ENCRYPTION | Non-reserved | N/A | N/A |
| ENCRYPTION_TYPE | Non-reserved | N/A | N/A |
| END | Reserved | Reserved | Reserved |
| END-EXEC | N/A | Reserved | Reserved |
| ENFORCED | Non-reserved | N/A | N/A |
| ENUM | Non-reserved | N/A | N/A |
| EOL | Non-reserved | N/A | N/A |
| ERRORS | Non-reserved | N/A | N/A |
| EQUALS | N/A | Reserved | N/A |
| ESCAPE | Non-reserved | Reserved | Reserved |
| ESCAPING | Non-reserved | N/A | N/A |
| EVERY | Non-reserved | Reserved | N/A |
| EXCEPT | Reserved | Reserved | Reserved |
| EXCEPTION | N/A | Reserved | Reserved |
| EXCHANGE | Non-reserved | N/A | N/A |
| EXCLUDE | Non-reserved | N/A | N/A |
| EXCLUDED | Reserved | N/A | N/A |
| EXCLUDING | Non-reserved | N/A | N/A |
| EXCLUSIVE | Non-reserved | N/A | N/A |
| EXEC | N/A | Reserved | Reserved |
| EXECUTE | Non-reserved | Reserved | Reserved |
| EXISTING | N/A | Non-reserved | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| EXISTS | Non-reserved (excluding functions and types) | Non-reserved | Reserved |
| EXPIRED_P | Non-reserved | N/A | N/A |
| EXPLAIN | Non-reserved | N/A | N/A |
| EXTENSION | Non-reserved | N/A | N/A |
| EXTERNAL | Non-reserved | Reserved | Reserved |
| EXTRACT | Non-reserved (excluding functions and types) | Non-reserved | Reserved |
| FALSE | Reserved | Reserved | Reserved |
| FAMILY | Non-reserved | N/A | N/A |
| FAST | Non-reserved | N/A | N/A |
| FEATURES | Non-reserved | N/A | N/A |
| FENCED | Reserved | N/A | N/A |
| FETCH | Reserved | Reserved | Reserved |
| FIELDS | Non-reserved | N/A | N/A |
| FILEHEADER | Non-reserved | N/A | N/A |
| FILL_MISSING_FIELDS | Non-reserved | N/A | N/A |
| FILLER | Non-reserved | N/A | N/A |
| FILTER | Non-reserved | Reserved | Reserved |
| FINAL | N/A | Non-reserved | N/A |
| FIRST | Non-reserved | Reserved | Reserved |
| FIXED | Non-reserved | Reserved | Reserved |
| FLOAT | Non-reserved (excluding functions and types) | Reserved | Reserved |
| FOLLOWING | Non-reserved | N/A | N/A |
| FOR | Reserved | Reserved | Reserved |
| FORCE | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| FOREIGN | Reserved | Reserved | Reserved |
| FORMATTER | Non-reserved | N/A | N/A |
| FORTRAN | N/A | Non-reserved | Non-reserved |
| FORWARD | Non-reserved | N/A | N/A |
| FOUND | N/A | Reserved | Reserved |
| FREE | N/A | Reserved | N/A |
| FREEZE | Reserved (functions and types allowed) | N/A | N/A |
| FROM | Reserved | Reserved | Reserved |
| FULL | Reserved (functions and types allowed) | Reserved | Reserved |
| FUNCTION | Non-reserved | Reserved | N/A |
| FUNCTIONS | Non-reserved | N/A | N/A |
| G | N/A | Non-reserved | N/A |
| GENERAL | N/A | Reserved | N/A |
| GENERATED | Non-reserved | Non-reserved | N/A |
| GET | N/A | Reserved | Reserved |
| GLOBAL | Non-reserved | Reserved | Reserved |
| GO | N/A | Reserved | Reserved |
| GOTO | N/A | Reserved | Reserved |
| GRANT | Reserved | Reserved | Reserved |
| GRANTED | Non-reserved | Non-reserved | N/A |
| GREATEST | Non-reserved (excluding functions and types) | N/A | N/A |
| GROUP | Reserved | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| GROUPING | Non-reserved (excluding functions and types) | Reserved | N/A |
| GROUPPARENT | Reserved | N/A | N/A |
| HANDLER | Non-reserved | N/A | N/A |
| HAVING | Reserved | Reserved | Reserved |
| HDFSDIRECTORY | Reserved (functions and types allowed) | N/A | N/A |
| HEADER | Non-reserved | N/A | N/A |
| HIERARCHY | N/A | Non-reserved | N/A |
| HOLD | Non-reserved | Non-reserved | N/A |
| HOST | N/A | Reserved | N/A |
| HOUR | Non-reserved | Reserved | Reserved |
| IDENTIFIED | Non-reserved | N/A | N/A |
| IDENTITY | Non-reserved | Reserved | Reserved |
| IF | Non-reserved | N/A | N/A |
| IGNORE | N/A | Reserved | N/A |
| IGNORE_EXTRA_DATA | Non-reserved | N/A | N/A |
| ILIKE | Reserved (functions and types allowed) | N/A | N/A |
| IMMEDIATE | Non-reserved | Reserved | Reserved |
| IMMUTABLE | Non-reserved | N/A | N/A |
| IMPLEMENTATION | N/A | Non-reserved | N/A |
| IMPLICIT | Non-reserved | N/A | N/A |
| IN | Reserved | Reserved | Reserved |
| INCLUDE | Non-reserved | N/A | N/A |
| INCLUDING | Non-reserved | N/A | N/A |
| INCREMENT | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| INCREMENTAL | Non-reserved | N/A | N/A |
| INDEX | Non-reserved | N/A | N/A |
| INDEXES | Non-reserved | N/A | N/A |
| INDICATOR | N/A | Reserved | Reserved |
| INFILE | Non-reserved | N/A | N/A |
| INFIX | N/A | Non-reserved | N/A |
| INHERIT | Non-reserved | N/A | N/A |
| INHERITS | Non-reserved | N/A | N/A |
| INITIAL | Non-reserved | N/A | N/A |
| INITIALIZE | N/A | Reserved | N/A |
| INITIALLY | Reserved | Reserved | Reserved |
| INITRANS | Non-reserved | N/A | N/A |
| INLINE | Non-reserved | N/A | N/A |
| INNER | Reserved (functions and types allowed) | Reserved | Reserved |
| INOUT | Non-reserved (excluding functions and types) | Reserved | N/A |
| INPUT | Non-reserved | Reserved | Reserved |
| INSENSITIVE | Non-reserved | Non-reserved | Reserved |
| INSERT | Non-reserved | Reserved | Reserved |
| INSTANCE | N/A | Non-reserved | N/A |
| INSTANTIABLE | N/A | Non-reserved | N/A |
| INSTEAD | Non-reserved | N/A | N/A |
| INT | Non-reserved (excluding functions and types) | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| INTEGER | Non-reserved (excluding functions and types) | Reserved | Reserved |
| INTERNAL | Non-reserved | N/A | N/A |
| INTERSECT | Reserved | Reserved | Reserved |
| INTERVAL | Non-reserved (excluding functions and types) | Reserved | Reserved |
| INTO | Reserved | Reserved | Reserved |
| INVOKER | Non-reserved | Non-reserved | N/A |
| IP | Non-reserved | N/A | N/A |
| IS | Reserved | Reserved | Reserved |
| ISNULL | Non-reserved | N/A | N/A |
| ISOLATION | Non-reserved | Reserved | Reserved |
| ITERATE | N/A | Reserved | N/A |
| JOIN | Reserved (functions and types allowed) | Reserved | Reserved |
| K | N/A | Non-reserved | N/A |
| KEY | Non-reserved | Reserved | Reserved |
| KEY_PATH | Non-reserved | N/A | N/A |
| KEY_MEMBER | N/A | Non-reserved | N/A |
| KEY_STORE | Non-reserved | N/A | N/A |
| KEY_TYPE | N/A | Non-reserved | N/A |
| KILL | Non-reserved | N/A | N/A |
| LABEL | Non-reserved | N/A | N/A |
| LANGUAGE | Non-reserved | Reserved | Reserved |
| LARGE | Non-reserved | Reserved | N/A |
| LAST | Non-reserved | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| LATERAL | N/A | Reserved | N/A |
| LC_COLLATE | Non-reserved | N/A | N/A |
| LC_CTYPE | Non-reserved | N/A | N/A |
| LEADING | Reserved | Reserved | Reserved |
| LEAKPROOF | Non-reserved | N/A | N/A |
| LEAST | Non-reserved (excluding functions and types) | N/A | N/A |
| LEFT | Reserved (functions and types allowed) | Reserved | Reserved |
| LENGTH | N/A | Non-reserved | Non-reserved |
| LESS | Reserved | Reserved | N/A |
| LEVEL | Non-reserved | Reserved | Reserved |
| LIKE | Reserved (functions and types allowed) | Reserved | Reserved |
| LIMIT | Reserved | Reserved | N/A |
| LIST | Non-reserved | N/A | N/A |
| LISTEN | Non-reserved | N/A | N/A |
| LOAD | Non-reserved | N/A | N/A |
| LOCAL | Non-reserved | Reserved | Reserved |
| LOCALTIME | Reserved | Reserved | N/A |
| LOCALTIMESTAMP | Reserved | Reserved | N/A |
| LOCATION | Non-reserved | N/A | N/A |
| LOCATOR | N/A | Reserved | N/A |
| LOCK | Non-reserved | N/A | N/A |
| LOG | Non-reserved | N/A | N/A |
| LOGGING | Non-reserved | N/A | N/A |
| LOGIN_ANY | Non-reserved | N/A | N/A |
| LOGIN_FAILURE | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| LOGIN_SUCCESS | Non-reserved | N/A | N/A |
| LOGOUT | Non-reserved | N/A | N/A |
| LOOP | Non-reserved | N/A | N/A |
| LOWER | N/A | Non-reserved | Reserved |
| M | N/A | Non-reserved | N/A |
| MAP | N/A | Reserved | N/A |
| MAPPING | Non-reserved | N/A | N/A |
| MASKING | Non-reserved | N/A | N/A |
| MASTER | Non-reserved | N/A | N/A |
| MATCH | Non-reserved | Reserved | Reserved |
| MATCHED | Non-reserved | N/A | N/A |
| MATERIALIZED | Non-reserved | N/A | N/A |
| MAX | N/A | Non-reserved | Reserved |
| MAXEXTENTS | Non-reserved | N/A | N/A |
| MAXSIZE | Non-reserved | N/A | N/A |
| MAXTRANS | Non-reserved | N/A | N/A |
| MAXVALUE | Reserved | N/A | N/A |
| MERGE | Non-reserved | N/A | N/A |
| MESSAGE_LENGTH | N/A | Non-reserved | Non-reserved |
| MESSAGE_OCTET_LENGTH | N/A | Non-reserved | Non-reserved |
| MESSAGE_TEXT | N/A | Non-reserved | Non-reserved |
| METHOD | N/A | Non-reserved | N/A |
| MIN | N/A | Non-reserved | Reserved |
| MINEXTENTS | Non-reserved | N/A | N/A |
| MINUS | Reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| MINUTE | Non-reserved | Reserved | Reserved |
| MINVALUE | Non-reserved | N/A | N/A |
| MOD | N/A | Non-reserved | N/A |
| MODE | Non-reserved | N/A | N/A |
| MODEL | Non-reserved | N/A | N/A |
| MODIFIES | N/A | Reserved | N/A |
| MODIFY | Reserved | Reserved | N/A |
| MODULE | N/A | Reserved | Reserved |
| MONTH | Non-reserved | Reserved | Reserved |
| MORE | N/A | Non-reserved | Non-reserved |
| MOVE | Non-reserved | N/A | N/A |
| MOVEMENT | Non-reserved | N/A | N/A |
| MUMPS | N/A | Non-reserved | Non-reserved |
| NAME | Non-reserved | Non-reserved | Non-reserved |
| NAMES | Non-reserved | Reserved | Reserved |
| NATIONAL | Non-reserved (excluding functions and types) | Reserved | Reserved |
| NATURAL | Reserved (functions and types allowed) | Reserved | Reserved |
| NCHAR | Non-reserved (excluding functions and types) | Reserved | Reserved |
| NCLOB | N/A | Reserved | N/A |
| NEW | N/A | Reserved | N/A |
| NEXT | Non-reserved | Reserved | Reserved |
| NO | Non-reserved | Reserved | Reserved |
| NOCOMPRESS | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| NOCYCLE | Reserved | N/A | N/A |
| NODE | Non-reserved | N/A | N/A |
| NOLOGGING | Non-reserved | N/A | N/A |
| NOMAXVALUE | Non-reserved | N/A | N/A |
| NOMINVALUE | Non-reserved | N/A | N/A |
| NONE | Non-reserved (excluding functions and types) | Reserved | N/A |
| NOT | Reserved | Reserved | Reserved |
| NOTHING | Non-reserved | N/A | N/A |
| NOTIFY | Non-reserved | N/A | N/A |
| NOTNULL | Reserved (functions and types allowed) | N/A | N/A |
| NOWAIT | Non-reserved | N/A | N/A |
| NULL | Reserved | Reserved | Reserved |
| NULLABLE | N/A | Non-reserved | Non-reserved |
| NULLIF | Non-reserved (excluding functions and types) | Non-reserved | Reserved |
| NULLS | Non-reserved | N/A | N/A |
| NULLCOLS | Non-reserved | N/A | N/A |
| NUMBER | Non-reserved (excluding functions and types) | Non-reserved | Non-reserved |
| NUMERIC | Non-reserved (excluding functions and types) | Reserved | Reserved |
| NUMSTR | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| NVARCHAR2 | Non-reserved (excluding functions and types) | N/A | N/A |
| NVL | Non-reserved (excluding functions and types) | N/A | N/A |
| OBJECT | Non-reserved | Reserved | N/A |
| OCTET_LENGTH | N/A | Non-reserved | Reserved |
| OF | Non-reserved | Reserved | Reserved |
| OFF | Non-reserved | Reserved | N/A |
| OFFSET | Reserved | N/A | N/A |
| OIDS | Non-reserved | N/A | N/A |
| OLD | N/A | Reserved | N/A |
| ON | Reserved | Reserved | Reserved |
| ONLY | Reserved | Reserved | Reserved |
| OPEN | N/A | Reserved | Reserved |
| OPERATION | N/A | Reserved | N/A |
| OPERATOR | Non-reserved | N/A | N/A |
| OPTIMIZATION | Non-reserved | N/A | N/A |
| OPTION | Non-reserved | Reserved | Reserved |
| OPTIONALLY | Non-reserved | N/A | N/A |
| OPTIONS | Non-reserved | Non-reserved | N/A |
| OR | Reserved | Reserved | Reserved |
| ORDER | Reserved | Reserved | Reserved |
| ORDINALITY | N/A | Reserved | N/A |
| OUT | Non-reserved (excluding functions and types) | Reserved | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| OUTER | Reserved (functions and types allowed) | Reserved | Reserved |
| OUTPUT | N/A | Reserved | Reserved |
| OVER | Non-reserved | N/A | N/A |
| OVERLAPS | Reserved (functions and types allowed) | Non-reserved | Reserved |
| OVERLAY | Non-reserved (excluding functions and types) | Non-reserved | N/A |
| OVERRIDING | N/A | Non-reserved | N/A |
| OWNED | Non-reserved | N/A | N/A |
| OWNER | Non-reserved | N/A | N/A |
| PACKAGE | Non-reserved | N/A | N/A |
| PACKAGES | Non-reserved | N/A | N/A |
| PAD | N/A | Reserved | Reserved |
| PARAMETER | N/A | Reserved | N/A |
| PARAMETERS | N/A | Reserved | N/A |
| PARAMETER_MODE | N/A | Non-reserved | N/A |
| PARAMETER_NAME | N/A | Non-reserved | N/A |
| PARAMETER_ORDINAL_POSITION | N/A | Non-reserved | N/A |
| PARAMETER_SPECIFIC_CATALOG | N/A | Non-reserved | N/A |
| PARAMETER_SPECIFIC_NAME | N/A | Non-reserved | N/A |
| PARAMETER_SPECIFIC_SCHEMA | N/A | Non-reserved | N/A |
| PARSER | Non-reserved | N/A | N/A |
| PARTIAL | Non-reserved | Reserved | Reserved |
| PARTITION | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| PARTITIONS | Non-reserved | N/A | N/A |
| PASCAL | N/A | Non-reserved | Non-reserved |
| PASSING | Non-reserved | N/A | N/A |
| PASSWORD | Non-reserved | N/A | N/A |
| PATH | N/A | Reserved | N/A |
| PCTFREE | Non-reserved | N/A | N/A |
| PER | Non-reserved | N/A | N/A |
| PERCENT | Non-reserved | N/A | N/A |
| PERFORMANCE | Reserved | N/A | N/A |
| PERM | Non-reserved | N/A | N/A |
| PLACING | Reserved | N/A | N/A |
| PLAN | Non-reserved | N/A | N/A |
| PLANS | Non-reserved | N/A | N/A |
| POLICY | Non-reserved | N/A | N/A |
| PLI | N/A | Non-reserved | Non-reserved |
| POOL | Non-reserved | N/A | N/A |
| POSITION | Non-reserved (excluding functions and types) | Non-reserved | Reserved |
| POSTFIX | N/A | Reserved | N/A |
| PRECEDING | Non-reserved | N/A | N/A |
| PRECISION | Non-reserved (excluding functions and types) | Reserved | Reserved |
| PREDICT | Non-reserved | N/A | N/A |
| PREFERRED | Non-reserved | N/A | N/A |
| PREFIX | Non-reserved | Reserved | N/A |
| PREORDER | N/A | Reserved | N/A |
| PREPARE | Non-reserved | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| PREPARED | Non-reserved | N/A | N/A |
| PRESERVE | Non-reserved | Reserved | Reserved |
| PRIMARY | Reserved | Reserved | Reserved |
| PRIOR | Reserved | Reserved | Reserved |
| PRIORER | Reserved | N/A | N/A |
| PRIVATE | Non-reserved | N/A | N/A |
| PRIVILEGE | Non-reserved | N/A | N/A |
| PRIVILEGES | Non-reserved | Reserved | Reserved |
| PROCEDURAL | Non-reserved | N/A | N/A |
| PROCEDURE | Reserved | Reserved | Reserved |
| PROFILE | Non-reserved | N/A | N/A |
| PUBLIC | N/A | Reserved | Reserved |
| PUBLICATION | Non-reserved | N/A | N/A |
| PUBLISH | Non-reserved | N/A | N/A |
| PURGE | Non-reserved | N/A | N/A |
| QUERY | Non-reserved | N/A | N/A |
| QUOTE | Non-reserved | N/A | N/A |
| RANDOMIZED | Non-reserved | N/A | N/A |
| RANGE | Non-reserved | N/A | N/A |
| RATIO | Non-reserved | N/A | N/A |
| RAW | Non-reserved | N/A | N/A |
| READ | Non-reserved | Reserved | Reserved |
| READS | N/A | Reserved | N/A |
| REAL | Non-reserved (excluding functions and types) | Reserved | Reserved |
| REASSIGN | Non-reserved | N/A | N/A |
| REBUILD | Non-reserved | N/A | N/A |
| RECHECK | Non-reserved | N/A | N/A |
| RECURSIVE | Non-reserved | Reserved | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| RECYCLEBIN | Reserved (functions and types allowed) | N/A | N/A |
| REDISANYVALUE | Non-reserved | N/A | N/A |
| REF | Non-reserved | Reserved | N/A |
| REFERENCES | Reserved | Reserved | Reserved |
| REFERENCING | N/A | Reserved | N/A |
| REFRESH | Non-reserved | N/A | N/A |
| REINDEX | Non-reserved | N/A | N/A |
| REJECT | Reserved | N/A | N/A |
| RELATIVE | Non-reserved | Reserved | Reserved |
| RELEASE | Non-reserved | N/A | N/A |
| RELOPTIONS | Non-reserved | N/A | N/A |
| REMOTE | Non-reserved | N/A | N/A |
| REMOVE | Non-reserved | N/A | N/A |
| RENAME | Non-reserved | N/A | N/A |
| REPEATABLE | Non-reserved | Non-reserved | Non-reserved |
| REPLACE | Non-reserved | N/A | N/A |
| REPLICA | Non-reserved | N/A | N/A |
| RESET | Non-reserved | N/A | N/A |
| RESIZE | Non-reserved | N/A | N/A |
| RESOURCE | Non-reserved | N/A | N/A |
| RESTART | Non-reserved | N/A | N/A |
| RESTRICT | Non-reserved | Reserved | Reserved |
| RESULT | N/A | Reserved | N/A |
| RETURN | Non-reserved | Reserved | N/A |
| RETURNED_LENGTH | N/A | Non-reserved | Non-reserved |
| RETURNED_OCTET_LENGTH | N/A | Non-reserved | Non-reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| RETURNED_SQLSTATE | N/A | Non-reserved | Non-reserved |
| RETURNING | Reserved | N/A | N/A |
| RETURNS | Non-reserved | Reserved | N/A |
| REUSE | Non-reserved | N/A | N/A |
| REVOKE | Non-reserved | Reserved | Reserved |
| RIGHT | Reserved (functions and types allowed) | Reserved | Reserved |
| ROLE | Non-reserved | Reserved | N/A |
| ROLES | Non-reserved | N/A | N/A |
| ROLLBACK | Non-reserved | Reserved | Reserved |
| ROLLUP | Non-reserved | Reserved | N/A |
| ROTATION | Non-reserved | N/A | N/A |
| ROUTINE | N/A | Reserved | N/A |
| ROUTINE_CATALOG | N/A | Non-reserved | N/A |
| ROUTINE_NAME | N/A | Non-reserved | N/A |
| ROUTINE_SCHEMA | N/A | Non-reserved | N/A |
| ROW | Non-reserved (excluding functions and types) | Reserved | N/A |
| ROWNUM | Reserved | N/A | N/A |
| ROWS | Non-reserved | Reserved | Reserved |
| ROWTYPE | Non-reserved | N/A | N/A |
| ROW_COUNT | N/A | Non-reserved | Non-reserved |
| RULE | Non-reserved | N/A | N/A |
| SAMPLE | Non-reserved | N/A | N/A |
| SAVEPOINT | Non-reserved | Reserved | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| SCALE | N/A | Non-reserved | Non-reserved |
| SCHEMA | Non-reserved | Reserved | Reserved |
| SCHEMA_NAME | N/A | Non-reserved | Non-reserved |
| SCOPE | N/A | Reserved | N/A |
| SCROLL | Non-reserved | Reserved | Reserved |
| SEARCH | Non-reserved | Reserved | N/A |
| SECOND | Non-reserved | Reserved | Reserved |
| SECTION | N/A | Reserved | Reserved |
| SECURITY | Non-reserved | Non-reserved | N/A |
| SELECT | Reserved | Reserved | Reserved |
| SELF | N/A | Non-reserved | N/A |
| SENSITIVE | N/A | Non-reserved | N/A |
| SEQUENCE | Non-reserved | Reserved | N/A |
| SEQUENCES | Non-reserved | N/A | N/A |
| SERIALIZABLE | Non-reserved | Non-reserved | Non-reserved |
| SERVER | Non-reserved | N/A | N/A |
| SERVER_NAME | N/A | Non-reserved | Non-reserved |
| SESSION | Non-reserved | Reserved | Reserved |
| SESSION_USER | Reserved | Reserved | Reserved |
| SET | Non-reserved | Reserved | Reserved |
| SETOF | Non-reserved (excluding functions and types) | N/A | N/A |
| SETS | Non-reserved | Reserved | N/A |
| SHARE | Non-reserved | N/A | N/A |
| SHIPPABLE | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| SHOW | Non-reserved | N/A | N/A |
| SHUTDOWN | Non-reserved | N/A | N/A |
| SIBLINGS | Non-reserved | N/A | N/A |
| SIMILAR | Reserved (functions and types allowed) | Non-reserved | N/A |
| SIMPLE | Non-reserved | Non-reserved | N/A |
| SIZE | Non-reserved | Reserved | Reserved |
| SKIP | Non-reserved | N/A | N/A |
| SLICE | Non-reserved | N/A | N/A |
| SMALLDATETIME | Non-reserved (excluding functions and types) | N/A | N/A |
| SMALLDATETIME_FORMAT | Non-reserved | N/A | N/A |
| SMALLINT | Non-reserved (excluding functions and types) | Reserved | Reserved |
| SNAPSHOT | Non-reserved | N/A | N/A |
| SOME | Reserved | Reserved | Reserved |
| SOURCE | Non-reserved | Non-reserved | N/A |
| SPACE | Non-reserved | Non-reserved | Reserved |
| SPECIFIC | N/A | Reserved | N/A |
| SPECIFICTYPE | N/A | Reserved | N/A |
| SPECIFIC_NAME | N/A | Non-reserved | N/A |
| SPILL | Non-reserved | N/A | N/A |
| SPLIT | Reserved | N/A | N/A |
| SQL | N/A | Reserved | Reserved |
| SQLCODE | N/A | N/A | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| SQLERROR | N/A | N/A | Reserved |
| SQLEXCEPTION | N/A | Reserved | N/A |
| SQLSTATE | N/A | Reserved | Reserved |
| SQLWARNING | N/A | Reserved | N/A |
| STABLE | Non-reserved | N/A | N/A |
| STANDALONE | Non-reserved | N/A | N/A |
| START | Non-reserved | Reserved | N/A |
| STATE | N/A | Reserved | N/A |
| STATEMENT | Non-reserved | Reserved | N/A |
| STATEMENT_ID | Non-reserved | N/A | N/A |
| STATIC | N/A | Reserved | N/A |
| STATISTICS | Non-reserved | N/A | N/A |
| STDIN | Non-reserved | N/A | N/A |
| STDOUT | Non-reserved | N/A | N/A |
| STORAGE | Non-reserved | N/A | N/A |
| STORE | Non-reserved | N/A | N/A |
| STORED | Non-reserved | N/A | N/A |
| STRATIFY | Non-reserved | N/A | N/A |
| STREAM | Non-reserved | N/A | N/A |
| STRICT | Non-reserved | N/A | N/A |
| STRIP | Non-reserved | N/A | N/A |
| SUBPARTITION | Non-reserved | N/A | N/A |
| SUBSCRIPTION | Non-reserved | N/A | N/A |
| STRUCTURE | N/A | Reserved | N/A |
| STYLE | N/A | Non-reserved | N/A |
| SUBCLASS_ORIGIN | N/A | Non-reserved | Non-reserved |
| SUBLIST | N/A | Non-reserved | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| SUBSTRING | Non-reserved (excluding functions and types) | Non-reserved | Reserved |
| SUM | N/A | Non-reserved | Reserved |
| SYMMETRIC | Reserved | Non-reserved | N/A |
| SYNONYM | Non-reserved | N/A | N/A |
| SYS_REFCURSOR | Non-reserved | N/A | N/A |
| SYSDATE | Reserved | N/A | N/A |
| SYSID | Non-reserved | N/A | N/A |
| SYSTEM | Non-reserved | Non-reserved | N/A |
| SYSTEM_USER | N/A | Reserved | Reserved |
| TABLE | Reserved | Reserved | Reserved |
| TABLES | Non-reserved | N/A | N/A |
| TABLESAMPLE | Reserved (functions and types allowed) | N/A | N/A |
| TABLESPACE | Non-reserved | N/A | N/A |
| TABLE_NAME | N/A | Non-reserved | Non-reserved |
| TARGET | Non-reserved | N/A | N/A |
| TEMP | Non-reserved | N/A | N/A |
| TEMPLATE | Non-reserved | N/A | N/A |
| TEMPORARY | Non-reserved | Reserved | Reserved |
| TERMINATE | N/A | Reserved | N/A |
| TERMINATED | Non-reserved | N/A | N/A |
| TEXT | Non-reserved | N/A | N/A |
| THAN | Non-reserved | Reserved | N/A |
| THEN | Reserved | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| TIME | Non-reserved (excluding functions and types) | Reserved | Reserved |
| TIME_FORMAT | Non-reserved | N/A | N/A |
| TIMECAPSULE | Reserved (functions and types allowed) | N/A | N/A |
| TIMESTAMP | Non-reserved (excluding functions and types) | Reserved | Reserved |
| TIMESTAMP_FORMAT | Non-reserved | N/A | N/A |
| TIMESTAMPDIFF | Non-reserved (excluding functions and types) | N/A | N/A |
| TIMEZONE_HOUR | N/A | Reserved | Reserved |
| TIMEZONE_MINUTE | N/A | Reserved | Reserved |
| TINYINT | Non-reserved (excluding functions and types) | N/A | N/A |
| TO | Reserved | Reserved | Reserved |
| TRAILING | Reserved | Reserved | Reserved |
| TRANSACTION | Non-reserved | Reserved | Reserved |
| TRANSACTIONS_COMMITTED | N/A | Non-reserved | N/A |
| TRANSACTIONS_ROLLED_BACK | N/A | Non-reserved | N/A |
| TRANSACTION_ACTIVE | N/A | Non-reserved | N/A |
| TRANSFORM | Non-reserved | N/A | N/A |
| TRANSFORMS | N/A | Non-reserved | N/A |
| TRANSLATE | N/A | Non-reserved | Reserved |
| TRANSLATION | N/A | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| TREAT | Non-reserved (excluding functions and types) | Reserved | N/A |
| TRIGGER | Non-reserved | Reserved | N/A |
| TRIGGER_CATALOG | N/A | Non-reserved | N/A |
| TRIGGER_NAME | N/A | Non-reserved | N/A |
| TRIGGER_SCHEMA | N/A | Non-reserved | N/A |
| TRIM | Non-reserved (excluding functions and types) | Non-reserved | Reserved |
| TRUE | Reserved | Reserved | Reserved |
| TRUNCATE | Non-reserved | N/A | N/A |
| TRUSTED | Non-reserved | N/A | N/A |
| TSFIELD | Non-reserved | N/A | N/A |
| TSTAG | Non-reserved | N/A | N/A |
| TSTIME | Non-reserved | N/A | N/A |
| TYPE | Non-reserved | Non-reserved | Non-reserved |
| TYPES | Non-reserved | N/A | N/A |
| UESCAPE | N/A | N/A | N/A |
| UNBOUNDED | Non-reserved | N/A | N/A |
| UNCOMMITTED | Non-reserved | Non-reserved | Non-reserved |
| UNDER | N/A | Reserved | N/A |
| UNENCRYPTED | Non-reserved | N/A | N/A |
| UNION | Reserved | Reserved | Reserved |
| UNIQUE | Reserved | Reserved | Reserved |
| UNKNOWN | Non-reserved | Reserved | Reserved |
| UNLIMITED | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| UNLISTEN | Non-reserved | N/A | N/A |
| UNLOCK | Non-reserved | N/A | N/A |
| UNLOGGED | Non-reserved | N/A | N/A |
| UNNAMED | N/A | Non-reserved | Non-reserved |
| UNNEST | N/A | Reserved | N/A |
| UNTIL | Non-reserved | N/A | N/A |
| UNUSABLE | Non-reserved | N/A | N/A |
| UPDATE | Non-reserved | Reserved | Reserved |
| USEEOF | Non-reserved | N/A | N/A |
| UPPER | N/A | Non-reserved | Reserved |
| USAGE | N/A | Reserved | Reserved |
| USER | Reserved | Reserved | Reserved |
| USER_DEFINED_TYPE_CATALOG | N/A | Non-reserved | N/A |
| USER_DEFINED_TYPE_NAME | N/A | Non-reserved | N/A |
| USER_DEFINED_TYPE_SCHEMA | N/A | Non-reserved | N/A |
| USING | Reserved | Reserved | Reserved |
| VACUUM | Non-reserved | N/A | N/A |
| VALID | Non-reserved | N/A | N/A |
| VALIDATE | Non-reserved | N/A | N/A |
| VALIDATION | Non-reserved | N/A | N/A |
| VALIDATOR | Non-reserved | N/A | N/A |
| VALUE | Non-reserved | Reserved | Reserved |
| VALUES | Non-reserved (excluding functions and types) | Reserved | Reserved |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| VARCHAR | Non-reserved (excluding functions and types) | Reserved | Reserved |
| VARCHAR2 | Non-reserved (excluding functions and types) | N/A | N/A |
| VARIABLE | N/A | Reserved | N/A |
| VARIABLES | Non-reserved | N/A | N/A |
| VARIADIC | Reserved | N/A | N/A |
| VARYING | Non-reserved | Reserved | Reserved |
| VCGROUP | Non-reserved | N/A | N/A |
| VERBOSE | Reserved (functions and types allowed) | N/A | N/A |
| VERIFY | Reserved | N/A | N/A |
| VERSION | Non-reserved | N/A | N/A |
| VIEW | Non-reserved | Reserved | Reserved |
| VOLATILE | Non-reserved | N/A | N/A |
| WAIT | Non-reserved | N/A | N/A |
| WEAK | Non-reserved | N/A | N/A |
| WHEN | Reserved | Reserved | Reserved |
| WHENEVER | N/A | Reserved | Reserved |
| WHERE | Reserved | Reserved | Reserved |
| WHITESPACE | Non-reserved | N/A | N/A |
| WINDOW | Reserved | N/A | N/A |
| WITH | Reserved | Reserved | Reserved |
| WITHIN | Non-reserved | N/A | N/A |
| WITHOUT | Non-reserved | Reserved | N/A |
| WORK | Non-reserved | Reserved | Reserved |
| WORKLOAD | Non-reserved | N/A | N/A |
| WRAPPER | Non-reserved | N/A | N/A |

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| Keyword | GaussDB | SQL:1999 | SQL-92 |
| --- | --- | --- | --- |
| WRITE | Non-reserved | Reserved | Reserved |
| XML | Non-reserved | N/A | N/A |
| XMLATTRIBUTES | Non-reserved (excluding functions and types) | N/A | N/A |
| XMLCONCAT | Non-reserved (excluding functions and types) | N/A | N/A |
| XMLELEMENT | Non-reserved (excluding functions and types) | N/A | N/A |
| XMLEXISTS | Non-reserved (excluding functions and types) | N/A | N/A |
| XMLFOREST | Non-reserved (excluding functions and types) | N/A | N/A |
| XMLPARSE | Non-reserved (excluding functions and types) | N/A | N/A |
| XMLPI | Non-reserved (excluding functions and types) | N/A | N/A |
| XMLROOT | Non-reserved (excluding functions and types) | N/A | N/A |
| XMLSERIALIZE | Non-reserved (excluding functions and types) | N/A | N/A |
| YEAR | Non-reserved | Reserved | Reserved |
| YES | Non-reserved | N/A | N/A |
| ZONE | Non-reserved | Reserved | Reserved |

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Fields listed in the following table cannot be used as column names during table creation.

| | | | | |
|---|---|---|---|---|
| CTID | XMIN | CMIN | XMAX | CMAX |
| TABLEOID | XC_NODE_ID | TID | OID | GS_TUPLE_UID |
| TABLEBUCKETID | N/A | N/A | N/A | N/A |

# 12.3 Data Type

Data type is a basic attribute of data that used to distinguish different types of data. Different data types occupy different storage space and support different operations. Data is stored in data tables in the database. Each column of a data table defines the data type. During storage, data must be stored according to data types.

GaussDB supports implicit conversions between certain data types. For details, see **15.2.45 PG_CAST**.

## 12.3.1 Numeric Types

**Table 12-2** lists all available types. For arithmetic operators and related built-in functions, see **12.5.7 Arithmetic Functions and Operators**.

**Table 12-2** Integer types

| Name | Description | Storage Space | Range |
|---|---|---|---|
| TINYINT | Tiny integer, also called INT1 | 1 byte | 0 to 255 |
| SMALLINT | Small integer, also called INT2 | 2 bytes | –32,768 to +32,767 |
| INTEGER | Typical choice for integers, also called INT4 | 4 bytes | –2,147,483,648 to +2,147,483,647 |
| BINARY_INTEGER | INTEGER alias, compatible with Oracle | 4 bytes | –2,147,483,648 to +2,147,483,647 |
| BIGINT | Big integer, also called INT8 | 8 bytes | –9,223,372,036,854,775,808 to +9,223,372,036,854,775,807 |

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Example:

```
-- Create a table containing TINYINT data.
openGauss=# CREATE TABLE int_type_t1
         (
          IT_COL1 TINYINT
         );

-- Insert data.
openGauss=# INSERT INTO int_type_t1 VALUES(10);

-- View data.
openGauss=# SELECT * FROM int_type_t1;
 it_col1
---------
 10
(1 row)

-- Drop the table.
openGauss=# DROP TABLE int_type_t1;
-- Create a table containing TINYINT, INTEGER, and BIGINT data.
openGauss=# CREATE TABLE int_type_t2
(
    a TINYINT,
    b TINYINT,
    c INTEGER,
    d BIGINT
);

-- Insert data.
openGauss=# INSERT INTO int_type_t2 VALUES(100, 10, 1000, 10000);

-- View data.
openGauss=# SELECT * FROM int_type_t2;
  a  | b  |  c   |   d
-----+----+------+-------
 100 | 10 | 1000 | 10000
(1 row)

-- Drop the table.
openGauss=# DROP TABLE int_type_t2;
```

**NOTE**

- The TINYINT, SMALLINT, INTEGER, and BIGINT types store whole numbers, that is, numbers without fractional components, of various ranges. Saving a number with a decimal in any of the data types will result in errors.
- The INTEGER type is the common choice, as it offers the best balance between range, storage size, and performance. Generally, use the SMALLINT type only if you are sure that the value range is within the SMALLINT value range. The storage speed of INTEGER is much faster. BIGINT is used only when the range of INTEGER is not large enough.

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**Table 12-3** Arbitrary precision types

| Name | Description | Storage Space | Range |
| --- | --- | --- | --- |
| NUMERIC[(p[,s])], DECIMAL[(p[,s])] | The value range of **p** is [1,1000], and the value range of **s** is [0,*p*].<br>**NOTE**<br>**p** indicates the total digits, and **s** indicates the decimal digit. | The precision is specified by users. Every four decimal digits occupy two bytes, and an extra eight-byte overhead is added to the entire data. | Up to 131,072 digits before the decimal point, and up to 16,383 digits after the decimal point when no precision is specified. |
| NUMBER[(p[,s])] | Alias for type NUMERIC, compatible with Oracle | The precision is specified by users. Every four decimal digits occupy two bytes, and an extra eight-byte overhead is added to the entire data. | Up to 131,072 digits before the decimal point, and up to 16,383 digits after the decimal point when no precision is specified. |

Example:

```
-- Create a table.
openGauss=# CREATE TABLE decimal_type_t1
(
    DT_COL1 DECIMAL(10,4)
);

-- Insert data.
openGauss=# INSERT INTO decimal_type_t1 VALUES(123456.122331);

-- Query data in the table.
openGauss=# SELECT * FROM decimal_type_t1;
   dt_col1
-------------
 123456.1223
(1 row)

-- Drop the table.
openGauss=# DROP TABLE decimal_type_t1;
-- Create a table.
openGauss=# CREATE TABLE numeric_type_t1
(
    NT_COL1 NUMERIC(10,4)
);

-- Insert data.
openGauss=# INSERT INTO numeric_type_t1 VALUES(123456.12354);

-- Query data in the table.
openGauss=# SELECT * FROM numeric_type_t1;
   nt_col1
-------------
 123456.1235
(1 row)

-- Drop the table.
openGauss=# DROP TABLE numeric_type_t1;
```

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NOTE

- Compared to the integer types, the arbitrary precision numbers require larger storage space and have lower storage efficiency, operation efficiency, and poorer compression ratio results. The INTEGER type is the common choice when number types are defined. Arbitrary precision numbers are used only when numbers exceed the maximum range indicated by the integers.
- When NUMERIC/DECIMAL is used for defining a column, you are advised to specify the precision (p) and scale (s) for the column.

**Table 12-4** Sequence integer

| Name | Description | Storage Space | Range |
| --- | --- | --- | --- |
| SMALLSERIAL | Two-byte serial integer | 2 bytes | –32,768 to +32,767 |
| SERIAL | Four-byte serial integer | 4 bytes | –2,147,483,648 to +2,147,483,647 |
| BIGSERIAL | Eight-byte serial integer | 8 bytes | –9,223,372,036,854,775,808 to +9,223,372,036,854,775,807 |

Example:

```
-- Create a table.
openGauss=# CREATE TABLE smallserial_type_tab(a SMALLSERIAL);

-- Insert data.
openGauss=# INSERT INTO smallserial_type_tab VALUES(default);

-- Insert data again.
openGauss=# INSERT INTO smallserial_type_tab VALUES(default);

-- View data.
openGauss=# SELECT * FROM smallserial_type_tab;
 a
---
 1
 2
(2 rows)

-- Create a table.
openGauss=# CREATE TABLE serial_type_tab(b SERIAL);

-- Insert data.
openGauss=# INSERT INTO serial_type_tab VALUES(default);

-- Insert data again.
openGauss=# INSERT INTO serial_type_tab VALUES(default);

-- View data.
openGauss=# SELECT * FROM serial_type_tab;
 b
---
 1
 2
(2 rows)
```

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```
-- Create a table.
openGauss=# CREATE TABLE bigserial_type_tab(c BIGSERIAL);

-- Insert data.
openGauss=# INSERT INTO bigserial_type_tab VALUES(default);

-- Insert data.
openGauss=# INSERT INTO bigserial_type_tab VALUES(default);

-- View data.
openGauss=# SELECT * FROM bigserial_type_tab;
 c
---
 1
 2
(2 rows)

-- Drop the table.
openGauss=# DROP TABLE smallserial_type_tab;

openGauss=# DROP TABLE serial_type_tab;

openGauss=# DROP TABLE bigserial_type_tab;
```

**NOTE**

SMALLSERIAL, SERIAL, and BIGSERIAL are not real types. They are concepts used for setting a unique identifier for a table. Therefore, an integer column is created and its default value plans to be read from a sequencer. A NOT NULL constraint is used to ensure NULL is not inserted. In most cases you would also want to attach a **UNIQUE** or **PRIMARY KEY** constraint to prevent duplicate values from being inserted unexpectedly, but this is not automatic. The sequencer is set so that it belongs to the column. In this case, when the column or the table is deleted, the sequencer is also deleted. Currently, the **SERIAL** column can be specified only when you create a table. You cannot add the **SERIAL** column in an existing table. In addition, **SERIAL** columns cannot be created in temporary tables. Because SERIAL is not a data type, columns cannot be converted to this type.

**Table 12-5** Floating point types

| Name | Description | Storage Space | Range |
| --- | --- | --- | --- |
| REAL,<br>FLOAT4 | Single precision floating points, inexact | 4 bytes | –3.402E+38 to 3.402E+38,<br>6-bit decimal digits |
| DOUBLE PRECISION,<br>FLOAT8 | Double precision floating points, inexact | 8 bytes | –1.79E+308 to 1.79E+308,<br>15-bit decimal digits |
| FLOAT[(p)] | Floating points, inexact The value range of precision (p) is [1,53].<br>**NOTE**<br>**p** is the precision, indicating the total number of binary bits. | 4 bytes or 8 bytes | **REAL** or **DOUBLE PRECISION** is selected as an internal identifier based on precision (p). If no precision is specified, **DOUBLE PRECISION** is used as the internal identifier. |

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| Name | Description | Storage Space | Range |
| --- | --- | --- | --- |
| BINARY_DOUBLE | DOUBLE PRECISION alias, compatible with Oracle | 8 bytes | –1.79E+308 to 1.79E+308, 15-bit decimal digits |
| DEC[(p[,s])] | The value range of **p** (precision) is [1,1000], and the value range of **s** (scale) is [0,*p*].<br>**NOTE**<br>**p** indicates the total digits, and **s** indicates the decimal digit. | The precision is specified by users. Every four decimal digits occupy two bytes, and an extra eight-byte overhead is added to the entire data. | Up to 131,072 digits before the decimal point, and up to 16,383 digits after the decimal point when no precision is specified. |
| INTEGER[(p[,s])] | The value range of **p** (precision) is [1,1000], and the value range of **s** (scale) is [0,*p*]. | The precision is specified by users. Every four decimal digits occupy two bytes, and an extra eight-byte overhead is added to the entire data. | - |

**NOTE**

For the precision of the floating-point type, only the number of precision bits can be ensured when the data is directly read. When distributed computing is involved, the computation is executed on each DN and is finally aggregated to a CN. Therefore, the error may be amplified as the number of compute nodes increases.

Example:

```
-- Create a table.
openGauss=# CREATE TABLE float_type_t2
(
    FT_COL1 INTEGER,
    FT_COL2 FLOAT4,
    FT_COL3 FLOAT8,
    FT_COL4 FLOAT(3),
    FT_COL5 BINARY_DOUBLE,
    FT_COL6 DECIMAL(10,4),
    FT_COL7 INTEGER(6,3)
)DISTRIBUTE BY HASH ( ft_col1);

-- Insert data.
openGauss=# INSERT INTO float_type_t2 VALUES(10,10.365456,123456.1234,10.3214, 321.321, 123.123654,
123.123654);

-- View data.
openGauss=# SELECT * FROM float_type_t2 ;
 ft_col1 | ft_col2 |   ft_col3   | ft_col4 | ft_col5 | ft_col6  | ft_col7
---------+---------+-------------+---------+---------+----------+---------
      10 | 10.3655 | 123456.1234 | 10.3214 | 321.321 | 123.1237 | 123.124
(1 row)
```

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```
-- Drop the table.
openGauss=# DROP TABLE float_type_t2;
```

## 12.3.2 Monetary Types

The money type stores a currency amount with fixed fractional precision.

The range shown in **Table 12-6** assumes there are two fractional digits. Input is accepted in a variety of formats, including integer and floating-point literals, as well as typical currency formatting, such as "$1,000.00". Output is generally in the last format but depends on the locale.

**Table 12-6** Monetary type

| Name | Storage Space | Description | Range |
| --- | --- | --- | --- |
| money | 8 bytes | Currency amount | –92233720368547758.08 to +92233720368547758.07 |

Values of the numeric, int, and bigint data types can be cast to money. Conversion from the real and double precision data types can be done by casting to numeric first, for example:

```
openGauss=# SELECT '12.34'::float8::numeric::money;
```

However, this is not recommended. Floating point numbers should not be used to handle money due to the potential for rounding errors.

A money value can be cast to numeric without loss of precision. Conversion to other types could potentially lose precision, and must also be done in two stages:

```
openGauss=# SELECT '52093.89'::money::numeric::float8;
```

When a money value is divided by another money value, the result is of the double precision type (that is, a pure number, not money); the currency units cancel each other out in the division.

## 12.3.3 Boolean Types

**Table 12-7** Boolean type

| Name | Description | Storage Space | Value |
| --- | --- | --- | --- |
| BOOLEAN | Boolean | 1 byte | • **true**<br>• **false**<br>• **null**: unknown |

Valid literal values for the "true" state are:

**TRUE**, **'t'**, **'true'**, **'y'**, **'yes'**, **'1'**, and all non-zero integers.

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Valid literal values for the "false" state include:

**FALSE**, **'f'**, **'false'**, **'n'**, **'no'**, **'0'**, and **0**.

**TRUE** and **FALSE** are standard expressions, compatible with SQL statements.

## Examples

Boolean values are displayed using the letters t and f.

```
-- Create a table.
openGauss=# CREATE TABLE bool_type_t1
(
    BT_COL1 BOOLEAN,
    BT_COL2 TEXT
)DISTRIBUTE BY HASH(BT_COL2);

-- Insert data.
openGauss=# INSERT INTO bool_type_t1 VALUES (TRUE, 'sic est');

openGauss=# INSERT INTO bool_type_t1 VALUES (FALSE, 'non est');

-- View data.
openGauss=# SELECT * FROM bool_type_t1;
 bt_col1 | bt_col2
---------+---------
 t       | sic est
 f       | non est
(2 rows)

openGauss=# SELECT * FROM bool_type_t1 WHERE bt_col1 = 't';
 bt_col1 | bt_col2
---------+---------
 t       | sic est
(1 row)

-- Drop the table.
openGauss=# DROP TABLE bool_type_t1;
```

# 12.3.4 Character Types

Table 12-8 lists the character data types supported by GaussDB. For string operators and related built-in functions, see 12.5.3 Character Processing Functions and Operators.

**Table 12-8** Character types

| Name | Description | Storage Space |
| --- | --- | --- |
| CHAR(n)<br>CHARACTER(n)<br>NCHAR(n) | Fixed-length character string, blank padded. **n** indicates the string length. If it is not specified, the default precision **1** is used. | The maximum value of **n** is **10485760** (10 MB). |

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| Name | Description | Storage Space |
| --- | --- | --- |
| VARCHAR(n)<br>CHARACTER VARYING(n) | Variable-length string. In PostgreSQL-compatible mode, **n** indicates the string length. In other compatibility modes, **n** indicates the byte length. | The maximum value of **n** is **10485760** (10 MB).<br>If **n** is not contained, the maximum storage length is 1 GB – 85 – Length of the first *n* columns. For example, the maximum length (of a int, b varchar) is 1 GB – 85 – 4 = 1,073,741,735. |
| VARCHAR2(n) | Variable-length string. It is an alias for VARCHAR(n) type, compatible with Oracle. **n** indicates the string length. | The maximum value of **n** is **10485760** (10 MB).<br>If **n** is not contained, the maximum storage length is 1 GB – 85 – Length of the first *n* columns. For example, the maximum length (of a int, b varchar) is 1 GB – 85 – 4 = 1,073,741,735. |

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| Name | Description | Storage Space |
| --- | --- | --- |
| NVARCHAR2(n) | Variable-length string. **n** indicates the string length. | The maximum value of **n** is **10485760** (10 MB).<br>If **n** is not contained, the maximum storage length is 1 GB – 85 – Length of the first *n* columns. For example, the maximum length (of a int, b varchar) is 1 GB – 85 – 4 = 1,073,741,735. |
| CLOB | Big text object. It is compatible with the Oracle database. | The maximum storage length is 1 GB – 85 – Length of the first *n* columns. For example, the maximum length (of a int, b varchar) is 1 GB – 85 – 4 = 1,073,741,735. |
| TEXT | Variable-length string. | The maximum storage length is 1 GB – 85 – Length of the first *n* columns. For example, the maximum length (of a int, b varchar) is 1 GB – 85 – 4 = 1,073,741,735. |

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NOTE

1. In addition to the size limitation on each column, the total size of each tuple is 1,073,741,739 bytes (1 GB – 85 bytes).
2. NCHAR is the alias of the bpchar type, and VARCHAR2(n) is the alias of the VARCHAR(n) type.

GaussDB has two other fixed-length character types, as shown in **Table 12-9**. The **name** type exists only for the storage of identifiers in the internal system catalogs and is not intended for use by general users. Its length is currently defined as 64 bytes (63 usable characters plus terminator). The type **"char"** only uses one byte of storage. It is internally used in the system catalogs as a simplistic enumeration type.

**Table 12-9** Special character types

| Name | Description | Storage Space |
| --- | --- | --- |
| name | Internal type for object names | 64 bytes |
| "char" | Single-byte internal type | 1 byte |

## Examples

```
-- Create a table.
openGauss=# CREATE TABLE char_type_t1
(
    CT_COL1 CHARACTER(4)
)DISTRIBUTE BY HASH (CT_COL1);

-- Insert data.
openGauss=# INSERT INTO char_type_t1 VALUES ('ok');

-- Query data in the table.
openGauss=# SELECT ct_col1, char_length(ct_col1) FROM char_type_t1;
 ct_col1 | char_length
---------+-------------
 ok      |           4
(1 row)

-- Delete the table.
openGauss=# DROP TABLE char_type_t1;
-- Create a table.
openGauss=# CREATE TABLE char_type_t2
(
    CT_COL1 VARCHAR(5)
)DISTRIBUTE BY HASH (CT_COL1);

-- Insert data.
openGauss=# INSERT INTO char_type_t2 VALUES ('ok');

openGauss=# INSERT INTO char_type_t2 VALUES ('good');

-- Specify the type length. An error is reported if an inserted string exceeds this length.
openGauss=# INSERT INTO char_type_t2 VALUES ('too long');
ERROR:  value too long for type character varying(5)
CONTEXT:  referenced column: ct_col1

-- Specify the type length. A string exceeding this length is truncated.
openGauss=# INSERT INTO char_type_t2 VALUES ('too long'::varchar(5));

-- Query data.
```

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```
openGauss=# SELECT ct_col1, char_length(ct_col1) FROM char_type_t2;
 ct_col1 | char_length
---------+-------------
 ok      |           2
 good    |           4
 too l   |           5
(3 rows)

-- Delete data.
openGauss=# DROP TABLE char_type_t2;
```

## 12.3.5 Binary Types

Table 12-10 lists the binary types supported by GaussDB.

**Table 12-10** Binary types

| Name | Description | Storage Space |
| --- | --- | --- |
| BLOB | Binary large object (BLOB).<br>Currently, BLOB only supports the following external access interfaces:<br>• DBE_LOB.GET_LENGTH<br>• DBE_LOB.READ<br>• DBE_LOB.WRITE<br>• DBE_LOB.WRITE_APPEND<br>• DBE_LOB.COPY<br>• DBE_LOB.ERASE<br>For details about the APIs, see 13.12.2.1 DBE_LOB.<br>**NOTE**<br>Column storage cannot be used for the BLOB type. | The maximum value is 1,073,741,818 bytes (that is,1 GB minus 6 bytes). |
| RAW | Variable-length hexadecimal string.<br>**NOTE**<br>Column storage cannot be used for the RAW type. | The maximum value is 1,073,741,818 bytes (that is,1 GB minus 6 bytes). |
| BYTEA | Variable-length binary string. | The maximum value is calculated as follows: 1 GB – (56 + 24 + 5 + 1 + Total number of bytes in the first *n* columns). For example, if the table is (a int, b bytea), the maximum storage length is 1 GB – 56 – 24 – 5 – 1 – 4(int) = 1073741735. |

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| Name | Description | Storage Space |
| --- | --- | --- |
| BYTEAWITHOUTORDERWITHEQUALCOL | Variable-length binary character string (new type for the encryption feature. If the encryption type of the encrypted column is specified as deterministic encryption, the column type is BYTEAWITHOUTORDERWITHEQUALCOL). The original data type is displayed when the encryption table is printed by running the meta command. | 4 bytes plus the actual binary string. The maximum value is 1,073,741,771 bytes (1 GB minus 53 bytes). |
| BYTEAWITHOUTORDERCOL | Variable-length binary character string (new type for the encryption feature. If the encryption type of the encrypted column is specified as random encryption, the column type is BYTEAWITHOUTORDERCOL). The original data type is displayed when the encryption table is printed by running the meta command. | 4 bytes plus the actual binary string. The maximum value is 1,073,741,771 bytes (1 GB minus 53 bytes). |
| _BYTEAWITHOUTORDERWITHEQUALCOL | Variable-length binary string, which is a new type for the encryption feature. | 4 bytes plus the actual binary string. The maximum value is 1,073,741,771 bytes (1 GB minus 53 bytes). |
| _BYTEAWITHOUTORDERCOL | Variable-length binary string, which is a new type for the encryption feature. | 4 bytes plus the actual binary string. The maximum value is 1,073,741,771 bytes (1 GB minus 53 bytes). |

**NOTE**

- In addition to the size limitation on each column, the total size of each tuple is 1,073,741,771 bytes (1 GB minus 53 bytes).
- BYTEAWITHOUTORDERWITHEQUALCOL, BYTEAWITHOUTORDERCOL, _BYTEAWITHOUTORDERWITHEQUALCOL, and _BYTEAWITHOUTORDERCOL cannot be directly used to create a table.

Example:

```
-- Create a table.
openGauss=# CREATE TABLE blob_type_t1
```

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```
(
    BT_COL1 INTEGER,
    BT_COL2 BLOB,
    BT_COL3 RAW,
    BT_COL4 BYTEA
) DISTRIBUTE BY REPLICATION;

-- Insert data.
openGauss=# INSERT INTO blob_type_t1 VALUES(10,empty_blob(),
HEXTORAW('DEADBEEF'),E'\\xDEADBEEF');

-- Query data in the table.
openGauss=# SELECT * FROM blob_type_t1;
 bt_col1 | bt_col2 | bt_col3  |  bt_col4
---------+---------+----------+------------
      10 |         | DEADBEEF | \xdeadbeef
(1 row)

-- Drop the table.
openGauss=# DROP TABLE blob_type_t1;
```

## 12.3.6 Date/Time Types

Table 12-11 lists the date/time types that can be used in GaussDB. For the operators and built-in functions of the types, see 12.5.8 Date and Time Processing Functions and Operators.

NOTE

If the time format of another database is different from that of GaussDB, modify the value of the **DateStyle** parameter to keep them consistent.

**Table 12-11** Date/Time types

| Name | Description | Storage Space |
| --- | --- | --- |
| DATE | Date.<br>Minimum value: 4713-01-01 B.C.<br>Maximum value: 5874897-12-31 A.D.<br>**NOTE**<br>For ORA compatibility, the database treats empty strings as **NULL** and replaces **DATE** with **TIMESTAMP(0) WITHOUT TIME ZONE**. | 4 bytes (The actual storage space is 8 bytes.) |
| TIME [(p)] [WITHOUT TIME ZONE] | Time within one day.<br>**p** indicates the precision after the decimal point. The value ranges from **0** to **6**.<br>Minimum value: 00:00:00.<br>Maximum value: 24:00:00. | 8 bytes |

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| Name | Description | Storage Space |
| --- | --- | --- |
| TIME [(p)] [WITH TIME ZONE] | Time within one day (with time zone).<br>**p** indicates the precision after the decimal point. The value ranges from **0** to **6**.<br>Minimum value: 00:00:00 + 1559. Maximum value: 24:00:00. | 12 bytes |
| TIMESTAMP[(p)] [WITHOUT TIME ZONE] | Date and time.<br>**p** indicates the precision after the decimal point. The value ranges from **0** to **6**.<br>Minimum: 4713 B.C., 4713-11-24 B.C. 00:00:00.000000. Maximum value: 294277 A.D., 294277-01-09 A.D. 00:00:00.000000. | 8 bytes |
| TIMESTAMP[(p)] [WITH TIME ZONE] | Date and time (with time zone). TIMESTAMP is also called TIMESTAMPTZ.<br>**p** indicates the precision after the decimal point. The value ranges from **0** to **6**.<br>Minimum: 00:00:00.000000, 4713-11-24 B.C. Maximum value: 00:00:00.000000, 294277-01-09 A.D. | 8 bytes |
| SMALLDATETIME | Date and time (without time zone).<br>The precision level is minute. 31s to 59s are rounded into 1 minute.<br>Minimum: 4713 B.C., 4713-11-24 B.C. 00:00:00.000000. Maximum value: 294277 A.D., 294277-01-09 A.D. 00:00:00.000000. | 8 bytes |
| INTERVAL DAY (l) TO SECOND (p) | Specifies the time interval (*X* days *X* hours *X* minutes *X* seconds).<br>• **l**: indicates the precision of days. The value ranges from 0 to 6. To adapt to Oracle syntax, the precision functions are not supported.<br>• **p**: indicates the precision of seconds. The value ranges from 0 to 6. The digit 0 at the end of a decimal number is not displayed. | 16 bytes |

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| Name | Description | Storage Space |
| --- | --- | --- |
| INTERVAL [FIELDS] [ (p) ] | Time interval.<br>• **FIELDS**: **YEAR**, **MONTH**, **DAY**, **HOUR**, **MINUTE**, **SECOND**, **DAY TO HOUR**, **DAY TO MINUTE**, **DAY TO SECOND**, **HOUR TO MINUTE**, **HOUR TO SECOND**, or **MINUTE TO SECOND**.<br>• **p**: indicates the precision of seconds. The value ranges from 0 to 6. **p** takes effect only when **FIELDS** is set to **SECOND**, **DAY TO SECOND**, **HOUR TO SECOND**, or **MINUTE TO SECOND**. The digit 0 at the end of a decimal number is not displayed. | 12 bytes |
| reltime | Relative time interval. The format is as follows:<br>*X* years *X* mons *X* days *XX:XX:XX*<br>• The Julian calendar is used. It specifies that a year has 365.25 days and a month has 30 days. The relative time interval needs to be calculated based on the input value. The output format is POSTGRES. | 4 bytes |
| abstime | Date and time. The format is as follows:<br>YYYY-MM-DD hh:mm:ss+timezone<br>The value range is from 1901-12-13 20:45:53 GMT to 2038-01-18 23:59:59 GMT. The precision is second. | 4 bytes |

**NOTE**

1. The data of the time type automatically ignores all zeros at the end of the data when it is displayed.

2. The default value of **p** is **6**.

3. For the INTERVAL type, the date and time are stored in the int32 and double types in the system. Therefore, the value ranges of the two types are the same as those of the corresponding data type.

4. If the insertion time is out of the range, the system may not report an error, but may not ensure that the operation is normal.

Example:

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```
-- Create a table.
openGauss=# CREATE TABLE date_type_tab(coll date);

-- Insert data.
openGauss=# INSERT INTO date_type_tab VALUES (date '12-10-2010');

-- View data.
openGauss=# SELECT * FROM date_type_tab;
    coll
------------
  2010-12-10
(1 row)

-- Drop the table.
openGauss=# DROP TABLE date_type_tab;

-- Create a table.
openGauss=# CREATE TABLE time_type_tab (da time without time zone ,dai time with time zone,dfgh
timestamp without time zone,dfga timestamp with time zone, vbg smalldatetime);

-- Insert data.
openGauss=# INSERT INTO time_type_tab VALUES ('21:21:21','21:21:21 pst','2010-12-12','2013-12-11
pst','2003-04-12 04:05:06');

-- View data.
openGauss=# SELECT * FROM time_type_tab;
    da    |     dai     |        dfgh         |          dfga          |         vbg
----------+-------------+---------------------+------------------------+---------------------
 21:21:21 | 21:21:21-08 | 2010-12-12 00:00:00 | 2013-12-11 16:00:00+08 | 2003-04-12 04:05:00
(1 row)

-- Drop the table.
openGauss=# DROP TABLE time_type_tab;

-- Create a table.
openGauss=# CREATE TABLE day_type_tab (a int,b INTERVAL DAY(3) TO SECOND (4));

-- Insert data.
openGauss=# INSERT INTO day_type_tab VALUES (1, INTERVAL '3' DAY);

-- View data.
openGauss=# SELECT * FROM day_type_tab;
 a |   b
---+--------
 1 | 3 days
(1 row)

-- Drop the table.
openGauss=# DROP TABLE day_type_tab;

-- Create a table.
openGauss=# CREATE TABLE year_type_tab(a int, b interval year (6));

-- Insert data.
openGauss=# INSERT INTO year_type_tab VALUES(1,interval '2' year);

-- View data.
openGauss=# SELECT * FROM year_type_tab;
 a |    b
---+---------
 1 | 2 years
(1 row)

-- Drop the table.
openGauss=# DROP TABLE year_type_tab;
```

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## Date Input

Date and time input is accepted in almost any reasonable formats, including ISO 8601, SQL-compatible, and traditional POSTGRES. The system allows you to customize the sequence of day, month, and year in the date input. Set the **DateStyle** parameter to **MDY** to select month-day-year interpretation, **DMY** to select day-month-year interpretation, or **YMD** to select year-month-day interpretation.

Remember that any date or time literal input needs to be enclosed with single quotation marks ('), and the syntax is as follows:

type [ ( p ) ] 'value'

The **p** that can be selected in the precision statement is an integer, indicating the number of fractional digits in the **seconds** column. Table 12-12 shows some possible inputs for the **date** type.

**Table 12-12** Date input

| Example | Description |
| --- | --- |
| 1999-01-08 | ISO 8601 (recommended format). January 8, 1999 in any mode |
| January 8, 1999 | Unambiguous in any **datestyle** input mode |
| 1/8/1999 | January 8 in **MDY** mode. August 1 in **DMY** mode |
| 1/18/1999 | January 18 in **MDY** mode, rejected in other modes |
| 01/02/03 | • January 2, 2003 in **MDY** mode<br>• February 1, 2003 in **DMY** mode<br>• February 3, 2001 in **YMD** mode |
| 1999-Jan-08 | January 8 in any mode |
| Jan-08-1999 | January 8 in any mode |
| 08-Jan-1999 | January 8 in any mode |
| 99-Jan-08 | January 8 in **YMD** mode, else error |
| 08-Jan-99 | January 8, except error in **YMD** mode |
| Jan-08-99 | January 8, except error in **YMD** mode |
| 19990108 | ISO 8601. January 8, 1999 in any mode |
| 990108 | ISO 8601. January 8, 1999 in any mode |
| 1999.008 | Year and day of year |
| J2451187 | Julian date |
| January 8, 99 BC | Year 99 BC |

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Example:

```
-- Create a table.
openGauss=# CREATE TABLE date_type_tab(coll date);

-- Insert data.
openGauss=# INSERT INTO date_type_tab VALUES (date '12-10-2010');

-- View data.
openGauss=# SELECT * FROM date_type_tab;
        coll
---------------------
 2010-12-10
(1 row)

-- View the date format.
openGauss=# SHOW datestyle;
 DateStyle
-----------
 ISO, MDY
(1 row)

-- Set the date format.
openGauss=# SET datestyle='YMD';
SET

-- Insert data.
openGauss=# INSERT INTO date_type_tab VALUES(date '2010-12-11');

-- View data.
openGauss=# SELECT * FROM date_type_tab;
        coll
---------------------
 2010-12-10
 2010-12-11
(2 rows)

-- Drop the table.
openGauss=# DROP TABLE date_type_tab;
```

## Time

The time-of-day types are **TIME [(p)] [WITHOUT TIME ZONE]** and **TIME [(p)] [WITH TIME ZONE]**. **TIME** alone is equivalent to **TIME WITHOUT TIME ZONE**.

If a time zone is specified in the input for **TIME WITHOUT TIME ZONE**, it is silently ignored.

For details about the time input types, see **Table 12-13**. For details about time zone input types, see **Table 12-14**.

**Table 12-13** Time input types

| Example | Description |
| --- | --- |
| 05:06.8 | ISO 8601 |
| 4:05:06 | ISO 8601 |
| 4:05 | ISO 8601 |
| 40506 | ISO 8601 |

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| Example | Description |
| --- | --- |
| 4:05 AM | Same as 04:05. AM does not affect value. |
| 4:05 PM | Same as 16:05. Input hours must be less than or equal to 12. |
| 04:05:06.789-8 | ISO 8601 |
| 04:05:06-08:00 | ISO 8601 |
| 04:05-08:00 | ISO 8601 |
| 040506-08 | ISO 8601 |
| 04:05:06 PST | Time zone specified by abbreviation |
| 2003-04-12 04:05:06 America/New_York | Time zone specified by full name |

**Table 12-14** Time zone input types

| Example | Description |
| --- | --- |
| PST | Abbreviation (for Pacific Standard Time) |
| America/New_York | Full time zone name |
| -8:00 | ISO-8601 offset for PST |
| -800 | ISO-8601 offset for PST |
| -8 | ISO-8601 offset for PST |

Example:

```
openGauss=# SELECT time '04:05:06';
   time
----------
 04:05:06
(1 row)

openGauss=# SELECT time '04:05:06 PST';
   time
----------
 04:05:06
(1 row)

openGauss=# SELECT time with time zone '04:05:06 PST';
   timetz
-------------
 04:05:06-08
(1 row)
```

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## Special Values

The special values supported by GaussDB are converted to common date/time values when being read. For details, see **Table 12-15**.

**Table 12-15** Special values

| Input String | Applicable Type | Description |
| --- | --- | --- |
| epoch | date and timestamp | 1970-01-01 00:00:00+00 (Unix system time zero) |
| infinity | timestamp | Later than any other timestamps |
| -infinity | timestamp | Earlier than any other timestamps |
| now | date, time, and timestamp | Start time of the current transaction |
| today | date and timestamp | Midnight today |
| tomorrow | date and timestamp | Midnight tomorrow |
| yesterday | date and timestamp | Midnight yesterday |
| allballs | time | 00:00:00.00 UTC |

## Interval Input

The input of **reltime** can be any valid interval in text format. It can be a number (negative numbers and decimals are also allowed) or a specific time, which must be in SQL standard format, ISO-8601 format, or POSTGRES format. In addition, the text input needs to be enclosed with single quotation marks ('').

For details, see **Table 6 Interval input types**.

**Table 12-16** Interval input types

| Input | Output | Description |
| --- | --- | --- |
| 60 | 2 mons | Numbers are used to indicate intervals. The default unit is day. Decimals and negative numbers are allowed. Particularly, a negative interval syntactically means how long before. |
| 31.25 | 1 mons 1 days 06:00:00 | |
| -365 | -12 mons -5 days | |

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| Input | Output | Description |
| --- | --- | --- |
| 1 years 1 mons 8 days 12:00:00 | 1 years 1 mons 8 days 12:00:00 | Intervals are in POSTGRES format. They can contain both positive and negative numbers and are case-insensitive. Output is a simplified POSTGRES interval converted from the input. |
| -13 months -10 hours | -1 years -25 days -04:00:00 | |
| -2 YEARS +5 MONTHS 10 DAYS | -1 years -6 mons -25 days -06:00:00 | |
| P-1.1Y10M | -3 mons -5 days -06:00:00 | Intervals are in ISO-8601 format. They can contain both positive and negative numbers and are case-insensitive. Output is a simplified POSTGRES interval converted from the input. |
| -12H | -12:00:00 | |

Example:

```
-- Create a table.
openGauss=# CREATE TABLE reltime_type_tab(col1 character(30), col2 reltime);

-- Insert data.
openGauss=# INSERT INTO reltime_type_tab VALUES ('90', '90');
openGauss=# INSERT INTO reltime_type_tab VALUES ('-366', '-366');
openGauss=# INSERT INTO reltime_type_tab VALUES ('1975.25', '1975.25');
openGauss=# INSERT INTO reltime_type_tab VALUES ('-2 YEARS +5 MONTHS 10 DAYS', '-2 YEARS +5
MONTHS 10 DAYS');
openGauss=# INSERT INTO reltime_type_tab VALUES ('30 DAYS 12:00:00', '30 DAYS 12:00:00');
openGauss=# INSERT INTO reltime_type_tab VALUES ('P-1.1Y10M', 'P-1.1Y10M');

-- View data.
openGauss=# SELECT * FROM reltime_type_tab;
              col1              |                col2
--------------------------------+-------------------------------------
 1975.25                        | 5 years 4 mons 29 days
 -2 YEARS +5 MONTHS 10 DAYS     | -1 years -6 mons -25 days -06:00:00
 P-1.1Y10M                      | -3 mons -5 days -06:00:00
 -366                           | -1 years -18:00:00
 90                             | 3 mons
 30 DAYS 12:00:00               | 1 mon 12:00:00
(6 rows)

-- Drop the table.
openGauss=# DROP TABLE reltime_type_tab;
```

## 12.3.7 Geometric Types

**Table 12-17** lists the geometric types that can be used in GaussDB. The most fundamental type, the point, forms the basis for all of the other types.

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**Table 12-17** Geometric types

| Name | Storage Space | Description | Representation |
| --- | --- | --- | --- |
| point | 16 bytes | Point on a plane | (x,y) |
| lseg | 32 bytes | Finite line segment | ((x1,y1),(x2,y2)) |
| box | 32 bytes | Rectangle | ((x1,y1),(x2,y2)) |
| path | 16 + 16*n* bytes | Closed path (similar to polygon) | ((x1,y1),...) |
| path | 16 + 16*n* bytes | Open path | [(x1,y1),...] |
| polygon | 40 + 16*n* bytes | Polygon (similar to closed paths) | ((x1,y1),...) |
| circle | 24 bytes | Circle | <(x,y),r> (center point and radius) |

A rich set of functions and operators is available in GaussDB to perform various geometric operations, such as scaling, translation, rotation, and determining intersections. For details, see **12.5.10 Geometric Functions and Operators**.

## Points

Points are the fundamental two-dimensional building block for geometric types. Values of the **point** type are specified using either of the following syntax:

```
( x , y )
x , y
```

**x** and **y** are the respective coordinates, as floating-point numbers. The value type of the points is float8.

Points are output using the first syntax.

Example:

```
openGauss=# select point(1.1, 2.2);
   point
-----------
 (1.1,2.2)
(1 row)
```

## Line Segments

Line segments (**lseg**) are represented by pairs of points. Values of the **lseg** type are specified using any of the following syntax:

```
[ ( x1 , y1 ) , ( x2 , y2 ) ]
( ( x1 , y1 ) , ( x2 , y2 ) )
( x1 , y1 ) , ( x2 , y2 )
x1 , y1   ,   x2 , y2
```

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**(x1,y1)** and **(x2,y2)** are the end points of the line segment. The value type of the points is float8.

Line segments are output using the first syntax.

Example:

```
openGauss=# select lseg(point(1.1, 2.2), point(3.3, 4.4));
        lseg
----------------------
 [(1.1,2.2),(3.3,4.4)]
(1 row)
```

## Rectangles

Rectangles are represented by pairs of points that are opposite corners of a rectangle. Values of the **box** type are specified using any of the following syntax:

```
( ( x1 , y1 ) , ( x2 , y2 ) )
( x1 , y1 ) , ( x2 , y2 )
x1 , y1   ,   x2 , y2
```

**(x1,y1)** and **(x2,y2)** are any two opposite corners of the rectangle. The value type of the points is float8.

Rectangles are output using the second syntax.

Any two opposite corners can be supplied on input, but in this order, the values will be reordered as needed to store the upper right and lower left corners.

Example:

```
openGauss=# select box(point(1.1, 2.2), point(3.3, 4.4));
         box
----------------------
 (3.3,4.4),(1.1,2.2)
(1 row)
```

## Paths

Paths are represented by lists of connected points. Paths can be open, where the first and last points in the list are considered not connected, or closed, where the first and last points are considered connected.

Values of the **path** type are specified using any of the following syntax:

```
[ ( x1 , y1 ) , ... , ( xn , yn ) ]
( ( x1 , y1 ) , ... , ( xn , yn ) )
( x1 , y1 ) , ... , ( xn , yn )
( x1 , y1   , ... ,   xn , yn )
x1 , y1   , ... ,   xn , yn
```

The points are the end points of the line segments comprising the path. The value type of the points is float8. Square brackets ([]) indicate an open path, while parentheses (()) indicate a closed path. When the outermost parentheses are omitted, as in the third through fifth syntax, a closed path is assumed.

Paths are output using the first or second syntax.

Example:

```
openGauss=# select path(polygon '((0,0),(1,1),(2,0))');
        path
---------------------
```

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```
 ((0,0),(1,1),(2,0))
(1 row)
```

## Polygons

Polygons are represented by lists of points (the vertexes of the polygon). Polygons are very similar to closed paths, but are stored differently and have their own set of support functions.

Values of the **polygon** type are specified using any of the following syntax:

```
( ( x1 , y1 ) , ... , ( xn , yn ) )
( x1 , y1 ) , ... , ( xn , yn )
( x1 , y1   , ... ,   xn , yn )
x1 , y1   , ... ,   xn , yn
```

The points are the end points of the line segments comprising the polygon. The value type of the points is float8.

Polygons are output using the first syntax.

Example:

```
openGauss=# select polygon(box '((0,0),(1,1))');
          polygon
----------------------------
 ((0,0),(0,1),(1,1),(1,0))
(1 row)
```

## Circles

Circles are represented by a center point and radius. Values of the **circle** type are specified using any of the following syntax:

```
< ( x , y ) , r >
( ( x , y ) , r )
( x , y ) , r
x , y   , r
```

**(x,y)** is the center point and **r** is the radius of the circle. The value type of the points is float8.

Circles are output using the first syntax.

Example:

```
openGauss=# select circle(point(0,0),1);
  circle
----------
 <(0,0),1>
(1 row)
```

# 12.3.8 Network Address Types

GaussDB offers data types to store IPv4 and MAC addresses.

It is better to use these types instead of plain text types to store network addresses, because these types offer input error checking and specialized operators and functions (see **12.5.11 Network Address Functions and Operators**).

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**Table 12-18** Network address types

| Name | Storage Space | Description |
| --- | --- | --- |
| cidr | 7 bytes | IPv4 networks |
| inet | 7 bytes | IPv4 hosts and networks |
| macaddr | 6 bytes | MAC address |

## cidr

The **cidr** type (Classless Inter-Domain Routing) holds an IPv4 network address. The format for specifying networks is **address/y** where **address** is the network represented as an IPv4 address, and **y** is the number of bits in the netmask. If **y** is omitted, it is calculated using assumptions from the older classful network numbering system, except it will be at least large enough to include all of the octets written in the input.

**Table 12-19** cidr type input examples

| cidr Input | cidr Output | abbrev(cidr) |
| --- | --- | --- |
| 192.168.100.128/25 | 192.168.100.128/25 | 192.168.100.128/25 |
| 192.168/24 | 192.168.0.0/24 | 192.168.0/24 |
| 192.168/25 | 192.168.0.0/25 | 192.168.0.0/25 |
| 192.168.1 | 192.168.1.0/24 | 192.168.1/24 |
| 192.168 | 192.168.0.0/24 | 192.168.0/24 |
| 10.1.2 | 10.1.2.0/24 | 10.1.2/24 |
| 10.1 | 10.1.0.0/16 | 10.1/16 |
| 10 | 10.0.0.0/8 | 10/8 |
| 10.1.2.3/32 | 10.1.2.3/32 | 10.1.2.3/32 |

## inet

The **inet** type holds an IPv4 host address, and optionally its subnet, all in one field. The subnet is represented by the number of network address bits present in the host address (the "netmask"). If the netmask is 32 and the address is an IPv4 address, then the value does not indicate a subnet, only a single host.

The input format for this type is **address/y** where **address** is an IPv4 address and **y** is the number of bits in the netmask. If the **/y** portion is omitted, the netmask is 32 for an IPv4 address, and the value represents just a single host. On display, the **/y** portion is suppressed if the netmask specifies a single host.

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The essential difference between the **inet** and **cidr** data types is that **inet** accepts values with nonzero bits to the right of the netmask, whereas **cidr** does not.

### macaddr

The **macaddr** type stores MAC addresses, known for example from Ethernet card hardware addresses (although MAC addresses are used for other purposes as well). Input is accepted in the following formats:

```
'08:00:2b:01:02:03'
'08-00-2b-01-02-03'
'08002b:010203'
'08002b-010203'
'0800.2b01.0203'
'08002b010203'
```

These examples would all specify the same address. Upper and lower cases are accepted for the digits a through f. Output is always in the first of the forms shown.

## 12.3.9 Bit String Types

Bit strings are strings of 1's and 0's. They can be used to store bit masks.

GaussDB supports two bit string types: bit(n) and bit varying(n). Here, *n* is a positive integer. The maximum value of *n* is **83886080**, which is equivalent to 10 MB.

The **bit** type data must match the length *n* exactly. It is an error to attempt to store shorter or longer bit strings. The **bit varying** data is of variable length up to the maximum length *n*; longer strings will be rejected. Writing **bit** without a length is equivalent to **bit(1)**, while **bit varying** without a length limit means unlimited length.

**NOTE**

If one explicitly casts a bit-string value to **bit(n)**, it will be truncated or zero-padded on the right to be exactly *n* bits, without raising an error.

Similarly, if one explicitly casts a bit-string value to **bit varying(n)**, it will be truncated on the right if it is more than *n* bits.

When the ADMS platform driver 8.1.3-200 or earlier is used, use **::bit varying** to convert the bit type. Otherwise, an error may occur.

```
-- Create a table.
openGauss=# CREATE TABLE bit_type_t1
(
    BT_COL1 INTEGER,
    BT_COL2 BIT(3),
    BT_COL3 BIT VARYING(5)
) DISTRIBUTE BY REPLICATION;

-- Insert data.
openGauss=# INSERT INTO bit_type_t1 VALUES(1, B'101', B'00');

-- Specify the type length. An error is reported if an inserted string exceeds this length.
openGauss=# INSERT INTO bit_type_t1 VALUES(2, B'10', B'101');
ERROR:  bit string length 2 does not match type bit(3)
CONTEXT:  referenced column: bt_col2

-- Specify the type length. Data is converted if it exceeds this length.
openGauss=# INSERT INTO bit_type_t1 VALUES(2, B'10'::bit(3), B'101');
```

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```
-- View data.
openGauss=# SELECT * FROM bit_type_t1;
 bt_col1 | bt_col2 | bt_col3
---------+---------+---------
       1 | 101     | 00
       2 | 100     | 101
(2 rows)

-- Delete the table.
openGauss=# DROP TABLE bit_type_t1;
```

# 12.3.10 Text Search Types

GaussDB offers two data types that are designed to support full text search. The **tsvector** type represents a document in a form optimized for text search. The **tsquery** type similarly represents a text query.

## tsvector

The **tsvector** type represents a retrieval unit, usually a textual column within a row of a database table, or a combination of such columns. A **tsvector** value is a sorted list of distinct lexemes, which are words that have been normalized to merge different variants of the same word. Sorting and deduplication are done automatically during input. The maximum length is 2046 bytes. The **to_tsvector** function is used to parse and normalize a document string.

A **tsvector** value is a sorted list of distinct lexemes, which are words that have been formatted different entries. During segmentation, **tsvector** automatically performs duplicate-elimination to the entries for input in a certain order. Example:

```
openGauss=# SELECT 'a fat cat sat on a mat and ate a fat rat'::tsvector;
                    tsvector
-----------------------------------------------------
 'a' 'and' 'ate' 'cat' 'fat' 'mat' 'on' 'rat' 'sat'
(1 row)
```

It can be seen from the preceding example that **tsvector** segments a string by spaces, and segmented lexemes are sorted based on their length and alphabetical order. To represent lexemes containing whitespace or punctuation, surround them with quotation marks:

```
openGauss=# SELECT $$the lexeme '    ' contains spaces$$::tsvector;
                tsvector
-------------------------------------------
 '    ' 'contains' 'lexeme' 'spaces' 'the'
(1 row)
```

Use double dollar signs ($$) to mark entries containing single quotation marks ('').

```
openGauss=# SELECT $$the lexeme 'Joe''s' contains a quote$$::tsvector;
                   tsvector
-------------------------------------------------
 'Joe''s' 'a' 'contains' 'lexeme' 'quote' 'the'
(1 row)
```

Optionally, integer positions can be attached to lexemes:

```
openGauss=# SELECT 'a:1 fat:2 cat:3 sat:4 on:5 a:6 mat:7 and:8 ate:9 a:10 fat:11 rat:12'::tsvector;
                                tsvector
-------------------------------------------------------------------------------
 'a':1,6,10 'and':8 'ate':9 'cat':3 'fat':2,11 'mat':7 'on':5 'rat':12 'sat':4
(1 row)
```

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A position normally indicates the source word's location in the document. Positional information can be used for proximity ranking. Position values range from 1 to 255. The default maximum value is **255**. Duplicate positions for the same lexeme are discarded.

Lexemes that have positions can further be labeled with a weight, which can be **A**, **B**, **C**, or **D**. **D** is the default and hence is not shown on output:

```
openGauss=# SELECT 'a:1A fat:2B,4C cat:5D'::tsvector;
          tsvector
-----------------------------
 'a':1A 'cat':5 'fat':2B,4C
(1 row)
```

Weights are typically used to reflect document structure, for example, by marking title words differently from body words. Text search ranking functions can assign different priorities to the different weight markers.

The following example is the standard usage of the **tsvector** type. Example:

```
openGauss=# SELECT 'The Fat Rats'::tsvector;
      tsvector
--------------------
 'Fat' 'Rats' 'The'
(1 row)
```

For most English-text-searching applications the above words would be considered non-normalized, which should usually be passed through **to_tsvector** to normalize the words appropriately for searching:

```
openGauss=# SELECT to_tsvector('english', 'The Fat Rats');
   to_tsvector
-----------------
 'fat':2 'rat':3
(1 row)
```

## tsquery

The **tsquery** type represents a retrieval condition. A **tsquery** value stores lexemes that are to be searched for, and combines them honoring the **Boolean** operators **& (AND)**, **| (OR)**, and **! (NOT)**. Parentheses can be used to enforce grouping of the operators. The **to_tsquery** and **plainto_tsquery** functions will normalize lexemes before the lexemes are converted to the **tsquery** type. The maximum length supported by the **tsquery** type is not limited.

```
openGauss=# SELECT 'fat & rat'::tsquery;
    tsquery
----------------
 'fat' & 'rat'
(1 row)

openGauss=# SELECT 'fat & (rat | cat)'::tsquery;
          tsquery
-----------------------------
 'fat' & ( 'rat' | 'cat' )
(1 row)

openGauss=# SELECT 'fat & rat & ! cat'::tsquery;
        tsquery
------------------------
 'fat' & 'rat' & !'cat'
(1 row)
```

In the absence of parentheses, **! (NOT)** binds most tightly, and **& (AND)** binds more tightly than **| (OR)**.

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Lexemes in a **tsquery** can be labeled with one or more weight letters, which restrict them to match only **tsvector** lexemes with matching weights:

```
openGauss=# SELECT 'fat:ab & cat'::tsquery;
     tsquery
------------------
 'fat':AB & 'cat'
(1 row)
```

Also, lexemes in a **tsquery** can be labeled with * to specify prefix matching:

```
openGauss=# SELECT 'super:*'::tsquery;
  tsquery
-----------
 'super':*
(1 row)
```

This query will match any word in a **tsvector** that begins with "super".

Note that prefixes are first processed by text search configurations, which means the following example returns true:

```
openGauss=# SELECT to_tsvector( 'postgraduate' ) @@ to_tsquery( 'postgres:*' ) AS RESULT;
  result
----------
 t
(1 row)
```

This is because **postgres** gets stemmed to **postgr**:

```
openGauss=# SELECT to_tsquery('postgres:*');
 to_tsquery
------------
 'postgr':*
(1 row)
```

It then matches **postgraduate**.

**'Fat:ab & Cats'** is normalized to the **tsquery** type as follows:

```
openGauss=# SELECT to_tsquery('Fat:ab & Cats');
    to_tsquery
------------------
 'fat':AB & 'cat'
(1 row)
```

# 12.3.11 UUID Type

The data type **UUID** stores Universally Unique Identifiers (UUID) as defined by RFC 4122, ISO/IEF 9834-8:2005, and related standards. This identifier is a 128-bit quantity that is generated by an algorithm chosen to make it very unlikely that the same identifier will be generated by anyone else in the known universe using the same algorithm.

Therefore, for distributed systems, these identifiers provide a better uniqueness guarantee than sequence generators, which are only unique within a single database.

A UUID is written as a sequence of lower-case hexadecimal digits, in several groups separated by hyphens, specifically a group of 8 digits followed by three groups of 4 digits followed by a group of 12 digits, for a total of 32 digits representing the 128 bits. An example of a UUID in this standard form is:

```
a0eebc99-9c0b-4ef8-bb6d-6bb9bd380a11
```

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GaussDB also accepts the following alternative forms for input: use of upper-case letters and digits, the standard format surrounded by braces, omitting some or all hyphens, adding a hyphen after any group of four digits. An example is provided as follows:

```
A0EEBC99-9C0B-4EF8-BB6D-6BB9BD380A11
{a0eebc99-9c0b-4ef8-bb6d-6bb9bd380a11}
a0eebc999c0b4ef8bb6d6bb9bd380a11
a0ee-bc99-9c0b-4ef8-bb6d-6bb9-bd38-0a11
```

Output is always in the standard form.

# 12.3.12 JSON/JSONB Types

JavaScript Object Notation (JSON) data can be a single scalar, an array, or a key-value pair object. The array and object can be called a container:

- Scalar: a number, Boolean, string, or null
- Array: defined in a pair of square brackets ([]), in which elements can be any type of JSON data, and are not necessarily of the same type.
- Object: defined in a pair of braces ({}), in which objects are stored in the format of key:value. Each key must be a string enclosed by a pair of double quotation marks (""), and its value can be any type of JSON data. In case of duplicate keys, the last key-value pair will be used.

GaussDB offers two types for storing JSON data: JSON and JSONB. The JSON data type stores a complete copy of the input, retaining the entered spaces, duplicate keys, and sequence, while the JSONB data type stores data in a decomposed binary form, removing semantic-irrelevant details and duplicate keys, and sorting key-values. Therefore, the JSONB data does not need to be parsed.

It can be found that both are of JSON type, and the same strings can be entered as input. The main difference between them is the efficiency. Because JSON data type stores an exact copy of the input text, the data must be parsed on every execution. In contrast, JSONB data is stored in a decomposed binary form and can be processed faster, though this makes it slightly slower to input due to the conversion mechanism. In addition, because the JSONB data type is normalized, it supports more operations, for example, comparing sizes according to a specific rule. JSONB also supports indexing, which is a significant advantage.

## Input Format

An input must be a JSON-compliant string, which is enclosed in single quotation marks ('').

null (null-json): The value can only be **null** in lowercase.

```
select 'null'::json;   -- suc
select 'NULL'::jsonb;  -- err
```

Number (num-json): The value can be a positive or negative integer, decimal fraction, or 0. The scientific notation is supported.

```
select '1'::json;select '-1.5'::json;select '-1.5e-5'::jsonb, '-1.5e+2'::jsonb;select '001'::json, '+15'::json, 'NaN'::json;
-- Redundant leading zeros, plus signs (+), NaN, and infinity are not supported.
```

Boolean (bool-json): The value can only be **true** or **false** in lowercase.

```
select 'true'::json;select 'false'::jsonb;
```

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String (str-json): The value must be a string enclosed in double quotation marks ("").

```
select '"a"'::json;select '"abc"'::jsonb;
```

Array (array-json): Arrays are enclosed in square brackets ([]). Elements in the array can be any valid JSON data, and are unnecessarily of the same type.

```
select '[1, 2, "foo", null]'::json;select '[]'::json;select '[1, 2, "foo", null, [[]], {}]'::jsonb;
```

Object (object-json): The value is enclosed in braces ({}). The key must be a JSON-compliant string, and the value can be any valid JSON string.

```
select '{}'::json;select '{"a": 1, "b": {"a": 2,  "b": null}}'::json;select '{"foo": [true, "bar"], "tags": {"a": 1, "b": null}}'::jsonb;
```

**CAUTION**

- Note that **'null'::json** and **null::json** are different, which are similar to the strings **str=""** and **str=null**.
- For numbers, when scientific notation is used, JSONB expands them, while JSON stores an exact copy of the input text.

## JSONB Advanced Features

- Precautions
  - Row-store tables are not supported.
  - It cannot be used as a partition key.
  - Foreign tables and MOTs are not supported.

The main difference between JSON and JSONB lies in the storage mode. JSONB stores parsed binary data, which reflects the JSON hierarchy and facilitates direct access. Therefore, JSONB has many advanced features that JSON does not have.

- Format normalization
  - After the input object-json string is parsed into JSONB binary, semantically irrelevant details are naturally discarded, for example, spaces:

    ```
    openGauss=# select '   [1, " a ", {"a"   :1    }]  '::jsonb;
          jsonb
    ----------------------
     [1, " a ", {"a": 1}]
    (1 row)
    ```

  - For object-json, duplicate key-values are deleted and only the last key-value is retained. For example:

    ```
    openGauss=# select '{"a" : 1, "a" : 2}'::jsonb;
      jsonb
    ----------
     {"a": 2}
    (1 row)
    ```

  - For object-json, key-values will be re-sorted. The sorting rule is as follows: 1. Longer key-values are sorted last. 2. If the key-values are of the same length, the key-values with a larger ASCII code are sorted after the key-values with a smaller ASCII code:

    ```
    openGauss=# select '{"aa" : 1, "b" : 2, "a" : 3}'::jsonb;
              jsonb
    ```

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```
----------------------------
{"a": 3, "b": 2, "aa": 1}
(1 row)
```

- Size comparison

  Format normalization ensures that only one form of JSONB data exists in the same semantics. Therefore, sizes may be compared according to a specific rule.

  - First, type comparison: **object-jsonb** > **array-jsonb** > **bool-jsonb** > **num-jsonb** > **str-jsonb** > **null-jsonb**
  - Content comparison if the data type is the same:
    - **str-json**: The default text sorting rule of the database is used for comparison. A positive value indicates greater than, a negative value indicates less than, and **0** indicates equal.
    - **num-json**: numeric comparison
    - **bool-json**: **true** > **false**
    - **array-jsonb**: long elements > short elements. If the lengths are the same, compare each element in sequence.
    - **object-jsonb**: If the length of a key-value pair is longer than that of a short key-value pair, the key is compared first, and then the value is compared.

  **CAUTION**

  For comparison within the **object-jsonb** type, the final result after format sorting is used for comparison. Therefore, the comparison result may not be intuitive compared with the direct input.

- Creating indexes, primary keys, and foreign keys
  - B-tree index

    B-tree indexes, primary keys, and foreign keys can be created for the **JSONB** type.
  - GIN index

    GIN indexes can be used to effectively search for keys or key-value pairs that appear in a large number of JSONB documents (datums). Two GIN operator classes (**jsonb_ops** and **jsonb_hash_ops**) are provided for different performance and flexibility choices. The default GIN operator class supports **@>**, **<@**, **?**, **?&** and **?|** operator query. The non-default GIN operator class **jsonb_path_ops** supports only the **@>** and **<@** operators.

    For details about the operators, see **12.5.13 JSON/JSONB Functions and Operators**.
- Inclusion and existence

  Querying whether a JSON contains some elements or whether some elements exist in a JSON is an important capability of JSONB.

  ```
  -- A simple scalar/original value contains only the same value: SELECT '"foo"'::jsonb @> '"foo"'::jsonb; -- The array on the left contains the string on the right. SELECT' [ 1, "aa", 3 ] '::jsonb?
  ```

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**'aa';** -- The array on the left contains all elements in the array on the right. The sequence and repetition are not specified. **SELECT '[1, 2, 3]'::jsonb @> '[1, 3, 1]'::jsonb;** -- The **object-json** on the left contains all key-values of the **object-json** on the right. **SELECT '{"product": "PostgreSQL", "version": 9.4, "jsonb":true}'::jsonb @> '{"version":9.4}'::jsonb;** -- The array on the left does not contain all elements of the array on the right, because the three elements of the array on the left are **1**, **2**, and **[1,3]**, and the elements on the right are **1** and **3**. **SELECT'[1, 2, [1, 3] ]. '::jsonb @>' [1, 3] '::jsonb;** -- Produces a **false**. **SELECT '{"foo": {"bar": "baz"}}'::jsonb @> '{"bar": "baz"}'::jsonb;** -- Similarly, **false** is produced.

For details about the operators, see **12.5.13 JSON/JSONB Functions and Operators**.

- Functions and operators

  For details about the functions and operators supported by the JSON/JSONB type, see **12.5.13 JSON/JSONB Functions and Operators**.

## 12.3.13 HLL

HyperLoglog (HLL) is an approximation algorithm for efficiently counting the number of distinct values in a dataset. It features faster computing and lower space usage. You only need to store HLL data structures, instead of data sets. When new data is added to a dataset, make hash calculation on the data and insert the result to an HLL. Then, you can obtain the final result based on the HLL.

**Table 12-20** compares HLL with other algorithms.

**Table 12-20** Comparison between HLL and other algorithms

| Item | Sorting Algorithm | Hash Algorithm | HLL |
| --- | --- | --- | --- |
| Time complexity | O(nlogn) | O(n) | O(n) |
| Space complexity | O(n) | O(n) | log(logn) |
| Error rate | 0 | 0 | ≈0.8% |
| Storage space requirement | Size of original data | Size of original data | The maximum size is 16 KB by default. |

HLL has advantages over others in the computing speed and storage space requirement. In terms of time complexity, the sorting algorithm needs O(nlogn) time for sorting, and the hash algorithm and HLL need O(n) time for full table scanning. In terms of storage space, the sorting algorithm and hash algorithm need to store raw data before collecting statistics, whereas the HLL algorithm needs to store only the HLL data structures rather than the raw data, and thereby occupies a fixed space of about 16 KB.

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**NOTICE**

- In the current default specifications, the maximum number of distinct values that can be calculated is about 1.1e + 15, and the error rate is 0.8%. If the calculation result exceeds the maximum, the error rate of the calculation result will increase, or the calculation will fail and an error will be reported.
- When using this feature for the first time, you need to evaluate the distinct values of the service, properly select configuration parameters, and perform verification to ensure that the accuracy meets requirements.
  - By default, the distinct value is 1.1e + 15. If the distinct value is NaN, you need to adjust log2m or use another algorithm to calculate the distinct value.
  - The hash algorithm has an extremely low probability of collision. However, you are still advised to select 2 or 3 hash seeds for verification when using the hash algorithm for the first time. If there is only a small difference between the distinct values, you can select any one of the seeds as the hash seed.

**Table 12-21** describes main HLL data structures.

**Table 12-21** Main HLL data structures

| Data Type | Description |
| --- | --- |
| hll | The HLL header is a 27-byte field. By default, the data length ranges from 0 KB to 16 KB. The distinct value can be obtained. |

When you create an HLL data type, 0 to 4 input parameters are supported. The parameter meanings and specifications are the same as those of the **hll_empty** function. The first parameter is **log2m**, indicating the logarithm of the number of buckets, and its value ranges from 10 to 16. The second parameter is **log2explicit**, indicating the threshold in explicit mode, and its value ranges from 0 to 12. The third parameter is **log2sparse**, indicating the threshold of the Sparse mode, and its value ranges from 0 to 14. The fourth parameter is **duplicatecheck**, indicating whether to enable duplicatecheck, and its value ranges from 0 to 1. When the input parameter is set to **–1**, the default value of the HLL parameter is used. You can run the **\d** or **\d+** command to view the parameters of the HLL type.

**NOTE**

When the HLL data type is created, the result varies depending on the input parameter behavior:

- When creating an HLL type, do not set the input parameter or set it to **–1**. Use the default value of the corresponding HLL parameter.
- If a valid value is set for the input parameter, the corresponding HLL parameter uses the input value.
- If the input value is invalid, an error is reported when the HLL type is created.

```
-- Create an HLL table without specifying input parameters.
openGauss=# create table t1 (id integer, set hll);
```

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```
openGauss=# \d t1
      Table "public.t1"
 Column |  Type   | Modifiers
--------+---------+-----------
 id     | integer |
 set    | hll     |

-- Create an HLL table, specify the first two input parameters, and use the default values for the last two
input parameters.
openGauss=# create table t2 (id integer, set hll(12,4));
openGauss=# \d t2
          Table "public.t2"
 Column |      Type      | Modifiers
--------+----------------+-----------
 id     | integer        |
 set    | hll(12,4,12,0) |

-- Create an HLL table, specify the third input parameter, and use default values for other parameters.
openGauss=# create table t3(id int, set hll(-1,-1,8,-1));
openGauss=# \d t3
          Table "public.t3"
 Column |      Type      | Modifiers
--------+----------------+-----------
 id     | integer        |
 set    | hll(14,10,8,0) |

-- When a user creates an HLL table and specifies an invalid input parameter, an error is reported.
openGauss=# create table t4(id int, set hll(5,-1));
ERROR:  log2m = 5 is out of range, it should be in range 10 to 16, or set -1 as default
```

**NOTE**

When inserting an HLL object to an HLL table, ensure that the parameters of the HLL type are the same as those of the inserted object. Otherwise, an error is reported.

```
-- Create an HLL table:
openGauss=# create table t1(id integer, set hll(14));

-- Insert an HLL object to a table. The insertion succeeds because parameter types are consistent.
openGauss=# insert into t1 values (1, hll_empty(14,-1));

-- Insert an HLL object to a table. The insertion fails because parameter types are inconsistent.
openGauss=# insert into t1(id, set) values (1, hll_empty(14,5));
ERROR:  log2explicit does not match: source is 5 and dest is 10
```

The following describes HLL application scenarios.

- Scenario 1: "Hello World"

  The following example shows how to use the HLL data type:

  ```
  -- Create a table with the HLL type:
  openGauss=# create table helloworld (id integer, set hll);

  -- Insert an empty HLL to the table:
  openGauss=# insert into helloworld(id, set) values (1, hll_empty());

  -- Add a hashed integer to the HLL:
  openGauss=# update helloworld set set = hll_add(set, hll_hash_integer(12345)) where id = 1;

  -- Add a hashed string to the HLL:
  openGauss=# update helloworld set set = hll_add(set, hll_hash_text('hello world')) where id = 1;

  -- Obtain the number of distinct values of the HLL:
  openGauss=# select hll_cardinality(set) from helloworld where id = 1;
   hll_cardinality
  -----------------
                 2
  (1 row)
  ```

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```
-- Delete the table.
openGauss=# drop table helloworld;
```

- Scenario 2: Collect statistics about website visitors.

  The following example shows how an HLL collects statistics on the number of users visiting a website within a period of time:

```
-- Create a raw data table to show that a user has visited the website at a certain time:
openGauss=# create table facts (
        date            date,
        user_id         integer
);

 -- Create a raw data table to show that a user has visited the website at a certain time:
openGauss=# insert into facts values ('2019-02-20', generate_series(1,100));
openGauss=# insert into facts values ('2019-02-21', generate_series(1,200));
openGauss=# insert into facts values ('2019-02-22', generate_series(1,300));
openGauss=# insert into facts values ('2019-02-23', generate_series(1,400));
openGauss=# insert into facts values ('2019-02-24', generate_series(1,500));
openGauss=# insert into facts values ('2019-02-25', generate_series(1,600));
openGauss=# insert into facts values ('2019-02-26', generate_series(1,700));
openGauss=# insert into facts values ('2019-02-27', generate_series(1,800));

-- Create another table and specify an HLL column:
openGauss=# create table daily_uniques (
    date            date UNIQUE,
    users           hll
);

-- Group data by date and insert the data into the HLL:
openGauss=# insert into daily_uniques(date, users)
    select date, hll_add_agg(hll_hash_integer(user_id))
    from facts
    group by 1;

-- Calculate the numbers of users visiting the website every day:
openGauss=# select date, hll_cardinality(users) from daily_uniques order by date;
    date    | hll_cardinality
------------+------------------
 2019-02-20 |              100
 2019-02-21 | 200.217913059312
 2019-02-22 |  301.76494508014
 2019-02-23 | 400.862858326446
 2019-02-24 | 502.626933349694
 2019-02-25 | 601.922606454213
 2019-02-26 | 696.602316769498
 2019-02-27 | 798.111731634412
(8 rows)

-- Calculate the number of users who had visited the website in the week from February 20, 2019 to
February 26, 2019:
openGauss=# select hll_cardinality(hll_union_agg(users)) from daily_uniques where date >=
'2019-02-20'::date and date <= '2019-02-26'::date;
 hll_cardinality
------------------
 696.602316769498
(1 row)

-- Calculate the number of users who had visited the website yesterday but have not visited the
website today:
openGauss=# SELECT date, (#hll_union_agg(users) OVER two_days) - #users AS lost_uniques FROM
daily_uniques WINDOW two_days AS (ORDER BY date ASC ROWS 1
PRECEDING);
    date    | lost_uniques
------------+--------------
 2019-02-20 |            0
 2019-02-21 |            0
 2019-02-22 |            0
 2019-02-23 |            0
 2019-02-24 |            0
```

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```
 2019-02-25 |          0
 2019-02-26 |          0
 2019-02-27 |          0
(8 rows)

-- Delete the table.
openGauss=# drop table facts;
openGauss=# drop table daily_uniques;
```

- Scenario 3: The data to be inserted does not meet the requirements of the HLL data structure.

  When inserting data into a column of the HLL type, ensure that the data meets the requirements of the HLL data structure. If the data does not meet the requirements after being parsed, an error will be reported. In the following example, **E\\1234** to be inserted does not meet the requirements of the HLL data structure after being parsed. As a result, an error is reported.

```
openGauss=# create table test(id integer, set hll);
openGauss=# insert into test values(1, 'E\\1234');
ERROR:  not a hll type, size=6 is not enough
openGauss=# drop table test;
```

# 12.3.14 Range

A range type is a data type that represents the range of a value of an element type (called the *subtype* of a range). For example, the range of timestamp may be used to express a time range in which a conference room is reserved. In this case, the data type is tsrange (short for timestamp range), and timestamp is the subtype. The subtype must have an overall order so that the element value can be clearly specified within a range, before, or after.

Range types are useful because they can express multiple element values in a single range value and can clearly express concepts such as range overlapping. The time and date range used for scheduling is the best example, as the range of an instrument are also examples of range type.

## Built-in Range

The following built-in ranges are available:

- int4range: integer range.
- int8range: bigint range.
- numrange: numeric range.
- tsrange: range of timestamp without the time zone.
- tstzrange: range of timestamp with the time zone
- daterange: date range.

In addition, you can define your own range types. For details, see **12.14.87 CREATE TYPE**.

## Example

```
CREATE TABLE reservation (room int, during tsrange);
INSERT INTO reservation VALUES (1108, '[2010-01-01 14:30, 2010-01-01 15:30)');
-- Inclusion
SELECT int4range(10, 20) @> 3;
-- Determine whether the two ranges overlap.
SELECT numrange(11.1, 22.2) && numrange(20.0, 30.0);
-- Upper bound extraction
```

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```
SELECT upper(int8range(15, 25));
-- Intersection set
SELECT int4range(10, 20) * int4range(15, 25);
-- Determine whether the range is empty.
SELECT isempty(numrange(1, 5));
```

See the complete list of operators and functions on a range type in **12.5.17 Range Functions and Operators**.

## Including and Excluding Bounds

Each non-empty range has two bounds, a lower bound and an upper bound. All values between the two bounds are included in the range. An inclusion bound means that the bound value itself is included in the range, while an exclusion bound means that the bound value is not included in the range.

In a textual form of a range, an inclusion lower bound is expressed as "[" and an exclusion lower bound is expressed as "(". Similarly, one including the upper bound is expressed as "]" and one excluding the upper bound is expressed as ")" (for details, see **Range Input/Output**).

The lower_inc and upper_inc functions test the upper and lower bounds of a range value, respectively.

## Infinite (Unbounded) Range

When the lower bound of a range is unbounded, it means that all values less than the upper bound are included in the range, for example, (,3] meaning all values less than the upper bound 3 are included in the range. Similarly, when the upper bound of a range is unbounded, all values greater than the upper bound are included in the range. When both the upper and lower bounds are unbounded, all values of the element type are considered within the range. The missing bounds are automatically converted to exclusions, for example, [,] is converted to (,). You can think of these missing values as positive infinity or negative infinity, but they are special range type values and are considered to be positive and negative infinity values that go beyond any range element type.

Element types with the infinity values can be used as explicit bound values. For example, in the timestamp range, [today, infinity) does not include a special timestamp value infinity.

The lower_inf and upper_inf functions test the infinite upper and lower bounds of a range, respectively.

## Range Input/Output

The input of a range value must follow one of the following formats:

```
(lower-bound, upper-bound)
(lower-bound, upper-bound]
[lower-bound, upper-bound)
[lower-bound, upper-bound]
Empty
```

Parentheses () or square brackets [] indicate whether the upper and lower bounds are excluded or included. Note that the last format is empty, which represents an empty range (a range that does not contain values).

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The value of *lower-bound* can be a valid input string of the subtype or null, indicating that there is no lower bound. Similarly, *upper-bound* can be a valid input string of the subtype or null, indicating that there is no upper bound.

Each bound value can be referenced using the quotation marks("") character. This is necessary if the bounds value contains parentheses (), square brackets [], commas (,), quotation marks (""), or backslashes (\), because otherwise those characters will be considered part of the range syntax. To put the quotation mark or backslash in a referenced bound value, put a backslash in front of it (and a pair of double quotation marks in its quoted bound value represents one quotation mark character, which is similar to the single quotation mark rule in SQL character strings). In addition, you can avoid referencing and use backslash escapes to protect all data characters, otherwise they will be used as part of the return syntax. Also, if you want to write a bound value that is an empty string, write **""**, indicating infinite bounds.

Spaces are allowed before and after a range value, but any space between parentheses() or square brackets[] is used as part of the upper or lower bound value (depending on the element type, the space may or may not represent a value).

Example:

```
-- 3 is included, 7 is not included, and all values between 3 and 7 are included.
SELECT '[3,7)'::int4range;
-- Neither 3 nor 7 is included, but all values between them are included.
SELECT '(3,7)'::int4range;
-- Only value 4 is included.
SELECT '[4,4]'::int4range;
-- Exclude any value (and will be normalized to empty).
SELECT '[4,4)'::int4range;
```

## Constructing Range

Each range type has a constructor function with the same name. Using constructor functions is often more convenient than writing a range literal constant because it avoids extra references to bound values. Constructor functions accept two or three parameters. Two parameters form a range in the standard form, where the lower bound is included and the upper bound is excluded, and three parameters form a range according to the bound specified by the third parameter. The third parameter must be one of the following character strings: (), (], [), or []. For example:

```
-- The complete format is: lower bound, upper bound, and textual parameters indicating the inclusion/
exclusion of bounds.
SELECT numrange(1.0, 14.0, '(]');
-- If the third parameter is ignored, it is assumed to be '[)'.
SELECT numrange(1.0, 14.0);
-- Although '(]' is specified here, the value will be converted to the standard format when displayed,
because int8range is a discrete range type (see below).
SELECT int8range(1, 14, '(]');
-- Using NULL for a bound causes the range to be unbounded on that side.
SELECT numrange(NULL, 2.2);
```

## Discrete Range

A range element type has a well-defined "step" such as integer or date. In these types, if there is no valid value between two elements, they can be said to be adjacent. This is in contrast to a continuous range in which other element values

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can always be identified between two given values. For example, the numeric type range is continuous, and the timestamp range is also continuous. (Although timestamp has limited precision and can be considered as discrete in theory, it is better to consider it as continuous because the step is not normally considered.)

Another way to consider discrete range types is to have a clear "next" or "previous" value for each element value. With this idea in mind, you can switch between inclusion and exclusion expressions of a range bound by replacing it with the original given next or previous element value. For example, in an integer range type, [4,8] and (3,9) represent the same set of values, but not for numeric ranges.

A discrete range type should have a *regularization* function that knows the expected step size of the element type. The regularization function can convert the equivalents of the range type to the same expression, in particular consistent with the inclusion or exclusion bounds. If you do not specify a regularization function, ranges with different formats will always be considered as unequal, even if they actually express the same set of values.

The built-in range types int4range, int8range, and daterange use a regularized form that includes the lower bound and excludes the upper bound, that is, [). However, user-defined range types can use other conventions.

### Index

GiST and SP-GiST indexes can be created for table columns of the range type. For example, to create a GiST index, run the following command:

```
CREATE INDEX reservation_idx ON reservation USING GIST (during);
```

A GiST or SP-GiST index can accelerate queries involving the following range operators: =, &&, <@, @>, <<, >>, -|-, &<, and &> (see **12.5.17 Range Functions and Operators**).

In addition, the B-tree and hash index can be created on table columns of the range type. For these index types, basically the only useful range operation is equivalence. Using the corresponding < and > operators, there is a B-tree sort oder for range value definitions, but that order is fairly arbitrary and is often less useful in the reality. The B-tree and hash support for range types is primarily designed to allow sorting and hashing within a query, rather than creating an index.

## 12.3.15 Object Identifier Types

Object identifiers (OIDs) are used internally by GaussDB as primary keys for various system catalogs. OIDs are not added to user-created tables by the system. The **OID** type represents an object identifier.

The **OID** type is currently implemented as an unsigned four-byte integer. So, using a user-created table's **OID** column as a primary key is discouraged.

**Table 12-22** Object identifier types

| Name | Reference | Description | Example |
| --- | --- | --- | --- |
| OID | N/A | Numeric object identifier | 564182 |

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| Name | Reference | Description | Example |
| --- | --- | --- | --- |
| CID | N/A | Command identifier. This is the data type of the system columns **cmin** and **cmax**. Command identifiers are 32-bit quantities. | N/A |
| XID | N/A | A transaction identifier. This is the data type of the system columns **xmin** and **xmax**. Transaction identifiers are also 64-bit quantities. | N/A |
| TID | N/A | Row identifier. This is the data type of the system column **ctid**. A row ID is a pair (block number, tuple index within block) that identifies the physical location of the row within its table. | N/A |
| REGCONFIG | pg_ts_config | Text search configuration | english |
| REGDICTIONARY | pg_ts_dict | Text search dictionary | simple |
| REGOPER | pg_operator | Operator name | N/A |
| REGOPERATOR | pg_operator | Operator with argument types | *(integer,integer) or -(NONE,integer) |
| REGPROC | pg_proc | Function name | sum |
| REGPROCEDURE | pg_proc | Function with argument types | sum(int4) |
| REGCLASS | pg_class | Relation name | pg_type |
| REGTYPE | pg_type | Data type name | integer |

The **OID** type is used for a column in the database system catalog.

Example:

```
openGauss=# SELECT oid FROM pg_class WHERE relname = 'pg_type';
 oid
------
 1247
(1 row)
```

The alias type for **OID** is **REGCLASS** which allows simplified search for **OID** values.

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Example:

```
openGauss=# SELECT attrelid,attname,atttypid,attstattarget FROM pg_attribute WHERE attrelid =
'pg_type'::REGCLASS;
 attrelid |  attname   | atttypid | attstattarget
----------+------------+----------+---------------
     1247 | xc_node_id     |       23 |             0
     1247 | tableoid       |       26 |             0
     1247 | cmax           |       29 |             0
     1247 | xmax           |       28 |             0
     1247 | cmin           |       29 |             0
     1247 | xmin           |       28 |             0
     1247 | oid            |       26 |             0
     1247 | ctid           |       27 |             0
     1247 | typname        |       19 |            -1
     1247 | typnamespace   |       26 |            -1
     1247 | typowner       |       26 |            -1
     1247 | typlen         |       21 |            -1
     1247 | typbyval       |       16 |            -1
     1247 | typtype        |       18 |            -1
     1247 | typcategory    |       18 |            -1
     1247 | typispreferred |       16 |            -1
     1247 | typisdefined   |       16 |            -1
     1247 | typdelim       |       18 |            -1
     1247 | typrelid       |       26 |            -1
     1247 | typelem        |       26 |            -1
     1247 | typarray       |       26 |            -1
     1247 | typinput       |       24 |            -1
     1247 | typoutput      |       24 |            -1
     1247 | typreceive     |       24 |            -1
     1247 | typsend        |       24 |            -1
     1247 | typmodin       |       24 |            -1
     1247 | typmodout      |       24 |            -1
     1247 | typanalyze     |       24 |            -1
     1247 | typalign       |       18 |            -1
     1247 | typstorage     |       18 |            -1
     1247 | typnotnull     |       16 |            -1
     1247 | typbasetype    |       26 |            -1
     1247 | typtypmod      |       23 |            -1
     1247 | typndims       |       23 |            -1
     1247 | typcollation   |       26 |            -1
     1247 | typdefaultbin  |      194 |            -1
     1247 | typdefault     |       25 |            -1
     1247 | typacl         |     1034 |            -1
(38 rows)
```

## 12.3.16 Pseudo-Types

GaussDB type system contains a number of special-purpose entries that are collectively called pseudo-types. A pseudo-type cannot be used as a column data type, but it can be used to declare a function's argument or result type.

Each of the available pseudo-types is useful in situations where a function's behavior does not correspond to simply taking or returning a value of a specific SQL data type. **Table 12-23** lists all pseudo-types.

**Table 12-23** Pseudo-types

| Name | Description |
| --- | --- |
| any | Indicates that a function accepts any input data type. |
| anyelement | Indicates that a function accepts any data type. |

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| Name | Description |
| --- | --- |
| anyarray | Indicates that a function accepts any array data type. |
| anynonarray | Indicates that a function accepts any non-array data type. |
| anyenum | Indicates that a function accepts any enum data type. |
| anyrange | Indicates that a function accepts any range data type. |
| cstring | Indicates that a function accepts or returns a null-terminated C string. |
| internal | Indicates that a function accepts or returns a server-internal data type. |
| language_handler | Indicates that a procedural language call handler is declared to return **language_handler**. |
| fdw_handler | Indicates that a foreign-data wrapper handler is declared to return **fdw_handler**. |
| record | Identifies a function returning an unspecified row type. |
| trigger | Indicates that a trigger function is declared to return **trigger**. |
| void | Indicates that a function returns no value. |
| opaque | Indicates an obsolete type name that formerly served all the above purposes. |

Functions coded in C (whether built in or dynamically loaded) can be declared to accept or return any of these pseudo data types. It is up to the function author to ensure that the function will behave safely when a pseudo-type is used as an argument type.

Functions coded in procedural languages can use pseudo-types only as allowed by their implementation languages. At present the procedural languages all forbid use of a pseudo-type as argument type, and allow only **void** and **record** as a result type. Some also support polymorphic functions using the **anyelement**, **anyarray**, **anynonarray**, **anyenum**, and **anyrange** types.

The **internal** pseudo-type is used to declare functions that are meant only to be called internally by the database system, and not by direct invocation in an SQL query. If a function has at least one **internal**-type argument then it cannot be called from SQL. You are advised not to create any function that is declared to return internal unless it has at least one **internal** argument.

Example:

```
-- Create a table.
openGauss=# create table t1 (a int);

-- Insert two data records.
openGauss=# insert into t1 values(1),(2);

-- Create the showall() function.
```

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```
openGauss=# CREATE OR REPLACE FUNCTION showall() RETURNS SETOF record
AS $$ SELECT count(*) from t1; $$
LANGUAGE SQL;

-- Invoke the showall() function.
openGauss=# SELECT showall();
 showall
---------
 (2)
(1 row)

-- Delete the function.
openGauss=# DROP FUNCTION showall();

-- Drop the table.
openGauss=# drop table t1;
```

## 12.3.17 Data Types Supported by Column-store Tables

Table 12-24 lists the data types supported by column-store tables.

**Table 12-24** Data types supported by column-store tables

| Category | Data Type | Length | Supported or Not |
| --- | --- | --- | --- |
| Numeric Types | smallint | 2 | Supported |
| | integer | 4 | Supported |
| | bigint | 8 | Supported |
| | decimal | -1 | Supported |
| | numeric | -1 | Supported |
| | real | 4 | Supported |
| | double precision | 8 | Supported |
| | smallserial | 2 | Supported |
| | serial | 4 | Supported |
| | bigserial | 8 | Supported |
| Monetary Types | money | 8 | Supported |

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| Category | Data Type | Length | Supported or Not |
| --- | --- | --- | --- |
| Character Types | character varying(n), varchar(n) | -1 | Supported |
| | character(n), char(n) | n | Supported |
| | character, char | 1 | Supported |
| | text | -1 | Supported |
| | nvarchar2 | -1 | Supported |
| | name | 64 | Not supported |
| Date/Time Types | timestamp with time zone | 8 | Supported |
| | timestamp without time zone | 8 | Supported |
| | date | 4 | Supported |
| | time without time zone | 8 | Supported |
| | time with time zone | 12 | Supported |
| | interval | 16 | Supported |
| big object | clob | -1 | Supported |
| | blob | -1 | Not supported |
| other types | ... | ... | Not supported |

## 12.3.18 Data Types Used by the Ledger Database

The ledger database uses the hash16 data type to store row-level hash digests or table-level hash digests, and uses the hash32 data type to store global hash

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digests or history table verification hashes. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 12-25** Hash type of the ledger database

| Name | Description | Storage Space | Range |
| --- | --- | --- | --- |
| HASH16 | Stored as an unsigned 64-bit integer | 8 bytes | 0 to +18446744073709551615 |
| HASH32 | Stored as an unsigned integer array of 16 elements | 16 bytes | Value range of an unsigned integer array of 16 elements |

The hash16 data type is used to store row-level or table-level hash digests in the ledger database. After obtaining the hash sequence of a 16-character hexadecimal string, the system invokes the **hash16in** function to convert the sequence into an unsigned 64-bit integer and stores the integer in a hash16 variable. Example:

```
Hexadecimal string: e697da2eaa3a775b; corresponding 64-bit unsigned integer: 16615989244166043483
Hexadecimal string: ffffffffffffffff; corresponding 64-bit unsigned integer: 18446744073709551615
```

The hash32 data type is used to store the global hash digest or history table verification hash in the ledger database. After obtaining the hash sequence of a 32-character hexadecimal string, the system invokes the **hash32in** function to convert the sequence to an unsigned integer array of 16 elements. Example:

```
Hexadecimal string: 685847ed1fe38e18f6b0e2b18c00edee
Corresponding hash32 array: [104,88,71,237,31,227,142,24,246,176,226,177,140,0,237,238]
```

## 12.3.19 ACLItem

The ACLItem data type is used to store object permission information. Its internal implementation is of the int type and supports the '*user1*=*privs*|*user2*' format.

The aclitem[] data type is an array consisting of ACL items. The supported format is {*user1*=*privs1*|*user3*, *user2*=*privs2*|*user3*}.

In the preceding command, *user1*, *user2*, and *user3* indicate the existing users or roles in the database, and *privs* indicates the permissions supported by the database. For details, see **Table 15-43**.

Example:

```
openGauss=# create table table_acl (id int,priv aclitem,privs aclitem[]);
-- Create a data table table_acl that contains three fields of the int, aclitem, and aclitem[] types.
openGauss=# insert into table_acl values (1,'user1=arw/omm','{omm=d/user2,omm=w/omm}');
-- Insert a record whose content is (1,'user1=arw/omm','{omm=d/user2,omm=w/omm}') into the table_acl table.
openGauss=# insert into table_acl values (2,'user1=aw/omm','{omm=d/user2}');
-- Insert a record whose content is (2,'user1=aw/omm','{omm=d/user2}') into the table_acl table.
openGauss=# select * from  table_acl;
 id |     priv      |          privs
----+---------------+-------------------------
  1 | user1=arw/omm | {omm=d/user2,omm=w/omm}
  2 | user1=aw/omm  | {omm=d/user2}
(2 rows)
```

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# 12.4 Constant and Macro

Table 12-26 lists the constants and macros that can be used in GaussDB.

**Table 12-26** Constant and macro

| Parameter | Description | Example |
| --- | --- | --- |
| CURRENT_CATALOG | Specifies the current database. | openGauss=# SELECT CURRENT_CATALOG;<br>current_database<br>----------<br>postgres<br>(1 row) |
| CURRENT_ROLE | Specifies the current user. | openGauss=# SELECT CURRENT_ROLE;<br>current_user<br>----------<br>omm<br>(1 row) |
| CURRENT_SCHEMA | Specifies the current database mode. | openGauss=# SELECT CURRENT_SCHEMA;<br>current_schema<br>----------<br>public<br>(1 row) |
| CURRENT_USER | Specifies the current user. | openGauss=# SELECT CURRENT_USER;<br>current_user<br>----------<br>omm<br>(1 row) |
| LOCALTIMESTAMP | Specifies the current session time (without time zone). | openGauss=# SELECT LOCALTIMESTAMP;<br>timestamp<br>----------<br>2015-10-10 15:37:30.968538<br>(1 row) |
| NULL | This parameter is left blank. | N/A |
| SESSION_USER | Specifies the current system user. | openGauss=# SELECT SESSION_USER;<br>session_user<br>----------<br>omm<br>(1 row) |
| SYSDATE | Specifies the current system date. | openGauss=# SELECT SYSDATE;<br>sysdate<br>----------<br>2015-10-10 15:48:53<br>(1 row) |
| USER | Specifies the current user, also called **CURRENT_USER**. | openGauss=# SELECT USER;<br>current_user<br>----------<br>omm<br>(1 row) |

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# 12.5 Functions and Operators

Operators can be used to process one or more operands and can be placed before, after, or between operands. Results are returned after the processing.

Functions encapsulate service logic to implement specific functions. A function may or may not have parameters. After a function is executed, the result is returned.

Users can modify system functions. However, after the modification, the meaning of the functions may change, which results in disorder in system control. Therefore, users are not allowed to manually modify system functions.

## 12.5.1 Logical Operators

The usual logical operators include AND, OR, and NOT. SQL uses a three-valued logical system with true, false, and null, which represents "unknown". Their priorities are NOT > AND > OR.

Table 12-27 lists the calculation rules, where a and b represent logical expressions.

**Table 12-27** Operation rules

| a | b | a AND b Result | a OR b Result | NOT a Result |
|---|---|---|---|---|
| TRUE | TRUE | TRUE | TRUE | FALSE |
| TRUE | FALSE | FALSE | TRUE | FALSE |
| TRUE | NULL | NULL | TRUE | FALSE |
| FALSE | FALSE | FALSE | FALSE | TRUE |
| FALSE | NULL | FALSE | NULL | TRUE |
| NULL | NULL | NULL | NULL | NULL |

NOTE

The operators AND and OR are commutative, that is, you can switch the left and right operand without affecting the result.

## 12.5.2 Comparison Operators

Comparison operators are available for all data types and return Boolean values.

All comparison operators are binary operators. Only data types that are the same or can be implicitly converted can be compared using comparison operators.

Table 12-28 describes comparison operators provided by GaussDB.

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**Table 12-28** Comparison operations

| Operator | Description |
| --- | --- |
| < | Less than |
| > | Greater than |
| <= | Less than or equal to |
| >= | Greater than or equal to |
| = | Equal to |
| <>, !=, or ^= | Not equal to |

Comparison operators are available for all relevant data types. All comparison operators are binary operators that returned values of Boolean type. Expressions like **1 < 2 < 3** are invalid. (Because there is no comparison operator to compare a Boolean value with **3**.)

Besides, each comparison operator has a corresponding function in the **pg_proc** system catalog. If the value of proleakproof attribute of the corresponding function is **f**, the function is not used to prevent data leakage. If a user only has the permission for a system view, but does not have the permission for the corresponding table, the query plan may not be optimal when the user searches the system view.

## 12.5.3 Character Processing Functions and Operators

String functions and operators provided by GaussDB are for concatenating strings with each other, concatenating strings with non-strings, and matching the patterns of strings.

- bit_length(string)

  Description: Specifies the number of bits occupied by a string.

  Return type: int

  Example:

  ```
  openGauss=# SELECT bit_length('world');
   bit_length
  ------------
          40
  (1 row)
  ```

- btrim(string text [, characters text])

  Description: Removes the longest string consisting only of characters in **characters** (a space by default) from the start and end of **string**.

  Return type: text

  Example:

  ```
  openGauss=# SELECT btrim('sring' , 'ing');
   btrim
  -------
   sr
  (1 row)
  ```

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- char_length(string) or character_length(string)

  Description: Specifies the number of characters in a string.

  Return type: int

  Example:

```
openGauss=# SELECT char_length('hello');
 char_length
-------------
           5
(1 row)
```

- instr(text,text,int,int)

  Description: **instr(string1,string2,int1,int2)** returns the text from **int1** to **int2** in **string1**. The first **int** indicates the start position for matching, and the second **int** indicates the number of matching times.

  Return type: int

  Example:

```
openGauss=# SELECT instr( 'abcdabcdabcd', 'bcd', 2, 2 );
 instr
-------
     6
(1 row)
```

- lengthb(text/bpchar)

  Description: Obtains the number of bytes of a specified string.

  Return type: int

  Example:

```
openGauss=# SELECT lengthb('hello');
 lengthb
---------
       5
(1 row)
```

- left(str text, n int)

  Description: Returns the first *n* characters in a string. When *n* is negative, all but the last **|n|** characters are returned.

  Return type: text

  Example:

```
openGauss=# SELECT left('abcde', 2);
 left
------
 ab
(1 row)
```

- length(string bytea, encoding name )

  Description: Specifies the number of characters in **string** in the given **encoding**. The **string** must be valid in this encoding.

  Return type: int

  Example:

```
openGauss=# SELECT length('jose', 'UTF8');
 length
--------
      4
(1 row)
```

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> **NOTE**
>
> If the length of the bytea type is queried and UTF8 encoding is specified, the maximum length can only be **536870888**.

- lpad(string text, length int [, fill text])

  Description: Fills up **string** to **length** by appending the characters **fill** (a space by default). If **string** is already longer than **length**, then it is truncated.

  Return type: text

  Example:

```
openGauss=# SELECT lpad('hi', 5, 'xyza');
 lpad
-------
 xyzhi
(1 row)
```

- notlike(x bytea name text, y bytea text)

  Description: Compares x and y to check whether they are inconsistent.

  Return type: Boolean

  Example:

```
openGauss=# SELECT notlike(1,2);
   notlike
--------------
           t
(1 row)
openGauss=# SELECT notlike(1,1);
   notlike
--------------
           f
(1 row)
```

- octet_length(string)

  Description: Specifies the number of bytes in a string.

  Return type: int

  Example:

```
openGauss=# SELECT octet_length('jose');
 octet_length
--------------
           4
(1 row)
```

- overlay(string placing string FROM int [for int])

  Description: Replaces substrings. **FROM int** indicates the start position of the replacement in the first string. **for int** indicates the number of characters replaced in the first string.

  Return type: text

  Example:

```
openGauss=# SELECT overlay('hello' placing 'world' from 2 for 3 );
 overlay
---------
 hworldo
(1 row)
```

- position(substring in string)

  Description: Specifies the position of a substring.

  Return type: int

  Example:

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```
openGauss=# SELECT position('ing' in 'string');
 position
----------
        4
(1 row)
```

- pg_client_encoding()

  Description: Specifies the current client encoding name.

  Return type: name

  Example:

```
openGauss=# SELECT pg_client_encoding();
 pg_client_encoding
--------------------
 UTF8
(1 row)
```

- quote_ident(string text)

  Description: Converts the given value to text and then quotes it as a literal. Quotation marks are added only if necessary (that is, if the string contains non-identifier characters or would be case-folded). Embedded quotation marks are properly doubled.

  Return type: text

  Example:

```
openGauss=# SELECT quote_ident('hello world');
 quote_ident
--------------
 "hello world"
(1 row)
```

- quote_literal(string text)

  Description: Converts the given value to text and then quotes it as a literal.

  Return type: text

  Example:

```
openGauss=# SELECT quote_literal('hello');
 quote_literal
---------------
 'hello'
(1 row)
```

  If a command similar to the following exists, the text will be escaped.

```
openGauss=# SELECT quote_literal(E'O\'hello');
 quote_literal
---------------
 'O''hello'
(1 row)
```

  If a command similar to the following exists, the backslash will be properly doubled.

```
openGauss=# SELECT quote_literal('O\hello');
 quote_literal
---------------
 E'O\\hello'
(1 row)
```

  If the parameter is null, **NULL** is returned. If the parameter may be null, you are advised to use **quote_nullable**.

```
openGauss=# SELECT quote_literal(NULL);
 quote_literal
---------------

(1 row)
```

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- quote_literal(value anyelement)

  Description: Converts the given value to text and then quotes it as a literal.

  Return type: text

  Example:

```
openGauss=# SELECT quote_literal(42.5);
 quote_literal
---------------
 '42.5'
(1 row)
```

  If a command similar to the following exists, the given value will be escaped.

```
openGauss=# SELECT quote_literal(E'O\'42.5');
 quote_literal
---------------
 '0''42.5'
(1 row)
```

  If a command similar to the following exists, the backslash will be properly doubled.

```
openGauss=# SELECT quote_literal('O\42.5');
 quote_literal
---------------
 E'O\\42.5'
(1 row)
```

- quote_nullable(string text)

  Description: Converts the given value to text and then quotes it as a literal.

  Return type: text

  Example:

```
openGauss=# SELECT quote_nullable('hello');
 quote_nullable
----------------
 'hello'
(1 row)
```

  If a command similar to the following exists, the text will be escaped.

```
openGauss=# SELECT quote_nullable(E'O\'hello');
 quote_nullable
----------------
 'O''hello'
(1 row)
```

  If a command similar to the following exists, the backslash will be properly doubled.

```
openGauss=# SELECT quote_nullable('O\hello');
 quote_nullable
----------------
 E'O\\hello'
(1 row)
```

  If the parameter is null, **NULL** is returned.

```
openGauss=# SELECT quote_nullable(NULL);
 quote_nullable
----------------
 NULL
(1 row)
```

- quote_nullable(value anyelement)

  Description: Converts the given value to text and then quotes it as a literal.

  Return type: text

  Example:

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```
openGauss=# SELECT quote_nullable(42.5);
 quote_nullable
----------------
 '42.5'
(1 row)
```

If a command similar to the following exists, the given value will be escaped.

```
openGauss=# SELECT quote_nullable(E'O\'42.5');
 quote_nullable
----------------
 'O''42.5'
(1 row)
```

If a command similar to the following exists, the backslash will be properly doubled.

```
openGauss=# SELECT quote_nullable('O\42.5');
 quote_nullable
----------------
 E'O\\42.5'
(1 row)
```

If the parameter is null, **NULL** is returned.

```
openGauss=# SELECT quote_nullable(NULL);
 quote_nullable
----------------
 NULL
(1 row)
```

- similar_escape(pat text, esc text)

  Description: Converts a regular expression of the SQL:2008 style to the POSIX style.

  Return type: text

  Example:

- substring_inner(string [from int] [for int])

  Description: Extracts a substring. **from int** indicates the start position of the truncation. **for int** indicates the number of characters truncated.

  Return type: text

  Example:

```
openGauss=# select substring_inner('adcde', 2,3);
 substring_inner
-----------------
 dcd
(1 row)
```

- substring(string [from int] [for int])

  Description: Extracts a substring. **from int** indicates the start position of the truncation. **for int** indicates the number of characters truncated.

  Return type: text

  Example:

```
openGauss=# SELECT substring('Thomas' from 2 for 3);
 substring
-----------
 hom
(1 row)
```

- substring(string from *pattern*)

  Description: Extracts substrings matching the POSIX regular expression. It returns the text that matches the pattern. If no match record is found, a null value is returned.

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Return type: text

Example:

```
openGauss=# SELECT substring('Thomas' from '...$');
 substring
-----------
 mas
(1 row)
openGauss=# SELECT substring('foobar' from 'o(.)b');
 result
--------
 o
(1 row)
openGauss=# SELECT substring('foobar' from '(o(.)b)');
 result
--------
 oob
(1 row)
```

NOTE

If the POSIX pattern contains any parentheses, the portion of the text that matched the first parenthesized sub-expression (the one whose left parenthesis comes first) is returned. You can put parentheses around the whole expression if you want to use parentheses within it without triggering this exception.

- substring(string from *pattern* for *escape*)

  Description: Extracts substrings matching the SQL regular expression. The declared schema must match the entire data string; otherwise, the function fails and returns a null value. To indicate the part of the pattern that should be returned on success, the pattern must contain two occurrences of the escape character followed by a double quotation mark ("). The text matching the portion of the pattern between these marks is returned.

  Return type: text

  Example:

  ```
  openGauss=# SELECT substring('Thomas' from '%#"o_a#"_' for '#');
   substring
  -----------
   oma
  (1 row)
  ```

- rawcat(raw,raw)

  Description: Indicates the string concatenation function.

  Return type: raw

  Example:

  ```
  openGauss=# SELECT rawcat('ab','cd');
   rawcat
  --------
   ABCD
  (1 row)
  ```

- regexp_like(text,text,text)

  Description: Indicates the mode matching function of a regular expression.

  Return type: Boolean

  Example:

  ```
  openGauss=# SELECT regexp_like('str','[ac]');
   regexp_like
  -------------
   f
  (1 row)
  ```

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- regexp_substr(string text, pattern text [, position int [, occurrence int [, flags text]]])

  Description: Extracts substrings from a regular expression. Its function is similar to **substr**. When a regular expression contains multiple parallel brackets, it also needs to be processed.

  Parameter description:

  **string**: source character string used for matching.

  **pattern**: regular expression pattern string used for matching.

  **position**: start character of the source string used for matching. This parameter is optional. The default value is **1**.

  **occurrence**: sequence number of the matched substring to be extracted. This parameter is optional. The default value is **1**.

  **flags**: contains zero or multiple single-letter flags that change the matching behavior of the function. This parameter is optional. **m** indicates multi-line matching. If the SQL syntax is compatible with products A and B and the value of the GUC parameter **behavior_compat_options** contains **aformat_regexp_match**, the option **n** indicates that the period (.) can match the **'\n'** character. If **n** is not specified in flags, the period (.) cannot match the **'\n'** character by default. If the value does not contain **aformat_regexp_match**, the period (.) matches the **'\n'** character by default. The meaning of option **n** is the same as that of option **m**.

  Return type: text

  Example:

  ```
  openGauss=# SELECT regexp_substr('str','[ac]');
   regexp_substr
  ---------------


  (1 row)

  openGauss=# SELECT regexp_substr('foobarbaz', 'b(..)', 3, 2) AS RESULT;
   result
  --------
   baz
  (1 row)
  ```

- regexp_count(string text, pattern text [, position int [, flags text]])

  Description: obtains the number of substrings used for matching.

  Parameter description:

  **string**: source character string used for matching.

  **pattern**: regular expression pattern string used for matching.

  **position**: sequence number of the character to be matched from the source character string. This parameter is optional. The default value is **1**.

  **flags**: contains zero or multiple single-letter flags that change the matching behavior of the function. This parameter is optional. **m** indicates multi-line matching. If the SQL syntax is compatible with products A and B and the value of the GUC parameter **behavior_compat_options** contains **aformat_regexp_match**, the option **n** indicates that the period (.) can match the **'\n'** character. If **n** is not specified in flags, the period (.) cannot match the **'\n'** character by default. If the value does not contain **aformat_regexp_match**, the period (.) matches the **'\n'** character by default. The meaning of option **n** is the same as that of option **m**.

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Return type: int

Example:

```
openGauss=# SELECT regexp_count('foobarbaz','b(..)', 5) AS RESULT;
result
--------
1
(1 row)
```

- regexp_instr(string text, pattern text [, position int [, occurrence int [, return_opt int [, flags text]]]])

  Description: obtains the position (starting from 1) of the substring that meets the matching condition. If no substring is matched, **0** is returned.

  Parameter description:

  **string**: source character string used for matching.

  **pattern**: regular expression pattern string used for matching.

  **position**: start character of the source string used for matching. This parameter is optional. The default value is **1**.

  **occurrence**: sequence number of the matched substring to be replaced. This parameter is optional. The default value is **1**.

  **return_opt**: specifies whether to return the position of the first or last character of the matched substring. This parameter is optional. If the value is **0**, the position of the first character (starting from 1) of the matched substring is returned. If the value is greater than 0, the position of the next character of the end character of the matched substring is returned. The default value is **0**.

  **flags**: contains zero or multiple single-letter flags that change the matching behavior of the function. This parameter is optional. **m** indicates multi-line matching. If the SQL syntax is compatible with products A and B and the value of the GUC parameter **behavior_compat_options** contains **aformat_regexp_match**, the option **n** indicates that the period (.) can match the **'\n'** character. If **n** is not specified in flags, the period (.) cannot match the **'\n'** character by default. If the value does not contain **aformat_regexp_match**, the period (.) matches the **'\n'** character by default. The meaning of option **n** is the same as that of option **m**.

  Return type: int

  Example:

  ```
  openGauss=# SELECT regexp_instr('foobarbaz','b(..)', 1, 1, 0) AS RESULT;
  result
  --------
  4
  (1 row)

  openGauss=# SELECT regexp_instr('foobarbaz','b(..)', 1, 2, 0) AS RESULT;
  result
  --------
  7
  (1 row)
  ```

- regexp_matches(string text, pattern text [, flags text])

  Description: Returns all captured substrings resulting from matching a POSIX regular expression against **string**. If the pattern does not match, the function returns no rows. If the pattern contains no parenthesized sub-expressions, then each row returned is a single-element text array containing the substring matching the whole pattern. If the pattern contains parenthesized sub-

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expressions, the function returns a text array whose *n*th element is the substring matching the *n*th parenthesized sub-expression of the pattern.

The optional **flags** argument contains zero or multiple single-letter flags that change function behavior. **i** indicates that the matching is not related to uppercase and lowercase. **g** indicates that each matching substring is replaced, instead of replacing only the first one.

**NOTICE**

If the last parameter is provided but the parameter value is an empty string ('') and the SQL compatibility mode of the database is set to ORA, the returned result is an empty set. This is because the ORA compatible mode treats the empty string ('') as **NULL**. To resolve this problem, you can:

- Change the database SQL compatibility mode to TD.
- Do not provide the last parameter or do not set the last parameter to an empty string.

Return type: SETOF text[]

Example:

```
openGauss=# SELECT regexp_matches('foobarbequebaz', '(bar)(beque)');
 regexp_matches
----------------
 {bar,beque}
(1 row)
openGauss=# SELECT regexp_matches('foobarbequebaz', 'barbeque');
 regexp_matches
----------------
 {barbeque}
(1 row)
openGauss=# SELECT regexp_matches('foobarbequebazilbarfbonk', '(b[^b]+)(b[^b]+)', 'g');
    result
--------------
 {bar,beque}
 {bazil,barf}
(2 rows)
```

- regexp_split_to_array(string text, pattern text [, flags text ])

  Description: Splits **string** using a POSIX regular expression as the delimiter. The **regexp_split_to_array** function behaves the same as **regexp_split_to_table**, except that **regexp_split_to_array** returns its result as an array of text.

  Return type: text[]

  Example:

  ```
  openGauss=# SELECT regexp_split_to_array('hello world', E'\\s+');
   regexp_split_to_array
  -----------------------
   {hello,world}
  (1 row)
  ```

- regexp_split_to_table(string text, pattern text [, flags text])

  Description: Splits **string** using a POSIX regular expression as the delimiter. If there is no match to the pattern, the function returns the string. If there is at least one match, for each match it returns the text from the end of the last match (or the beginning of the string) to the beginning of the match. When there are no more matches, it returns the text from the end of the last match to the end of the string.

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The **flags** parameter is a text string containing zero or more single-letter flags that change the function's behavior. **i** indicates that the matching is not related to uppercase and lowercase. **g** indicates that each matching substring is replaced, instead of replacing only the first one.

Return type: SETOF text

Example:

```
openGauss=# SELECT regexp_split_to_table('hello world', E'\\s+');
 regexp_split_to_table
-----------------------
 hello
 world
(2 rows)
```

- repeat(string text, number int )

  Description: Repeats **string** the specified number of times.

  Return type: text

  Example:

  ```
  openGauss=# SELECT repeat('Pg', 4);
    repeat
  ----------
   PgPgPgPg
  (1 row)
  ```

  NOTE

  The maximum size of memory allocated at a time cannot exceed 1 GB due to the memory allocation mechanism of the database. Therefore, the maximum value of **number** cannot exceed (1 GB – **x**)/**lengthb** (**string**) – 1. **x** indicates the length of the header information, which is usually greater than 4 bytes. The value varies among different scenarios.

- replace(string text, from text, to text)

  Description: Replaces all occurrences in **string** of substring **from** with substring **to**.

  Return type: text

  Example:

  ```
  openGauss=# SELECT replace('abcdefabcdef', 'cd', 'XXX');
     replace
  ----------------
   abXXXefabXXXef
  (1 row)
  ```

- replace(string, substring)

  Description: Deletes all substrings in a string.

  String type: text

  Substring type: text

  Return type: text

  Example:

  ```
  openGauss=# SELECT replace('abcdefabcdef', 'cd');
     replace
  ----------------
   abefabef
  (1 row)
  ```

- reverse(str)

  Description: Returns the reversed string.

  Return type: text

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Example:

```
openGauss=# SELECT reverse('abcde');
 reverse
---------
 edcba
(1 row)
```

- right(str text, n int)

  Description: Returns the last *n* characters in a string. When *n* is negative, all but the first **|n|** characters are returned.

  Return type: text

  Example:

```
openGauss=# SELECT right('abcde', 2);
 right
-------
 de
(1 row)

openGauss=# SELECT right('abcde', -2);
 right
-------
 cde
(1 row)
```

- rpad(string text, length int [, fill text])

  Description: Fills up **string** to **length** by appending the characters **fill** (a space by default). If **string** is already longer than **length**, then it is truncated.

  Return type: text

  Example:

```
openGauss=# SELECT rpad('hi', 5, 'xy');
 rpad
-------
 hixyx
(1 row)
```

- rtrim(string text [, characters text])

  Description: Removes the longest string containing only characters from characters (a space by default) from the end of string.

  Return type: text

  Example:

```
openGauss=# SELECT rtrim('trimxxxx', 'x');
 rtrim
-------
 trim
(1 row)
```

- substrb(text,int,int)

  Description: Extracts a substring. The first **int** indicates the start position of the subtraction. The second **int** indicates the number of characters extracted.

  Return type: text

  Example:

```
openGauss=# SELECT substrb('string',2,3);
 substrb
---------
 tri
(1 row)
```

- substrb(text,int)

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Description: Extracts a substring. **int** indicates the start position of the extraction.

Return type: text

Example:

```
openGauss=# SELECT substrb('string',2);
 substrb
---------
 tring
(1 row)
```

- substr(bytea,from,count)

  Description: Extracts a substring from **bytea**. **from** specifies the position where the extraction starts. **count** specifies the length of the extracted substring.

  Return type: text

  Example:

  ```
  openGauss=# SELECT substr('string',2,3);
   substr
  --------
   tri
  (1 row)
  ```

- string || string

  Description: Concatenates strings.

  Return type: text

  Example:

  ```
  openGauss=# SELECT 'MPP'||'DB' AS RESULT;
   result
  --------
   MPPDB
  (1 row)
  ```

- string || non-string or non-string || string

  Description: Concatenates strings and non-strings.

  Return type: text

  Example:

  ```
  openGauss=# SELECT 'Value: '||42 AS RESULT;
    result
  -----------
   Value: 42
  (1 row)
  ```

- split_part(string text, delimiter text, field int)

  Description: Splits **string** on **delimiter** and returns the **field**th column (counting from text of the first appeared delimiter).

  Return type: text

  Example:

  ```
  openGauss=# SELECT split_part('abc~@~def~@~ghi', '~@~', 2);
   split_part
  ------------
   def
  (1 row)
  ```

- strpos(string, substring)

  Description: Specifies the position of a substring. It is the same as **position(substring in string)**. However, the parameter sequences of them are reversed.

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Return type: int

Example:

```
openGauss=# SELECT strpos('source', 'rc');
 strpos
--------
      4
(1 row)
```

- to_hex(number int or bigint)

  Description: Converts a number to a hexadecimal expression.

  Return type: text

  Example:

  ```
  openGauss=# SELECT to_hex(2147483647);
    to_hex
  ----------
   7fffffff
  (1 row)
  ```

- translate(string text, from text, to text)

  Description: Any character in **string** that matches a character in the **from** set is replaced by the corresponding character in the **to** set. If **from** is longer than **to**, extra characters occurred in **from** are removed.

  Return type: text

  Example:

  ```
  openGauss=# SELECT translate('12345', '143', 'ax');
   translate
  -----------
   a2x5
  (1 row)
  ```

- length(string)

  Description: Obtains the number of characters in a string.

  Return type: integer

  Example:

  ```
  openGauss=# SELECT length('abcd');
   length
  --------
       4
  (1 row)
  ```

- lengthb(string)

  Description: Obtains the number of characters in a string. The value depends on character sets (GBK and UTF8).

  Return type: integer

  Example:

  ```
  openGauss=# SELECT lengthb('Chinese');
   lengthb
  ---------
        7
  (1 row)
  ```

- substr(string,from)

  Description:

  Extracts substrings from a string.

  **from** indicates the start position of the extraction.

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  - If **from** starts at 0, the value **1** is used.
  - If the value of **from** is positive, all characters from **from** to the end are extracted.
  - If the value of **from** is negative, the last *n* characters in the string are extracted, in which **n** indicates the absolute value of **from**.

  Return type: varchar

  Example:

  If the value of **from** is positive:

```
openGauss=# SELECT substr('ABCDEF',2);
 substr
--------
 BCDEF
(1 row)
```

  If the value of **from** is negative:

```
openGauss=# SELECT substr('ABCDEF',-2);
 substr
--------
 EF
(1 row)
```

- substr(string,from,count)

  Description:

  Extracts substrings from a string.

  **from** indicates the start position of the extraction.

  **count** indicates the length of the extracted substring.

  - If **from** starts at 0, the value **1** is used.
  - If the value of **from** is positive, extract **count** characters starting from **from**.
  - If the value of **from** is negative, extract the last **n count** characters in the string, in which **n** indicates the absolute value of **from**.
  - If the value of **count** is smaller than **1**, **null** is returned.

  Return type: varchar

  Example:

  If the value of **from** is positive:

```
openGauss=# SELECT substr('ABCDEF',2,2);
 substr
--------
 BC
(1 row)
```

  If the value of **from** is negative:

```
openGauss=# SELECT substr('ABCDEF',-3,2);
 substr
--------
 DE
(1 row)
```

- substrb(string,from)

  Description: The functionality of this function is the same as that of **SUBSTR(string,from)**. However, the calculation unit is byte.

  Return type: bytea

  Example:

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```
openGauss=# SELECT substrb('ABCDEF',-2);
 substrb
---------
 EF
(1 row)
```

- substrb(string,from,count)

  Description: The functionality of this function is the same as that of **SUBSTR(string,from,count)**. However, the calculation unit is byte.

  Return type: bytea

  Example:

```
openGauss=# SELECT substrb('ABCDEF',2,2);
 substrb
---------
 BC
(1 row)
```

- trim([leading |trailing |both] [characters] from string)

  Description: Removes the longest string containing only the characters (a space by default) from the start/end/both ends of the string.

  Return type: text

  Example:

```
openGauss=# SELECT trim(BOTH 'x' FROM 'xTomxx');
 btrim
-------
 Tom
(1 row)
openGauss=# SELECT trim(LEADING 'x' FROM 'xTomxx');
 ltrim
-------
 Tomxx
(1 row)
openGauss=# SELECT trim(TRAILING 'x' FROM 'xTomxx');
 rtrim
-------
 xTom
(1 row)
```

- rtrim(string [, characters])

  Description: Removes the longest string containing only characters from characters (a space by default) from the end of string.

  Return type: text

  Example:

```
openGauss=# SELECT rtrim('TRIMxxxx','x');
 rtrim
-------
 TRIM
(1 row)
```

- ltrim(string [, characters])

  Description: Removes the longest string containing only characters from characters (a space by default) from the start of string.

  Return type: text

  Example:

```
openGauss=# SELECT ltrim('xxxxTRIM','x');
 ltrim
-------
 TRIM
(1 row)
```

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- upper(string)

  Description: Converts the string into the uppercase.

  Return type: text

  Example:

  ```
  openGauss=# SELECT upper('tom');
   upper
  -------
   TOM
  (1 row)
  ```

- lower(string)

  Description: Converts the string into the lowercase.

  Return type: text

  Example:

  ```
  openGauss=# SELECT lower('TOM');
   lower
  -------
   tom
  (1 row)
  ```

- rpad(string varchar, length int [, fill varchar])

  Description: Fills up **string** to **length** by appending the characters **fill** (a space by default). If **string** is already longer than **length**, then it is truncated.

  **length** in GaussDB indicates the character length. One Chinese character is counted as one character.

  Return type: text

  Example:

  ```
  openGauss=# SELECT rpad('hi',5,'xyza');
   rpad
  -------
   hixyx
  (1 row)
  openGauss=# SELECT rpad('hi',5,'abcdefg');
   rpad
  -------
   hiabc
  (1 row)
  ```

- instr(string,substring[,position,occurrence])

  Description: Queries and returns the value of the substring position that occurs the **occurrence** (1 by default) times from the **position** (1 by default) in the string.

  - If the value of **position** is **0**, **0** is returned.
  - If the value of **position** is negative, searches backwards from the last *n*th character in the string, in which *n* indicates the absolute value of **position**.

  In this function, the calculation unit is character. One Chinese character is one character.

  Return type: integer

  Example:

  ```
  openGauss=# SELECT instr('corporate floor','or', 3);
   instr
  -------
       5
  (1 row)
  ```

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```
openGauss=# SELECT instr('corporate floor','or',-3,2);
 instr
-------
     2
(1 row)
```

- initcap(string)

  Description: Converts the first letter of each word in the string into the uppercase and the other letters into the lowercase.

  Return type: text

  Example:

```
openGauss=# SELECT initcap('hi THOMAS');
  initcap
-----------
 Hi Thomas
(1 row)
```

- ascii(string)

  Description: Indicates the ASCII code of the first character in the string.

  Return type: integer

  Example:

```
openGauss=# SELECT ascii('xyz');
 ascii
-------
   120
(1 row)
```

- replace(string varchar, search_string varchar, replacement_string varchar)

  Description: Replaces all **search_string** in the string with **replacement_string**.

  Return type: varchar

  Example:

```
openGauss=# SELECT replace('jack and jue','j','bl');
    replace
----------------
 black and blue
(1 row)
```

- lpad(string varchar, length int[, repeat_string varchar])

  Description: Adds a series of **repeat_string** (a space by default) on the left of the string to generate a new string with the total length of *n*.

  If the length of the string is longer than the specified length, the function truncates the string and returns the substrings with the specified length.

  Return type: varchar

  Example:

```
openGauss=# SELECT lpad('PAGE 1',15,'*.');
      lpad
-----------------
 *.*.*.*.*PAGE 1
(1 row)
openGauss=# SELECT lpad('hello world',5,'abcd');
 lpad
-------
 hello
(1 row)
```

- concat(str1,str2)

  Description: Concatenates **str1** and **str2** and returns the concatenated string. If **str1** or **str2** is set to **NULL**, **NULL** is returned. Note: **concat** calls the output

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function of the data type and the return value is uncertain. As a result, the optimizer cannot calculate the result in advance when generating a plan. If there are performance requirements, you are advised to use the operator **||**.

Return type: varchar

Example:

```
openGauss=# SELECT concat('Hello', ' World!');
    concat
--------------
 Hello World!
(1 row)
openGauss=# SELECT concat('Hello', NULL);
 concat
--------

(1 row)
```

- chr(integer)

  Description: Specifies the character of the ASCII code.

  Return type: varchar

  Example:

  ```
  openGauss=# SELECT chr(65);
   chr
  -----
   A
  (1 row)
  ```

- regexp_substr(source_char, pattern)

  Description: Extracts substrings from a regular expression.

  Return type: text

  Example:

  ```
  openGauss=# SELECT regexp_substr('500 Hello World, Redwood Shores, CA', ',[^,]+,')
  "REGEXPR_SUBSTR";
    REGEXPR_SUBSTR
  -------------------
   , Redwood Shores,
  (1 row)
  ```

- regexp_replace(string, pattern, replacement [,flags ])

  Description: Replaces substrings matching the POSIX regular expression. The source string is returned unchanged if there is no match to the pattern. If there is a match, the source string is returned with the replacement string substituted for the matching substring.

  The replacement string can contain \n, where n is 1 through 9, to indicate that the source substring matching the *n*th parenthesized sub-expression of the pattern should be inserted, and it can contain \& to indicate that the substring matching the entire pattern should be inserted.

  The optional **flags** argument contains zero or multiple single-letter flags that change function behavior. **i** indicates that the matching is not related to uppercase and lowercase. **g** indicates that each matching substring is replaced, instead of replacing only the first one.

  Return type: varchar

  Example:

  ```
  openGauss=# SELECT regexp_replace('Thomas', '.[mN]a.', 'M');
   regexp_replace
  ----------------
   ThM
  ```

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```
(1 row)
openGauss=# SELECT regexp_replace('foobarbaz','b(..)', E'X\\1Y', 'g') AS
RESULT;
   result
-------------
 fooXarYXazY
(1 row)
```

- concat_ws(sep text, str"any" [, str"any" [, ...] ])

  Description: Uses the first parameter as the separator, which is associated with all following parameters.

  Return type: text

  Example:

```
openGauss=# SELECT concat_ws(',', 'ABCDE', 2, NULL, 22);
 concat_ws
------------
 ABCDE,2,22
(1 row)
```

- nlssort(string text, sort_method text)

  Description: Returns the encoding value of a string in the sorting mode specified by **sort_method**. The encoding value can be used for sorting and determines the sequence of the string in the sorting mode. Currently, **sort_method** can be set to **nls_sort=schinese_pinyin_m** or **nls_sort=generic_m_ci**. **nls_sort=generic_m_ci** supports only the case-insensitive order for English characters.

  String type: text

  sort_method type: text

  Return type: text

  Example:

```
openGauss=# create table test(a text);

openGauss=# insert into test(a) values('abC not');

openGauss=# insert into test(a) values('abC a');

openGauss=# insert into test(a) values('abC a');

openGauss=# select * from test order by nlssort(a,'nls_sort=schinese_pinyin_m');
   a
--------
 abc 啊
 abC 啊
 abC 不
(3 rows)

openGauss=# select * from test order by nlssort(a, 'nls_sort=generic_m_ci');
   a
--------
 abC 啊
 abc 啊
 abC 不
(3 rows)
```

- convert(string bytea, src_encoding name, dest_encoding name)

  Description: Converts the bytea string to **dest_encoding**. **src_encoding** specifies the source code encoding. The string must be valid in this encoding.

  Return type: bytea

  Example:

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```
openGauss=# SELECT convert('text_in_utf8', 'UTF8', 'GBK');
         convert
--------------------------
 \x746578745f696e5f75746638
(1 row)
```

**NOTE**

If the rule for converting between source to target encoding (for example, GBK and LATIN1) does not exist, the string is returned without conversion. See the **pg_conversion** system catalog for details.

Example:

```
openGauss=# show server_encoding;
 server_encoding
-----------------
 LATIN1
(1 row)

openGauss=# SELECT convert_from('some text', 'GBK');
 convert_from
--------------
 some text
(1 row)

db_latin1=# SELECT convert_to('some text', 'GBK');
      convert_to
----------------------
 \x736f6d652074657874
(1 row)

db_latin1=# SELECT convert('some text', 'GBK', 'LATIN1');
       convert
----------------------
 \x736f6d652074657874
(1 row)
```

- convert_from(string bytea, src_encoding name)

  Description: Converts the long bytea using the coding mode of the database.

  **src_encoding** specifies the source code encoding. The string must be valid in this encoding.

  Return type: text

  Example:

  ```
  openGauss=# SELECT convert_from('text_in_utf8', 'UTF8');
   convert_from
  --------------
   text_in_utf8
  (1 row)
  ```

- convert_to(string text, dest_encoding name)

  Description: Converts a string to **dest_encoding**.

  Return type: bytea

  Example:

  ```
  openGauss=# SELECT convert_to('some text', 'UTF8');
      convert_to
  ----------------------
   \x736f6d652074657874
  (1 row)
  ```

- string [NOT] LIKE pattern [ESCAPE escape-character]

  Description: Specifies the pattern matching function.

  If the pattern does not include a percentage sign (%) or an underscore (_), this mode represents itself only. In this case, the behavior of LIKE is the same

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as the equal operator. The underscore (_) in the pattern matches any single character while one percentage sign (%) matches no or multiple characters.

To match with underscores (_) or percent signs (%), corresponding characters in **pattern** must lead escape characters. The default escape character is a backward slash (\) and can be specified using the **ESCAPE** clause. To match with escape characters, enter two escape characters.

Return type: Boolean

Example:

```
openGauss=# SELECT 'AA_BBCC' LIKE '%A@_B%' ESCAPE '@' AS RESULT;
 result
--------
 t
(1 row)
openGauss=# SELECT 'AA_BBCC' LIKE '%A@_B%' AS RESULT;
 result
--------
 f
(1 row)
openGauss=# SELECT 'AA@_BBCC' LIKE '%A@_B%' AS RESULT;
 result
--------
 t
(1 row)
```

- REGEXP_LIKE(source_string, pattern [, match_parameter])

  Description: Indicates the mode matching function of a regular expression.

  **source_string** indicates the source string and **pattern** indicates the matching pattern of the regular expression. **match_parameter** indicates the matching items and the values are as follows:

  – 'i': case-insensitive
  – 'c': case-sensitive
  – 'n': allowing the metacharacter "." in a regular expression to be matched with a linefeed.
  – 'm': allows **source_string** to be regarded as multiple rows.

  If **match_parameter** is ignored, **case-sensitive** is enabled by default, "." is not matched with a linefeed, and **source_string** is regarded as a single row.

  Return type: Boolean

  Example:

```
openGauss=# SELECT regexp_like('ABC', '[A-Z]');
 regexp_like
-------------
 t
(1 row)
openGauss=# SELECT regexp_like('ABC', '[D-Z]');
 regexp_like
-------------
 f
(1 row)
openGauss=# SELECT regexp_like('ABC', '[A-Z]','i');
 regexp_like
-------------
 t
(1 row)
openGauss=# SELECT regexp_like('ABC', '[A-Z]');
 regexp_like
-------------
 t
(1 row)
```

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- format(formatstr text [, str"any" [, ...] ])

  Description: Formats a string.

  Return type: text

  Example:

```
openGauss=# SELECT format('Hello %s, %1$s', 'World');
      format
-------------------
 Hello World, World
(1 row)
```

- md5(string)

  Description: Encrypts a string in MD5 mode and returns a value in hexadecimal form.

  **NOTE**

  The MD5 encryption algorithm has lower security and poses security risks. Therefore, you are advised to use a more secure encryption algorithm.

  Return type: text

  Example:

```
openGauss=# SELECT md5('ABC');
              md5
----------------------------------
 902fbdd2b1df0c4f70b4a5d23525e932
(1 row)
```

- decode(string text, format text)

  Description: Decodes binary data from textual representation.

  Return type: bytea

  Example:

```
openGauss=# SELECT decode('MTIzAAE=', 'base64');
   decode
--------------
 \x3132330001
(1 row)
```

- similar_escape(pat text, esc text)

  Description: Converts a regular expression of the SQL:2008 style to the POSIX style.

  Return type: text

  Example:

```
openGauss=# select similar_escape('\s+ab','2');
 similar_escape
----------------
 ^(?:\\s+ab)$
(1 row)
```

- svals(hstore)

  Description: Obtains the value of the hstore type.

  Return type: SETOF text

  Example:

```
openGauss=# select svals('"aa"=>"bb"');
 svals
-------
 bb
(1 row)
```

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- tconvert(key text, value text)

  Description: Converts character strings to the hstore format.

  Return type: hstore

  Example:

```
openGauss=# select tconvert('aa', 'bb');
  tconvert
------------
 "aa"=>"bb"
(1 row)
```

- encode(data bytea, format text)

  Description: Encodes binary data into a textual representation.

  Return type: text

  Example:

```
openGauss=# SELECT encode(E'123\\000\\001', 'base64');
  encode
----------
 MTIzAAE=
(1 row)
```

NOTE

- For a string containing newline characters, for example, a string consisting of a newline character and a space, the value of **length** and **lengthb** in GaussDB is **2**.
- In GaussDB, *n* in the CHAR(n) type indicates the number of characters. Therefore, for multiple-octet coded character sets, the length returned by the LENGTHB function may be longer than *n*.

# 12.5.4 Binary String Functions and Operators

## String Operators

SQL defines some string functions that use keywords, rather than commas, to separate arguments.

- octet_length(string)

  Description: Specifies the number of bytes in a binary string.

  Return type: int

  Example:

```
openGauss=# SELECT octet_length(E'jo\\000se'::bytea) AS RESULT;
 result
--------
      5
(1 row)
```

- overlay(string placing string from int [for int])

  Description: Replaces substrings.

  Return type: bytea

  Example:

```
openGauss=# SELECT overlay(E'Th\\000omas'::bytea placing E'\\002\\003'::bytea from 2 for 3) AS
RESULT;
    result
----------------
 \x5402036d6173
(1 row)
```

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- position(substring in string)

  Description: Specifies the location of the specified substring.

  Return type: int

  Example:

```
openGauss=# SELECT position(E'\\000om'::bytea in E'Th\\000omas'::bytea) AS RESULT;
 result
--------
      3
(1 row)
```

- substring(string [from int] [for int])

  Description: Truncates substrings.

  Return type: bytea

  Example:

```
openGauss=# SELECT substring(E'Th\\000omas'::bytea from 2 for 3) AS RESULT;
  result
----------
 \x68006f
(1 row)
```

- substr(bytea [from int] [for int])

  Description: Truncates substrings.

  Return type: bytea

  Example:

```
openGauss=# select substr(E'Th\\000omas'::bytea,2, 3) as result;
  result
----------
 \x68006f
(1 row)
```

- trim([both] bytes from string)

  Description: Removes the longest string containing only bytes from **bytes** from the start and end of **string**.

  Return type: bytea

  Example:

```
openGauss=# SELECT trim(E'\\000'::bytea from E'\\000Tom\\000'::bytea) AS RESULT;
  result
----------
 \x546f6d
(1 row)
```

## Other Binary String Functions

GaussDB provides common syntax used for calling functions.

- btrim(string bytea,bytes bytea)

  Description: Removes the longest string containing only bytes from **bytes** from the start and end of **string**.

  Return type: bytea

  Example:

```
openGauss=# SELECT btrim(E'\\000trim\\000'::bytea, E'\\000'::bytea) AS RESULT;
   result
------------
 \x7472696d
(1 row)
```

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- get_bit(string, offset)

  Description: Extracts bits from a string.

  Return type: int

  Example:

```
openGauss=# SELECT get_bit(E'Th\\000omas'::bytea, 45) AS RESULT;
 result
--------
      1
(1 row)
```

- get_byte(string, offset)

  Description: Extracts bytes from a string.

  Return type: int

  Example:

```
openGauss=# SELECT get_byte(E'Th\\000omas'::bytea, 4) AS RESULT;
 result
--------
    109
(1 row)
```

- set_bit(string,offset, newvalue)

  Description: Sets bits in a string.

  Return type: bytea

  Example:

```
openGauss=# SELECT set_bit(E'Th\\000omas'::bytea, 45, 0) AS RESULT;
      result
------------------
 \x5468006f6d4173
(1 row)
```

- set_byte(string,offset, newvalue)

  Description: Sets bytes in a string.

  Return type: bytea

  Example:

```
openGauss=# SELECT set_byte(E'Th\\000omas'::bytea, 4, 64) AS RESULT;
      result
------------------
 \x5468006f406173
(1 row)
```

- rawcmp

  Description: Specifies the raw data type comparison function.

  Parameter: raw, raw

  Return type: integer

- raweq

  Description: Specifies the raw data type comparison function.

  Parameter: raw, raw

  Return type: Boolean

- rawge

  Description: Specifies the raw data type comparison function.

  Parameter: raw, raw

  Return type: Boolean

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- rawgt
  Description: Specifies the raw data type comparison function.
  Parameter: raw, raw
  Return type: Boolean
- rawin
  Description: Specifies the raw data type parsing function.
  Parameter: cstring
  Return type: bytea
- rawle
  Description: Specifies the raw data type parsing function.
  Parameter: raw, raw
  Return type: Boolean
- rawlike
  Description: Specifies the raw data type parsing function.
  Parameter: raw, raw
  Return type: Boolean
- rawlt
  Description: Specifies the raw data type parsing function.
  Parameter: raw, raw
  Return type: Boolean
- rawne
  Description: Compares whether the raw types are the same.
  Parameter: raw, raw
  Return type: Boolean
- rawnlike
  Description: Checks whether the raw type matches the mode.
  Parameter: raw, raw
  Return type: Boolean
- rawout
  Description: Specifies the RAW output API.
  Parameter: bytea
  Return type: cstring
- rawsend
  Description: Converts bytea to the binary type.
  Parameter: raw
  Return type: bytea
- rawtohex
  Description: Converts the raw format to the hexadecimal format.
  Parameter: text
  Return type: text

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# 12.5.5 Bit String Functions and Operators

## Bit String Operators

Aside from the usual comparison operators, the following operators can be used. Bit string operands of **&**, **|**, and **#** must be of equal length. In case of bit shifting, the original length of the string is preserved by zero padding (if necessary).

- ||

  Description: Connects bit strings.

  Example:

  ```
  openGauss=# SELECT B'10001' || B'011' AS RESULT;
   result
  ----------
   10001011
  (1 row)
  ```

  NOTE

  A column can have a maximum of 180 consecutive internal joins. A column with excessive joins will be split into joined consecutive strings.

  Example: **str1||str2||str3||str4** is split into **(str1||str2)||(str3||str4)**.

- &

  Description: Specifies the AND operation between bit strings.

  Example:

  ```
  openGauss=# SELECT B'10001' & B'01101' AS RESULT;
   result
  --------
   00001
  (1 row)
  ```

- |

  Description: Specifies the OR operation between bit strings.

  Example:

  ```
  openGauss=# SELECT B'10001' | B'01101' AS RESULT;
   result
  --------
   11101
  (1 row)
  ```

- #

  Description: Specifies the OR operation between bit strings if they are inconsistent. If the same positions in the two bit strings are both 1 or 0, the position returns **0**.

  Example:

  ```
  openGauss=# SELECT B'10001' # B'01101' AS RESULT;
   result
  --------
   11100
  (1 row)
  ```

- ~

  Description: Specifies the NOT operation between bit strings.

  Example:

  ```
  openGauss=# SELECT ~B'10001'AS RESULT;
   result
  ```

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```
----------
 01110
(1 row)
```

- <<

  Description: Shifts left in a bit string.

  Example:

```
openGauss=# SELECT B'10001' << 3 AS RESULT;
 result
----------
 01000
(1 row)
```

- >>

  Description: Shifts right in a bit string.

  Example:

```
openGauss=# SELECT B'10001' >> 2 AS RESULT;
 result
----------
 00100
(1 row)
```

The following SQL-standard functions work on bit strings as well as strings: **length**, **bit_length**, **octet_length**, **position**, **substring**, and **overlay**.

The following functions work on bit strings as well as binary strings: **get_bit** and **set_bit**. When working with a bit string, these functions number the first (leftmost) bit of the string as bit 0.

In addition, it is possible to convert between integral values and type **bit**. Example:

```
openGauss=# SELECT 44::bit(10) AS RESULT;
   result
------------
 0000101100
(1 row)

openGauss=# SELECT 44::bit(3) AS RESULT;
 result
--------
 100
(1 row)

openGauss=# SELECT cast(-44 as bit(12)) AS RESULT;
    result
--------------
 111111010100
(1 row)

openGauss=# SELECT '1110'::bit(4)::integer AS RESULT;
 result
--------
     14
(1 row)

openGauss=# select substring('10101111'::bit(8), 2);
 substring
-----------
 0101111
(1 row)
```

**NOTE**

Casting to just "bit" means casting to bit(1), and so will deliver only the least significant bit of the integer.

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## 12.5.6 Pattern Matching Operators

The database provides three independent methods for implementing pattern matching: SQL LIKE operator, SIMILAR TO operator, and POSIX-style regular expressions. Besides these basic operators, functions can be used to extract or replace matching substrings and to split a string at matching locations.

- LIKE

  Description: Specifies whether the string matches the pattern string following LIKE. The LIKE expression returns true if the string matches the supplied pattern. (As expected, the NOT LIKE expression returns false if LIKE returns true, and vice versa.)

  Matching rules:

  a. This operator can succeed only when its pattern matches the entire string. If you want to match a sequence in any position within the string, the pattern must begin and end with a percent sign.
  b. The underscore (_) represents (matching) any single character. Percentage (%) indicates the wildcard character of any string.
  c. To match a literal underscore or percent sign, the respective character in pattern must be preceded by the escape character. The default escape character is one backslash but a different one can be selected by using the ESCAPE clause.
  d. To match with escape characters, enter two escape characters. For example, to write a pattern constant containing a backslash (\), you need to enter two backslashes in SQL statements.

     NOTE

     When **standard_conforming_strings** is set to **off**, any backslashes you write in literal string constants will need to be doubled. Therefore, writing a pattern matching a single backslash is actually going to write four backslashes in the statement. You can avoid this by selecting a different escape character by using ESCAPE, so that the backslash is no longer a special character of LIKE. But the backslash is still the special character of the character text analyzer, so you still need two backslashes. You can also select no escape character by writing **ESCAPE ''**. This effectively disables the escape mechanism, but it does not eliminate the special meaning of underscore and percent signs in the pattern.
  e. The keyword ILIKE can be used instead of LIKE to make the match case-insensitive.
  f. Operator **~~** is equivalent to LIKE, and operator **~~*** corresponds to ILIKE.

  Example:

```
openGauss=# SELECT 'abc' LIKE 'abc' AS RESULT;
 result
------------
 t
(1 row)
openGauss=# SELECT 'abc' LIKE 'a%' AS RESULT;
 result
------------
 t
(1 row)
openGauss=# SELECT 'abc' LIKE '_b_' AS RESULT;
 result
------------
 t
(1 row)
```

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```
openGauss=# SELECT 'abc' LIKE 'c' AS RESULT;
 result
-----------
 f
(1 row)
```

- SIMILAR TO

  Description: Returns true or false depending on whether the pattern matches the given string. It is similar to LIKE, but differs in that SIMILAR TO uses the regular expression understanding pattern defined by the SQL standard.

  Matching rules:

  a. Similar to LIKE, this operator succeeds only when its pattern matches the entire string. If you want to match a sequence in any position within the string, the pattern must begin and end with a percent sign.

  b. The underscore (_) represents (matching) any single character. Percentage (%) indicates the wildcard character of any string.

  c. SIMILAR TO supports these pattern-matching metacharacters borrowed from POSIX-style regular expressions:

| Metacharacter | Description |
| --- | --- |
| \| | Specifies alternation (either of two alternatives). |
| * | Specifies repetition of the previous item zero or more times. |
| + | Specifies repetition of the previous item one or more times. |
| ? | Specifies repetition of the previous item zero or one time. |
| {m} | Specifies repetition of the previous item exactly *m* times. |
| {m,} | Specifies repetition of the previous item *m* or more times. |
| {m,n} | Specifies repetition of the previous item at least *m* times and does not exceed *n* times. |
| () | Specifies that parentheses () can be used to group items into a single logical item. |
| [...] | Specifies a character class, just as in POSIX-style regular expressions. |

  d. A preamble escape character disables the special meaning of any of these metacharacters. The rules for using escape characters are the same as those for LIKE.

  Regular expressions:

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The **substring(stringfrompatternforescape)** function extracts a substring that matches an SQL regular expression pattern.

Example:

```
openGauss=# SELECT 'abc' SIMILAR TO 'abc' AS RESULT;
 result
-----------
 t
(1 row)
openGauss=# SELECT 'abc' SIMILAR TO 'a' AS RESULT;
 result
-----------
 f
(1 row)
openGauss=# SELECT 'abc' SIMILAR TO '%(b|d)%' AS RESULT;
 result
-----------
 t
(1 row)
openGauss=# SELECT 'abc' SIMILAR TO '(b|c)%'  AS RESULT;
 result
-----------
 f
(1 row)
```

- POSIX-style regular expressions

  Description: A regular expression is a character sequence that is an abbreviated definition of a set of strings (a regular set). If a string is a member of a regular expression described by a regular expression, the string matches the regular expression. POSIX-style regular expressions provide a more powerful means for pattern matching than the LIKE and SIMILAR TO operators. **Table 1 Regular expression match operators** lists all available operators for pattern matching using POSIX-style regular expressions.

  **Table 12-29** Regular expression match operators

| Operator | Description | Example |
| --- | --- | --- |
| ~ | Matches a regular expression, which is case-sensitive. | 'thomas' ~ '.*thomas.*' |
| ~* | Matches a regular expression, which is case-insensitive. | 'thomas' ~* '.*Thomas.*' |
| ! ~ | Does not match a regular expression, which is case-sensitive. | 'thomas' !~ '.*Thomas.*' |
| ! ~* | Does not match a regular expression, which is case-insensitive. | 'thomas' !~* '.*vadim.*' |

  Matching rules:

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a. Unlike LIKE patterns, a regular expression is allowed to match anywhere within a string, unless the regular expression is explicitly anchored to the beginning or end of the string.

b. Besides the metacharacters mentioned above, POSIX-style regular expressions also support the following pattern matching metacharacters:

| Metacharacter | Description |
| --- | --- |
| ^ | Specifies the match starting with a string. |
| $ | Specifies the match at the end of a string. |
| . | Matches any single character. |

Regular expressions:

POSIX-style regular expressions support the following functions:

- The **substring(string from pattern)** function provides a method for extracting a substring that matches the POSIX-style regular expression pattern.
- The **regexp_count(string tex....** function counts the number of substrings that match the POSIX-style regular expression pattern.
- The **regexp_instr(string text...** function obtains the position of a substring that matches the POSIX-style regular expression pattern.
- The **regexp_substr(string tex...** function extracts a substring that matches the POSIX-style regular expression pattern.
- The **regexp_replace(string, pattern, replacement [,flags ])** function replaces the substring matching the POSIX-style regular expression pattern with the new text.
- The **regexp_matches(string text, pattern text [, flags text])** function returns a text array consisting of all captured substrings that match a POSIX-style regular expression pattern.
- The **regexp_split_to_table(string text, pattern text [, flags text])** function splits a string using a POSIX-style regular expression pattern as a delimiter.
- The **regexp_split_to_array(string text, pattern text [, flags text ])** function behaves the same as **regexp_split_to_table**, except that **regexp_split_to_array** returns its result as an array of text.

  NOTE

  The regular expression split functions ignore zero-length matches, which occur at the beginning or end of a string or after the previous match. This is contrary to the strict definition of regular expression matching. The latter is implemented by **regexp_matches**, but the former is usually the most commonly used behavior in practice.

Example:

```
openGauss=# SELECT 'abc' ~ 'Abc' AS RESULT;
result
--------
```

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```
 f
(1 row)
openGauss=# SELECT 'abc' ~* 'Abc' AS RESULT;
 result
--------
 t
(1 row)
openGauss=# SELECT 'abc' !~ 'Abc' AS RESULT;
 result
--------
 t
(1 row)
openGauss=# SELECT 'abc'!~* 'Abc' AS RESULT;
 result
--------
 f
(1 row)
openGauss=# SELECT 'abc' ~ '^a' AS RESULT;
 result
--------
 t
(1 row)
openGauss=# SELECT 'abc' ~ '(b|d)'AS RESULT;
 result
--------
 t
(1 row)
openGauss=# SELECT 'abc' ~ '^(b|c)'AS RESULT;
 result
--------
 f
(1 row)
```

Although most regular expression searches can be executed quickly, regular expressions can still be artificially made up of memory that takes a long time and any amount of memory. It is not recommended that you accept the regular expression search pattern from the non-security pattern source. If you must do this, you are advised to add the statement timeout limit. The search with the SIMILAR TO pattern has the same security risks as the SIMILAR TO provides many capabilities that are the same as those of the POSIX-style regular expression. The LIKE search is much simpler than the other two options. Therefore, it is more secure to accept the non-secure pattern source search.

# 12.5.7 Arithmetic Functions and Operators

## Arithmetic Operators

- +

  Description: Addition

  Example:

  ```
  openGauss=# SELECT 2+3 AS RESULT;
   result
  --------
       5
  (1 row)
  ```

- -

  Description: Subtraction

  Example:

  ```
  openGauss=# SELECT 2-3 AS RESULT;
   result
  ```

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```
--------
    -1
(1 row)
```

- *

  Description: Multiplication

  Example:

  ```
  openGauss=# SELECT 2*3 AS RESULT;
   result
  --------
       6
  (1 row)
  ```

- /

  Description: Division (The result is not rounded.)

  Example:

  ```
  openGauss=# SELECT 4/2 AS RESULT;
   result
  --------
       2
  (1 row)
  openGauss=# SELECT 4/3 AS RESULT;
        result
  ------------------
   1.33333333333333
  (1 row)
  ```

- +/-

  Description: Positive/Negative

  Example:

  ```
  openGauss=# SELECT -2 AS RESULT;
   result
  --------
      -2
  (1 row)
  ```

- %

  Description: Model (to obtain the remainder)

  Example:

  ```
  openGauss=# SELECT 5%4 AS RESULT;
   result
  --------
       1
  (1 row)
  ```

- @

  Description: Absolute value

  Example:

  ```
  openGauss=# SELECT @ -5.0 AS RESULT;
   result
  --------
     5.0
  (1 row)
  ```

- ^

  Description: Power (exponent calculation)

  Example:

  ```
  openGauss=# SELECT 2.0^3.0 AS RESULT;
         result
  --------------------
  ```

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```
 8.0000000000000000
(1 row)
```

- |/

  Description: Square root

  Example:

```
openGauss=# SELECT |/ 25.0 AS RESULT;
 result
--------
      5
(1 row)
```

- ||/

  Description: Cubic root

  Example:

```
openGauss=# SELECT ||/ 27.0 AS RESULT;
 result
--------
      3
(1 row)
```

- !

  Description: Factorial

  Example:

```
openGauss=# SELECT 5! AS RESULT;
 result
--------
    120
(1 row)
```

- !!

  Description: Factorial (prefix operator)

  Example:

```
openGauss=# SELECT !!5 AS RESULT;
 result
--------
    120
(1 row)
```

- &

  Description: Binary AND

  Example:

```
openGauss=# SELECT 91&15  AS RESULT;
 result
--------
     11
(1 row)
```

- |

  Description: Binary OR

  Example:

```
openGauss=# SELECT 32|3  AS RESULT;
 result
--------
     35
(1 row)
```

- #

  Description: Binary XOR

  Example:

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```
openGauss=# SELECT 17#5  AS RESULT;
 result
--------
     20
(1 row)
```

- ~

  Description: Binary NOT

  Example:

```
openGauss=# SELECT ~1 AS RESULT;
 result
--------
     -2
(1 row)
```

- <<

  Description: Binary shift left

  Example:

```
openGauss=# SELECT 1<<4 AS RESULT;
 result
--------
     16
(1 row)
```

- >>

  Description: Binary shift right

  Example:

```
openGauss=# SELECT 8>>2 AS RESULT;
 result
--------
      2
(1 row)
```

## Arithmetic Functions

- abs(x)

  Description: Absolute value

  Return type: same as the input

  Example:

```
openGauss=# SELECT abs(-17.4);
 abs
------
 17.4
(1 row)
```

- acos(x)

  Description: Arc cosine

  Return type: double precision

  Example:

```
openGauss=# SELECT acos(-1);
       acos
------------------
 3.14159265358979
(1 row)
```

- asin(x)

  Description: Arc sine

  Return type: double precision

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Example:

```
openGauss=# SELECT asin(0.5);
       asin
------------------
 .523598775598299
(1 row)
```

- atan(x)

  Description: Arc tangent

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT atan(1);
        atan
  ------------------
   .785398163397448
  (1 row)
  ```

- atan2(y, x)

  Description: Arc tangent of y/x

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT atan2(2, 1);
       atan2
  ------------------
   1.10714871779409
  (1 row)
  ```

- bitand(integer, integer)

  Description: Performs AND (&) operation on two integers.

  Return type: bigint

  Example:

  ```
  openGauss=# SELECT bitand(127, 63);
   bitand
  --------
      63
  (1 row)
  ```

- cbrt(dp)

  Description: Cubic root

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT cbrt(27.0);
   cbrt
  ------
     3
  (1 row)
  ```

- ceil(x)

  Description: Minimum integer greater than or equal to the parameter

  Return type: integer

  Example:

  ```
  openGauss=# SELECT ceil(-42.8);
   ceil
  ------
    -42
  (1 row)
  ```

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- ceiling(dp or numeric)

  Description: Minimum integer (alias of ceil) greater than or equal to the parameter

  Return type: same as the input

  Example:

```
openGauss=# SELECT ceiling(-95.3);
 ceiling
---------
     -95
(1 row)
```

- cos(x)

  Description: Cosine

  Return type: double precision

  Example:

```
openGauss=# SELECT cos(-3.1415927);
        cos
--------------------
 -.999999999999999
(1 row)
```

- cot(x)

  Description: Cotangent

  Return type: double precision

  Example:

```
openGauss=# SELECT cot(1);
       cot
------------------
 .642092615934331
(1 row)
```

- degrees(dp)

  Description: Converts radians to angles.

  Return type: double precision

  Example:

```
openGauss=# SELECT degrees(0.5);
     degrees
------------------
 28.6478897565412
(1 row)
```

- div(y numeric, x numeric)

  Description: Integer part of y/x

  Return type: numeric

  Example:

```
openGauss=# SELECT div(9,4);
 div
-----
   2
(1 row)
```

- exp(x)

  Description: Natural exponent

  Return type: same as the input

  Example:

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```
openGauss=# SELECT exp(1.0);
        exp
--------------------
 2.7182818284590452
(1 row)
```

- floor(x)

  Description: Not larger than the maximum integer of the parameter

  Return type: same as the input

  Example:

```
openGauss=# SELECT floor(-42.8);
 floor
-------
   -43
(1 row)
```

- int1(in)

  Description: Converts the input text parameter to a value of the int1 type and returns the value.

  Return type: int1

  Example:

```
openGauss=# select int1('123');
 int1
------
 123
(1 row)
openGauss=# select int1('a');
 int1
------
   0
(1 row)
```

- int2(in)

  Description: Converts the input parameter to a value of the int2 type and returns the value. The supported input parameter types include bigint, float4, float8, int16, integer, numeric, real, and text.

  Return type: int2

  Example:

```
openGauss=# select int2('1234');
 int2
------
 1234
(1 row)
openGauss=# select int2(25.3);
 int2
------
   25
(1 row)
```

- int4(in)

  Description: Converts the input parameter to a value of the int4 type and returns the value. The supported input parameter types include bit, boolean, char, double precision, int16, numeric, real, smallint, and text

  Return type: int4

  Example:

```
openGauss=# select int4('789');
 int4
------
 789
```

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```
(1 row)
openGauss=# select int4(99.9);
 int4
------
   99
(1 row)
```

- int8(in)

  Description: Converts the input parameter to a value of the int8 type and returns the value. The supported input parameter types include bit, double precision, int16, integer, numeric, oid, real, smallint, and text.

  Return type: int8

  Example:

```
openGauss=# select int8('789');
 int8
------
 789
(1 row)
openGauss=# select int8(99.9);
 int8
------
   99
(1 row)
```

- float4(in)

  Description: Converts the input parameter to a value of the float4 type and returns the value. The supported input parameter types include bigint, double precision, int16, integer, numeric, smallint, and text.

  Return type: float4

  Example:

```
openGauss=# select float4('789');
 float4
--------
    789
(1 row)

openGauss=# select float4(99.9);
 float4
--------
   99.9
(1 row)
```

- float8(in)

  Description: Converts the input parameter to a value of the float8 type and returns the value. The supported input parameter types include bigint, int16, integer, numeric, real, smallint, and text.

  Return type: float8

  Example:

```
openGauss=# select float8('789');
 float8
--------
    789
(1 row)

openGauss=# select float8(99.9);
 float8
--------
   99.9
(1 row)
```

- int16(in)

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Description: Converts the input parameter to a value of the int16 type and returns the value. The supported input parameter types include bigint, boolean, double precision, integer, numeric, oid, real, smallint, and tinyint.

Return type: int16

Example:

```
openGauss=# select int16('789');
 int16
--------
    789
(1 row)

openGauss=# select int16(99.9);
 int16
--------
   99
(1 row)
```

- numeric(in)

  Description: Converts the input parameter to a value of the numeric type and returns the value. The supported input parameter types include bigint, boolean, double precision, int16, integer, money, real, and smallint.

  Return type: numeric

  Example:

  ```
  openGauss=# select "numeric"('789');
   numeric
  ---------
      789
  (1 row)

  openGauss=# select "numeric"(99.9);
   numeric
  ---------
    99.9
  (1 row)
  ```

- oid(in)

  Description: Converts the input parameter to a value of the oid type and returns the value. The supported input parameter types include bigint and int16.

  Return type: oid

- radians(dp)

  Description: Converts angles to radians.

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT radians(45.0);
      radians
  ------------------
   .785398163397448
  (1 row)
  ```

- random()

  Description: Random number between 0.0 and 1.0

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT random();
       random
  ------------------
  ```

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```
 .824823560658842
(1 row)
```

- multiply(x double precision or text, y double precision or text)

  Description: product of x and y.

  Return type: double precision

  Example:

```
openGauss=# SELECT multiply(9.0, '3.0');
    multiply
-------------------
              27
(1 row)
openGauss=# SELECT multiply('9.0', 3.0);
    multiply
-------------------
              27
(1 row)
```

- ln(x)

  Description: Natural logarithm

  Return type: same as the input

  Example:

```
openGauss=# SELECT ln(2.0);
        ln
-------------------
 .6931471805599453
(1 row)
```

- log(x)

  Description: Logarithm with 10 as the base

  Return type: same as the input

  Example:

```
openGauss=# SELECT log(100.0);
        log
--------------------
 2.0000000000000000
(1 row)
```

- log(b numeric, x numeric)

  Description: Logarithm with b as the base

  Return type: numeric

  Example:

```
openGauss=# SELECT log(2.0, 64.0);
        log
--------------------
 6.0000000000000000
(1 row)
```

- mod(x,y)

  Description:

  Remainder of x/y (model)

  If x equals to 0, y is returned.

  Return type: same as the parameter type

  Example:

```
openGauss=# SELECT mod(9,4);
 mod
-----
```

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```
  1
(1 row)
openGauss=# SELECT mod(9,0);
 mod
-----
   9
(1 row)
```

- pi()

  Description: π constant value

  Return type: double precision

  Example:

```
openGauss=# SELECT pi();
        pi
------------------
 3.14159265358979
(1 row)
```

- power(a double precision, b double precision)

  Description: b power of a

  Return type: double precision

  Example:

```
openGauss=# SELECT power(9.0, 3.0);
        power
----------------------
 729.0000000000000000
(1 row)
```

- round(x)

  Description: Integer closest to the input parameter

  Return type: same as the input

  Example:

```
openGauss=# SELECT round(42.4);
 round
-------
    42
(1 row)

openGauss=# SELECT round(42.6);
 round
-------
    43
(1 row)
```

- round(v numeric, s int)

  Description: **s** digits are kept after the decimal point.

  Return type: numeric

  Example:

```
openGauss=# SELECT round(42.4382, 2);
 round
-------
 42.44
(1 row)
```

- setseed(dp)

  Description: Sets seed for the following random() invoking (between –1.0 and 1.0, inclusive).

  Return type: void

  Example:

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```
openGauss=# SELECT setseed(0.54823);
 setseed
---------

(1 row)
```

- sign(x)

  Description: Returns symbols of this parameter.

  Return type: **–1** indicates negative numbers. **0** indicates 0, and **1** indicates positive numbers.

  Example:

```
openGauss=# SELECT sign(-8.4);
 sign
------
   -1
(1 row)
```

- sin(x)

  Description: Sine

  Return type: double precision

  Example:

```
openGauss=# SELECT sin(1.57079);
       sin
------------------
 .999999999979986
(1 row)
```

- sqrt(x)

  Description: Square root

  Return type: same as the input

  Example:

```
openGauss=# SELECT sqrt(2.0);
       sqrt
-------------------
 1.414213562373095
(1 row)
```

- tan(x)

  Description: Tangent

  Return type: double precision

  Example:

```
openGauss=# SELECT tan(20);
       tan
------------------
 2.23716094422474
(1 row)
```

- trunc(x)

  Description: Truncates (the integral part).

  Return type: same as the input

  Example:

```
openGauss=# SELECT trunc(42.8);
 trunc
-------
    42
(1 row)
```

- trunc(v numeric, s int)

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Description: Truncates a number with **s** digits after the decimal point.

Return type: numeric

Example:

```
openGauss=# SELECT trunc(42.4382, 2);
 trunc
-------
 42.43
(1 row)
```

- width_bucket(op numeric, b1 numeric, b2 numeric, count int)

  Description: Returns a bucket to which the operand will be assigned in an equi-depth histogram with **count** buckets, ranging from **b1** to **b2**.

  Return type: int

  Example:

  ```
  openGauss=# SELECT width_bucket(5.35, 0.024, 10.06, 5);
   width_bucket
  --------------
             3
  (1 row)
  ```

- width_bucket(op dp, b1 dp, b2 dp, count int)

  Description: Returns a bucket to which the operand will be assigned in an equi-depth histogram with **count** buckets, ranging from **b1** to **b2**.

  Return type: int

  Example:

  ```
  openGauss=# SELECT width_bucket(5.35, 0.024, 10.06, 5);
   width_bucket
  --------------
             3
  (1 row)
  ```

- int1abs

  Description: Returns the absolute value of data of the uint8 type.

  Parameter: tinyint

  Return type: tinyint

- int1and

  Description: Returns the bitwise AND result of two data records of the uint8 type.

  Parameter: tinyint, tinyint

  Return type: tinyint

- int1cmp

  Description: Returns the comparison result of two data records of the uint8 type. If the value of the first parameter is greater, **1** is returned. If the value of the second parameter is greater, **–1** is returned. If they are the same, **0** is returned.

  Parameter: tinyint, tinyint

  Return type: integer

- int1div

  Description: Returns the result of dividing two data records of the uint8 type. The result is of the float8 type.

  Parameter: tinyint, tinyint

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Return type: tinyint

- int1eq

  Description: Compares two pieces of data of the uint8 type to check whether they are the same.

  Parameter: tinyint, tinyint

  Return type: Boolean

- int1ge

  Description: Determines whether the value of the first parameter is greater than or equal to the value of the second parameter in two data records of the uint8 type.

  Parameter: tinyint, tinyint

  Return type: Boolean

- int1gt

  Description: Performs the greater-than operation on an unsigned 1-byte integer.

  Parameter: tinyint, tinyint

  Return type: Boolean

- int1larger

  Description: Returns the larger value of unsigned one-byte integers.

  Parameter: tinyint, tinyint

  Return type: tinyint

- int1le

  Description: Determines whether the unsigned 1-byte integer is less than or equal to.

  Parameter: tinyint, tinyint

  Return type: Boolean

- int1lt

  Description: Determines whether the unsigned 1-byte integer is less than.

  Parameter: tinyint, tinyint

  Return type: Boolean

- int1smaller

  Description: Returns the smaller of two unsigned one-byte integers.

  Parameter: tinyint, tinyint

  Return type: tinyint

- int1inc

  Description: Performs an addition operation on an unsigned 1-byte integer.

  Parameter: tinyint

  Return type: tinyint

- int1mi

  Description: Performs a minus operation on an unsigned 1-byte integer.

  Parameter: tinyint, tinyint

  Return type: tinyint

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- int1mod

  Description: Performs a reminder operation on an unsigned 1-byte integer.

  Parameter: tinyint, tinyint

  Return type: tinyint

- int1mul

  Description: Performs a multiplication operation on an unsigned 1-byte integer.

  Parameter: tinyint, tinyint

  Return type: tinyint

- int1ne

  Description: Performs a not-equal-to operation on an unsigned 1-byte integer.

  Parameter: tinyint, tinyint

  Return type: Boolean

- int1pl

  Description: Performs an addition operation on an unsigned 1-byte integer.

  Parameter: tinyint, tinyint

  Return type: tinyint

- int1um

  Description: Returns an unsigned 2-byte integer after subtracting the opposite number from the unsigned 1-byte integer.

  Parameter: tinyint

  Return type: smallint

- int1xor

  Description: Performs an exclusive OR operation on an unsigned 1-byte integer.

  Parameter: tinyint, tinyint

  Return type: tinyint

- cash_div_int1

  Description: Performs a division operation on the money type.

  Parameter: money, tinyint

  Return type: money

- cash_mul_int1

  Description: Performs a multiplication operation on the money type.

  Parameter: money, tinyint

  Return type: money

- int1not

  Description: Reverts binary bits of an unsigned 1-byte integer.

  Parameter: tinyint

  Return type: tinyint

- int1or

  Description: Performs an OR operation on an unsigned 1-byte integer.

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Parameter: tinyint, tinyint

Return type: tinyint

- int1shl

  Description: Shifts an unsigned 1-byte integer leftwards by a specified number of bits.

  Parameter: tinyint, integer

  Return type: tinyint

- int1shr

  Description: Shifts an unsigned 1-byte integer rightwards by a specified number of bits.

  Parameter: tinyint, integer

  Return type: tinyint

# 12.5.8 Date and Time Processing Functions and Operators

## Date and Time Operators

**WARNING**

When the user uses date and time operators, explicit type prefixes are modified for corresponding operands to ensure that the operands parsed by the database are consistent with what the user expects, and no unexpected results occur.

For example, abnormal mistakes will occur in the following example without an explicit data type.

```
SELECT date '2001-10-01' - '7' AS RESULT;
```

**Table 12-30** Time and date operators

| Operator | Example |
| --- | --- |
| + | openGauss=# SELECT date '2001-9-28' + integer '7' AS RESULT;<br>  result<br>------------<br> 2001-10-05<br>(1 row) |
| | openGauss=# SELECT date '2001-09-28' + interval '1 hour' AS RESULT;<br>  result<br>---------------------<br> 2001-09-28 01:00:00<br>(1 row) |
| | openGauss=# SELECT date '2001-09-28' + time '03:00' AS RESULT;<br>  result<br>---------------------<br> 2001-09-28 03:00:00<br>(1 row) |

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| Operator | Example |
| --- | --- |
| | openGauss=# SELECT interval '1 day' + interval '1 hour' AS RESULT;<br>  result<br>----------<br> 1 day 01:00:00<br>(1 row) |
| | openGauss=# SELECT timestamp '2001-09-28 01:00' + interval '23 hours' AS RESULT;<br>  result<br>----------<br> 2001-09-29 00:00:00<br>(1 row) |
| | openGauss=# SELECT time '01:00' + interval '3 hours' AS RESULT;<br>  result<br>----------<br> 04:00:00<br>(1 row) |
| - | openGauss=# SELECT date '2001-10-01' - date '2001-09-28' AS RESULT;<br> result<br>--------<br>  3<br>(1 row) |
| | openGauss=# SELECT date '2001-10-01' - integer '7' AS RESULT;<br>  result<br>----------<br> 2001-09-24 00:00:00<br>(1 row) |
| | openGauss=# SELECT date '2001-09-28' - interval '1 hour' AS RESULT;<br>  result<br>----------<br> 2001-09-27 23:00:00<br>(1 row) |
| | openGauss=# SELECT time '05:00' - time '03:00' AS RESULT;<br>  result<br>----------<br> 02:00:00<br>(1 row) |
| | openGauss=# SELECT time '05:00' - interval '2 hours' AS RESULT;<br>  result<br>----------<br> 03:00:00<br>(1 row) |
| | openGauss=# SELECT timestamp '2001-09-28 23:00' - interval '23 hours' AS RESULT;<br>  result<br>----------<br> 2001-09-28 00:00:00<br>(1 row) |
| | openGauss=# SELECT interval '1 day' - interval '1 hour' AS RESULT;<br>  result<br>----------<br> 23:00:00<br>(1 row) |
| | openGauss=# SELECT timestamp '2001-09-29 03:00' - timestamp '2001-09-27 12:00' AS RESULT;<br>  result<br>----------<br> 1 day 15:00:00<br>(1 row) |

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| Operator | Example |
| --- | --- |
| * | openGauss=# SELECT 900 * interval '1 second' AS RESULT;<br>  result<br>----------<br> 00:15:00<br>(1 row) |
| | openGauss=# SELECT 21 * interval '1 day' AS RESULT;<br> result<br>---------<br> 21 days<br>(1 row) |
| | openGauss=# SELECT double precision '3.5' * interval '1 hour' AS RESULT;<br>  result<br>----------<br> 03:30:00<br>(1 row) |
| / | openGauss=# SELECT interval '1 hour' / double precision '1.5' AS RESULT;<br>  result<br>----------<br> 00:40:00<br>(1 row) |

## Time and Date Functions

- age(timestamp, timestamp)

  Description: Subtracts parameters, producing a result in YYYY-MM-DD format. If the result is negative, the returned result is also negative. The input parameters can contain timezone or not.

  Return type: interval

  Example:

  ```
  openGauss=# SELECT age(timestamp '2001-04-10', timestamp '1957-06-13');
           age
  --------------------------
   43 years 9 mons 27 days
  (1 row)
  ```

- age(timestamp)

  Description: Minuses the current time with the parameter. The input parameter can contain timezone or not.

  Return type: interval

  Example:

  ```
  openGauss=# SELECT age(timestamp '1957-06-13');
           age
  --------------------------
   60 years 2 mons 18 days
  (1 row)
  ```

- clock_timestamp()

  Description: Specifies the current timestamp of the real-time clock. The volatile function obtains the latest timestamp for each scan. Therefore, the result of each call in a query is different.

  Return type: timestamp with time zone

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Example:

```
openGauss=# SELECT clock_timestamp();
       clock_timestamp
-------------------------------
 2017-09-01 16:57:36.636205+08
(1 row)
```

- current_date

  Description: Specifies the current date.

  Return type: date

  Example:

  ```
  openGauss=# SELECT current_date;
     date
  ------------
   2017-09-01
  (1 row)
  ```

- current_time

  Description: Specifies the current time.

  Return type: time with time zone

  Example:

  ```
  openGauss=# SELECT current_time;
       timetz
  --------------------
   16:58:07.086215+08
  (1 row)
  ```

- current_timestamp

  Description: Specifies the current date and time. This is a statement-level timestamp. The returned results within the same statement remain unchanged.

  Return type: timestamp with time zone

  Example:

  ```
  openGauss=# SELECT current_timestamp;
       pg_systimestamp
  -------------------------------
   2017-09-01 16:58:19.22173+08
  (1 row)
  ```

- date_part(text, timestamp)

  Description:

  Retrieves subcolumns such as year or hour from date/time values.

  It is equivalent to **extract(field from timestamp)**.

  Timestamp types: abstime, date, interval, reltime, time with time zone, time without time zone, timestamp with time zone, timestamp without time zone

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT date_part('hour', timestamp '2001-02-16 20:38:40');
   date_part
  -----------
          20
  (1 row)
  ```

- date_part(text, interval)

  Description: Obtains the month. If the value is greater than 12, obtain the remainder after it is divided by 12. It is equivalent to **extract(field from timestamp)**.

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Return type: double precision

Example:

```
openGauss=# SELECT date_part('month', interval '2 years 3 months');
 date_part
-----------
         3
(1 row)
```

- date_trunc(text, timestamp)

  Description: Truncates to the precision specified by **text**.

  Return type: interval, timestamp with time zone, timestamp without time zone

  Example:

```
openGauss=# SELECT date_trunc('hour', timestamp  '2001-02-16 20:38:40');
     date_trunc
---------------------
 2001-02-16 20:00:00
(1 row)
```

- trunc(timestamp)

  Description: Truncates to day by default.

  Example:

```
openGauss=# SELECT trunc(timestamp  '2001-02-16
20:38:40');
                        trunc
---------------------
2001-02-16 00:00:00
(1 row)
```

- trunc(arg1, arg2)

  Description: Truncates to the precision specified by **arg2**.

  Type of **arg1**: interval, timestamp with time zone, timestamp without time zone

  Type of **arg2**: text

  Return type: interval, timestamp with time zone, timestamp without time zone

  Example:

```
openGauss=# SELECT trunc(timestamp  '2001-02-16 20:38:40',
'hour');
                     trunc
---------------------
2001-02-16 20:00:00
(1 row)
```

- daterange(arg1, arg2)

  Description: Obtains time boundary information.

  **arg1** type: date

  **arg2** type: date

  Return type: daterange

  Example:

```
openGauss=# select daterange('2000-05-06','2000-08-08');
       daterange
-------------------------
 [2000-05-06,2000-08-08)
(1 row)
```

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- daterange(arg1, arg2, text)

  Description: Obtains time boundary information.

  **arg1** type: date

  **arg2** type: date

  **text** type: text

  Return type: daterange

  Example:

```
openGauss=# select daterange('2000-05-06','2000-08-08','[]');
       daterange
-------------------------
 [2000-05-06,2000-08-09)
(1 row)
```

- extract(field from timestamp)

  Description: Obtains the hour.

  Return type: double precision

  Example:

```
openGauss=# SELECT extract(hour from timestamp '2001-02-16 20:38:40');
 date_part
-----------
        20
(1 row)
```

- extract(field from interval)

  Description: Obtains the month. If the value is greater than 12, obtain the remainder after it is divided by 12.

  Return type: double precision

  Example:

```
openGauss=# SELECT extract(month from interval '2 years 3 months');
 date_part
-----------
         3
(1 row)
```

- isfinite(date)

  Description: Tests for a valid date.

  Return type: Boolean

  Example:

```
openGauss=# SELECT isfinite(date '2001-02-16');
 isfinite
----------
 t
(1 row)
```

- isfinite(timestamp)

  Description: Tests for a valid timestamp.

  Return type: Boolean

  Example:

```
openGauss=# SELECT isfinite(timestamp '2001-02-16 21:28:30');
 isfinite
----------
 t
(1 row)
```

- isfinite(interval)

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Description: Tests for a valid interval.

Return type: Boolean

Example:

```
openGauss=# SELECT isfinite(interval '4 hours');
 isfinite
----------
 t
(1 row)
```

- justify_days(interval)

  Description: Adjusts intervals to 30-day time periods, which are represented as months.

  Return type: interval

  Example:

  ```
  openGauss=# SELECT justify_days(interval '35 days');
   justify_days
  --------------
   1 mon 5 days
  (1 row)
  ```

- justify_hours(interval)

  Description: Sets the time interval in days (24 hours is one day).

  Return type: interval

  Example:

  ```
  openGauss=# SELECT JUSTIFY_HOURS(INTERVAL '27 HOURS');
   justify_hours
  ----------------
   1 day 03:00:00
  (1 row)
  ```

- justify_interval(interval)

  Description: Adjusts **interval** using **justify_days** and **justify_hours**.

  Return type: interval

  Example:

  ```
  openGauss=# SELECT JUSTIFY_INTERVAL(INTERVAL '1 MON -1 HOUR');
   justify_interval
  ------------------
   29 days 23:00:00
  (1 row)
  ```

- localtime

  Description: Specifies the current time.

  Return type: time

  Example:

  ```
  openGauss=# SELECT localtime AS RESULT;
      result
  ----------------
   16:05:55.664681
  (1 row)
  ```

- localtimestamp

  Description: Specifies the current date and time.

  Return type: timestamp

  Example:

  ```
  openGauss=# SELECT localtimestamp;
          timestamp
  ```

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```
----------------------------
 2017-09-01 17:03:30.781902
(1 row)
```

- now()

  Description: Specifies the current date and time. This is a transaction-level timestamp. The results returned within the same transaction remain unchanged.

  Return type: timestamp with time zone

  Example:

```
openGauss=# SELECT now();
              now
-------------------------------
 2017-09-01 17:03:42.549426+08
(1 row)
```

- timenow()

  Description: Specifies the current date and time.

  Return type: timestamp with time zone

  Example:

```
openGauss=# select timenow();
       timenow
------------------------
 2020-06-23 20:36:56+08
(1 row)
```

- numtodsinterval(num, interval_unit)

  Description: Converts a number to the interval type. **num** is a numeric-typed number. **interval_unit** is a string in the following format: 'DAY' | 'HOUR' | 'MINUTE' | 'SECOND'

  You can set the **IntervalStyle** parameter to **oracle** to be compatible with the interval output format of the function in the Oracle database.

  Example:

```
openGauss=# SELECT numtodsinterval(100, 'HOUR');
 numtodsinterval
-----------------
 100:00:00
(1 row)

openGauss=# SET intervalstyle = oracle;
SET
openGauss=# SELECT numtodsinterval(100, 'HOUR');
       numtodsinterval
------------------------------
 +000000004 04:00:00.000000000
(1 row)
```

- pg_sleep(seconds)

  Description: Specifies the delay time of the server thread in unit of second. Note that when the database invokes this function, the corresponding transaction snapshot is obtained, which is equivalent to a long transaction. If the input parameter time is too long, the database **oldestxmin** may fail to be executed, affecting the table recycling and query performance.

  Return type: void

  Example:

```
openGauss=# SELECT pg_sleep(10);
 pg_sleep
----------
```

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```
(1 row)
```

- statement_timestamp()

  Description: Specifies the current date and time.

  Return type: timestamp with time zone

  Example:

  ```
  openGauss=# SELECT statement_timestamp();
       statement_timestamp
  -------------------------------
   2017-09-01 17:04:39.119267+08
  (1 row)
  ```

- sysdate

  Description: Specifies the current date and time.

  Return type: timestamp

  Example:

  ```
  openGauss=# SELECT sysdate;
        sysdate
  ---------------------
   2017-09-01 17:04:49
  (1 row)
  ```

- timeofday()

  Description: Specifies the current date and time (like **clock_timestamp**, but returned as a **text** string)

  Return type: text

  Example:

  ```
  openGauss=# SELECT timeofday();
               timeofday
  -------------------------------------
   Fri Sep 01 17:05:01.167506 2017 CST
  (1 row)
  ```

- transaction_timestamp()

  Description: Specifies the current date and time (equivalent to **current_timestamp**)

  Return type: timestamp with time zone

  Example:

  ```
  openGauss=# SELECT transaction_timestamp();
      transaction_timestamp
  -------------------------------
   2017-09-01 17:05:13.534454+08
  (1 row)
  ```

- add_months(d,n)

  Description: Returns the date *date* plus *integer* months.

  **d**: indicates the value of the timestamp type and the value that can be implicitly converted to the timestamp type.

  **n**: indicates the value of the INTEGER type and the value that can be implicitly converted to the INTEGER type.

  Return type: timestamp

  Example:

  ```
  openGauss=# SELECT add_months(to_date('2017-5-29', 'yyyy-mm-dd'), 11) FROM sys_dummy;
      add_months
  ---------------------
  ```

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```
 2018-04-29 00:00:00
(1 row)
```

- last_day(d)

  Description: Returns the date of the last day of the month that contains *date*.

  Return type: timestamp

  Example:

  ```
  openGauss=# select last_day(to_date('2017-01-01', 'YYYY-MM-DD')) AS cal_result;
      cal_result
  ---------------------
   2017-01-31 00:00:00
  (1 row)
  ```

- next_day(x,y)

  Description: Calculates the time of the next week y started from x.

  Return type: timestamp

  Example:

  ```
  openGauss=# select next_day(timestamp '2017-05-25 00:00:00','Sunday')AS cal_result;
      cal_result
  ---------------------
   2017-05-28 00:00:00
  (1 row)
  ```

- tinterval(abstime, abstime)

  Description: Creates a time interval with two pieces of absolute time.

  Return type: tinterval

  Example:

  ```
  openGauss=# call tinterval(abstime 'May 10, 1947 23:59:12', abstime 'Mon May  1 00:30:30 1995');
                       tinterval
  ------------------------------------------------------
   ["1947-05-10 23:59:12+08" "1995-05-01 00:30:30+08"]
  (1 row)
  ```

- tintervalend(tinterval)

  Description: Returns the end time of tinterval.

  Return type: abstime

  Example:

  ```
  openGauss=# select tintervalend('["Sep 4, 1983 23:59:12" "Oct4, 1983 23:59:12"]');
       tintervalend
  ------------------------
   1983-10-04 23:59:12+08
  (1 row)
  ```

- tintervalrel(tinterval)

  Description: Calculates and returns the relative time of **tinterval**.

  Return type: reltime

  Example:

  ```
  openGauss=# select tintervalrel('["Sep 4, 1983 23:59:12" "Oct4, 1983 23:59:12"]');
   tintervalrel
  --------------
   1 mon
  (1 row)
  ```

- smalldatetime_ge

  Description: Determines whether the first parameter is greater than the second.

  Parameter: smalldatetime, smalldatetime

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Return type: Boolean

- smalldatetime_cmp

  Description: Compares two smalldatetime values to check whether they are the same.

  Parameter: smalldatetime, smalldatetime

  Return type: integer

- smalldatetime_eq

  Description: Compares two smalldatetime values to check whether they are the same.

  Parameter: smalldatetime, smalldatetime

  Return type: Boolean

- smalldatetime_gt

  Description: Determines whether the first parameter is less than the second parameter.

  Parameter: smalldatetime, smalldatetime

  Return type: Boolean

- smalldatetime_hash

  Description: Calculates the hash value corresponding to a timestamp.

  Parameter: smalldatetime

  Return type: integer

- smalldatetime_in

  Description: Inputs a timestamp.

  Parameter: cstring, oid, integer

  Return type: smalldatetime

- smalldatetime_larger

  Description: Returns a larger timestamp.

  Parameter: smalldatetime, smalldatetime

  Return type: smalldatetime

- smalldatetime_le

  Description: Determines whether the first parameter is less than the second parameter.

  Parameter: smalldatetime, smalldatetime

  Return type: Boolean

- smalldatetime_lt

  Description: Determines whether the first parameter is greater than the second.

  Parameter: smalldatetime, smalldatetime

  Return type: Boolean

- smalldatetime_ne

  Description: Compares two timestamps to check whether they are different.

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Parameter: smalldatetime, smalldatetime
Return type: Boolean

- smalldatetime_out
  Description: Converts a timestamp into the external form.
  Parameter: smalldatetime
  Return type: cstring
- smalldatetime_send
  Description: Converts a timestamp to the binary format.
  Parameter: smalldatetime
  Return type: bytea
- smalldatetime_smaller
  Description: Returns a smaller smalldatetime.
  Parameter: smalldatetime, smalldatetime
  Return type: smalldatetime
- smalldatetime_to_abstime
  Description: Converts smalldatetime to abstime.
  Parameter: smalldatetime
  Return type: abstime
- smalldatetime_to_time
  Description: Converts smalldatetime to time.
  Parameter: smalldatetime
  Return type: time without time zone
- smalldatetime_to_timestamp
  Description: Converts smalldatetime to timestamp.
  Parameter: smalldatetime
  Return type: timestamp without time zone
- smalldatetime_to_timestamptz
  Description: Converts smalldatetime to timestamptz.
  Parameter: smalldatetime
  Return type: timestamp with time zone
- smalldatetime_to_varchar2
  Description: Converts smalldatetime to varchar2.
  Parameter: smalldatetime
  Return type: character varying

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NOTE

There are multiple methods for obtaining the current time. Select an appropriate API based on the actual service scenario.

(1) The following APIs return values based on the start time of the current transaction:

```
CURRENT_DATE CURRENT_TIME CURRENT_TIME(precision) CURRENT_TIMESTAMP(precision)
LOCALTIME LOCALTIMESTAMP LOCALTIME(precision) LOCALTIMESTAMP(precision)
```

The values transferred by **CURRENT_TIME** and **CURRENT_TIMESTAMP(precision)** contain time zone information. The values transferred by **LOCALTIME** and **LOCALTIMESTAMP** do not contain time zone information. **CURRENT_TIME**, **LOCALTIME**, and **LOCALTIMESTAMP** can be optionally attached with a precision parameter, which rounds the second field of the result to the specified decimal place. If there is no precision parameter, the result is given the full precision that can be obtained.

Because these functions all return results by the start time of the current transaction, their values do not change throughout the transaction. We think this is a feature with the purpose to allow a transaction to have a consistent concept at the "current" time, so that multiple modifications in the same transaction can maintain the same timestamp.

(2) The following APIs return the start time of the current statement:

```
transaction_timestamp() statement_timestamp() now()
```

**transaction_timestamp()** is equivalent to **CURRENT_TIMESTAMP(precision)**, and its name clearly reflects its return value. **statement_timestamp()** returns the start time of the current statement (more accurately, the time when the last instruction is received from the client). The return values of **statement_timestamp()** and **transaction_timestamp()** are the same during the execution of the first instruction of a transaction, but may be different in subsequent commands.

**now()** is equivalent to **transaction_timestamp()**.

(3) The following APIs return the actual "current" time when the function is called:

```
clock_timestamp() timeofday()
```

**clock_timestamp()** returns the actual current time, and its value changes even in the same SQL command. Similar to **clock_timestamp()**, **timeofday()** also returns the actual current time. However, the result of **timeofday()** is a formatted text string instead of a timestamp with time zone information.

**Table 12-31** shows the templates for truncating date/time values.

**Table 12-31** Truncating date/time values

| Item | Format | Description |
| --- | --- | --- |
| Microsecond | MICROSECON | Truncates date/time values, accurate to the microsecond (000000–999999). |
| | US | |
| | USEC | |
| | USECOND | |
| Millisecond | MILLISECON | Truncates date/time values, accurate to the millisecond (000–999). |
| | MS | |
| | MSEC | |
| | MSECOND | |

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| Item | Format | Description |
| --- | --- | --- |
| Second | S | Truncates date/time values, accurate to the second (00–59). |
| | SEC | |
| | SECOND | |
| Minute | M | Truncates date/time values, accurate to the minute (00–59). |
| | MI | |
| | MIN | |
| | MINUTE | |
| Hour | H | Truncates date/time values, accurate to the hour (00–23). |
| | HH | |
| | HOUR | |
| | HR | |
| Day | D | Truncates date/time values, accurate to the day (01-01 to 12–31) |
| | DAY | |
| | DD | |
| | DDD | |
| | J | |
| Week | W | Truncates date/time values, accurate to the week (the first day of the current week). |
| | WEEK | |
| Month | MM | Truncates date/time values, accurate to the month (the first day of the current month). |
| | MON | |
| | MONTH | |
| Quarter | Q | Truncates date/time values, accurate to the quarter (the first day of the current quarter). |
| | QTR | |
| | QUARTER | |
| Year | Y | Truncates date/time values, accurate to the year (the first day of the current year). |
| | YEAR | |
| | YR | |
| | YYYY | |
| Decade | DEC | Truncates date/time values, accurate to the decade (the first day of the current decade). |
| | DECADE | |

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| Item | Format | Description |
| --- | --- | --- |
| Century | C | Truncates date/time values, accurate to the century (the first day of the current century). |
| | CC | |
| | CENT | |
| | CENTURY | |
| Millennium | MIL | Truncates date/time values, accurate to the millennium (the first day of the current millennium). |
| | MILLENNIA | |
| | MILLENNIUM | |

## TIMESTAMPDIFF

- **TIMESTAMPDIFF(***unit , timestamp_expr1, timestamp_expr2***)**

  The **timestampdiff** function returns the result of **timestamp_expr2** - **timestamp_expr1** in the specified unit. **timestamp_expr1** and **timestamp_expr2** must be value expressions of the **timestamp**, **timestamptz**, or **date** type. **unit** specifies the unit of the difference between two dates.

  NOTE

  This function is valid only when GaussDB is compatible with MySQL (that is, **dbcompatibility** is set to **'MYSQL'**).

- year

  Year.

  ```
  openGauss=# SELECT TIMESTAMPDIFF(YEAR, '2018-01-01', '2020-01-01');
   timestamp_diff
  ----------------
                2
  (1 row)
  ```

- quarter

  Quarter.

  ```
  openGauss=# SELECT TIMESTAMPDIFF(QUARTER, '2018-01-01', '2020-01-01');
   timestamp_diff
  ----------------
                8
  (1 row)
  ```

- month

  Month.

  ```
  openGauss=# SELECT TIMESTAMPDIFF(MONTH, '2018-01-01', '2020-01-01');
   timestamp_diff
  ----------------
               24
  (1 row)
  ```

- week

  Week.

  ```
  openGauss=# SELECT TIMESTAMPDIFF(WEEK, '2018-01-01', '2020-01-01');
   timestamp_diff
  ```

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```
----------------
           104
(1 row)
```

- day

  Day.

```
openGauss=# SELECT TIMESTAMPDIFF(DAY, '2018-01-01', '2020-01-01');
 timestamp_diff
----------------
           730
(1 row)
```

- hour

  Hour.

```
openGauss=# SELECT TIMESTAMPDIFF(HOUR, '2020-01-01 10:10:10', '2020-01-01 11:11:11');
 timestamp_diff
----------------
             1
(1 row)
```

- minute

  Minute.

```
openGauss=# SELECT TIMESTAMPDIFF(MINUTE, '2020-01-01 10:10:10', '2020-01-01 11:11:11');
 timestamp_diff
----------------
            61
(1 row)
```

- second

  Second.

```
openGauss=# SELECT TIMESTAMPDIFF(SECOND, '2020-01-01 10:10:10', '2020-01-01 11:11:11');
 timestamp_diff
----------------
          3661
(1 row)
```

- microseconds

  The seconds column, including fractional parts, is multiplied by 1,000,000.

```
openGauss=# SELECT TIMESTAMPDIFF(MICROSECOND, '2020-01-01 10:10:10.000000', '2020-01-01
10:10:10.111111');
 timestamp_diff
----------------
        111111
(1 row)
```

- timestamp_expr with the time zone

```
openGauss=# SELECT TIMESTAMPDIFF(HOUR,'2020-05-01 10:10:10-01','2020-05-01 10:10:10-03');
 timestamp_diff
----------------
             2
(1 row)
```

## EXTRACT

- **EXTRACT(***field* **FROM** *source***)**

  The **extract** function retrieves subcolumns such as year or hour from date/time values. **source** must be a value expression of type **timestamp**, **time**, or **interval**. (Expressions of type **date** are cast to **timestamp** and can therefore be used as well.) **field** is an identifier or string that selects what column to extract from the source value. The **extract** function returns values of type **double precision**. The following are valid **field** names:

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- century

  Century.

  The first century starts at 0001-01-01 00:00:00 AD. This definition applies to all Gregorian calendar countries. There is no century number 0. You go from **-1** century to **1** century.

  Example:

  ```
  openGauss=# SELECT EXTRACT(CENTURY FROM TIMESTAMP '2000-12-16 12:21:13');
   date_part
  -----------
         20
  (1 row)
  ```

- day
  - For **timestamp** values, the day (of the month) column (1–31)

    ```
    openGauss=# SELECT EXTRACT(DAY FROM TIMESTAMP '2001-02-16 20:38:40');
     date_part
    -----------
          16
    (1 row)
    ```

  - For **interval** values, the number of days

    ```
    openGauss=# SELECT EXTRACT(DAY FROM INTERVAL '40 days 1 minute');
     date_part
    -----------
          40
    (1 row)
    ```

- decade

  Year column divided by 10

  ```
  openGauss=# SELECT EXTRACT(DECADE FROM TIMESTAMP '2001-02-16 20:38:40');
   date_part
  -----------
        200
  (1 row)
  ```

- dow

  Day of the week as Sunday (**0**) to Saturday (**6**)

  ```
  openGauss=# SELECT EXTRACT(DOW FROM TIMESTAMP '2001-02-16 20:38:40');
   date_part
  -----------
          5
  (1 row)
  ```

- doy

  Day of the year (1–365 or 366)

  ```
  openGauss=# SELECT EXTRACT(DOY FROM TIMESTAMP '2001-02-16 20:38:40');
   date_part
  -----------
        47
  (1 row)
  ```

- epoch
  - For **timestamp with time zone** values, the number of seconds since 1970-01-01 00:00:00-00 UTC (can be negative).

    For **date** and **timestamp** values, the number of seconds since 1970-01-01 00:00:00-00 local time.

    For **interval** values, the total number of seconds in the interval.

    ```
    openGauss=# SELECT EXTRACT(EPOCH FROM TIMESTAMP WITH TIME ZONE '2001-02-16
    20:38:40.12-08');
      date_part
    --------------
    ```

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```
 982384720.12
(1 row)
openGauss=# SELECT EXTRACT(EPOCH FROM INTERVAL '5 days 3 hours');
 date_part
-----------
    442800
(1 row)
```

  - Way to convert an epoch value back to a timestamp

```
openGauss=# SELECT TIMESTAMP WITH TIME ZONE 'epoch' + 982384720.12 * INTERVAL '1
second' AS RESULT;
          result
---------------------------
 2001-02-17 12:38:40.12+08
(1 row)
```

- hour

  Hour column (0–23)

```
openGauss=# SELECT EXTRACT(HOUR FROM TIMESTAMP '2001-02-16 20:38:40');
 date_part
-----------
        20
(1 row)
```

- isodow

  Day of the week (1–7)

  Monday is 1 and Sunday is 7.

  **NOTE**

  This is identical to **dow** except for Sunday.

```
openGauss=# SELECT EXTRACT(ISODOW FROM TIMESTAMP '2001-02-18 20:38:40');
 date_part
-----------
         7
(1 row)
```

- isoyear

  The ISO 8601 year that the date falls in (not applicable to intervals).

  Each ISO year begins with the Monday of the week containing January 4, so in early January or late December the ISO year may be different from the Gregorian year. See the **week** column for more information.

```
openGauss=# SELECT EXTRACT(ISOYEAR FROM DATE '2006-01-01');
 date_part
-----------
      2005
(1 row)
openGauss=# SELECT EXTRACT(ISOYEAR FROM DATE '2006-01-02');
 date_part
-----------
      2006
(1 row)
```

- microseconds

  The seconds column, including fractional parts, is multiplied by 1,000,000.

```
openGauss=# SELECT EXTRACT(MICROSECONDS FROM TIME '17:12:28.5');
 date_part
-----------
  28500000
(1 row)
```

- millennium

  Millennium.

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Years in the 1900s are in the second millennium. The third millennium started from January 1, 2001.

```
openGauss=# SELECT EXTRACT(MILLENNIUM FROM TIMESTAMP '2001-02-16 20:38:40');
 date_part
-----------
         3
(1 row)
```

- milliseconds

  Seconds column, including fractional parts, is multiplied by 1000. Note that this includes full seconds.

```
openGauss=# SELECT EXTRACT(MILLISECONDS FROM TIME '17:12:28.5');
 date_part
-----------
     28500
(1 row)
```

- minute

  Minutes column (0–59).

```
openGauss=# SELECT EXTRACT(MINUTE FROM TIMESTAMP '2001-02-16 20:38:40');
 date_part
-----------
        38
(1 row)
```

- month

  For **timestamp** values, the specific month in the year (1–12).

```
openGauss=# SELECT EXTRACT(MONTH FROM TIMESTAMP '2001-02-16 20:38:40');
 date_part
-----------
         2
(1 row)
```

  For **interval** values, the number of months, modulo 12 (0–11).

```
openGauss=# SELECT EXTRACT(MONTH FROM INTERVAL '2 years 13 months');
 date_part
-----------
         1
(1 row)
```

- quarter

  Quarter of the year (1–4) that the date is in.

```
openGauss=# SELECT EXTRACT(QUARTER FROM TIMESTAMP '2001-02-16 20:38:40');
 date_part
-----------
         1
(1 row)
```

- second

  Seconds column, including fractional parts (0–59).

```
openGauss=# SELECT EXTRACT(SECOND FROM TIME '17:12:28.5');
 date_part
-----------
      28.5
(1 row)
```

- timezone

  Time zone offset from UTC, measured in seconds. Positive values correspond to time zones east of UTC, negative values to zones west of UTC.

- timezone_hour

  Hour component of the time zone offset.

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- timezone_minute

  Minute component of the time zone offset.

- week

  Number of the week of the year that the day is in. By definition (ISO 8601), the first week of a year contains January 4 of that year. (The ISO-8601 week starts on Monday.) In other words, the first Thursday of a year is in week 1 of that year.

  Because of this, it is possible for early January dates to be part of the 52nd or 53rd week of the previous year, and late December dates to be part of the 1st week of the next year. For example, **2005-01-01** is part of the 53rd week of year 2004, **2006-01-01** is part of the 52nd week of year 2005, and **2012-12-31** is part of the 1st week of year 2013. You are advised to use the columns **isoyear** and **week** together to ensure consistency.

  ```
  openGauss=# SELECT EXTRACT(WEEK FROM TIMESTAMP '2001-02-16 20:38:40');
   date_part
  -----------
           7
  (1 row)
  ```

- year

  Year column.

  ```
  openGauss=# SELECT EXTRACT(YEAR FROM TIMESTAMP '2001-02-16 20:38:40');
   date_part
  -----------
        2001
  (1 row)
  ```

## date_part

The **date_part** function is modeled on the traditional Ingres equivalent to the SQL-standard function **extract**:

**date_part('***field***',** *source***)**

Note that here the **field** parameter needs to be a string value, not a name. The valid field names for **date_part** are the same as for **extract**. For details, see **EXTRACT**.

Example:

```
openGauss=# SELECT date_part('day', TIMESTAMP '2001-02-16 20:38:40');
 date_part
-----------
          16
(1 row)
openGauss=# SELECT date_part('hour', INTERVAL '4 hours 3 minutes');
 date_part
-----------
           4
(1 row)
```

**Table 12-32** specifies the schema for formatting date and time values.

**Table 12-32** Schema for formatting date and time

| Category | Format | Description |
| --- | --- | --- |
| Hour | HH | Number of hours in one day (01–12) |

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| Category | Format | Description |
| --- | --- | --- |
| | HH12 | Number of hours in one day (01–12) |
| | HH24 | Number of hours in one day (00–23) |
| Minute | MI | Minute (00–59) |
| Second | SS | Second (00–59) |
| | FF | Microsecond (000000–999999) |
| | SSSSS | Second after midnight (0–86399) |
| Morning and afternoon | AM or A.M. | Morning identifier |
| | PM or P.M. | Afternoon identifier |
| Year | Y,YYY | Year with comma (with four digits or more) |
| | SYYYY | Year with four digits BC |
| | YYYY | Year (with four digits or more) |
| | YYY | Last three digits of a year |
| | YY | Last two digits of a year |
| | Y | Last one digit of a year |
| | IYYY | ISO year (with four digits or more) |
| | IYY | Last three digits of an ISO year |
| | IY | Last two digits of an ISO year |
| | I | Last one digit of an ISO year |
| | RR | Last two digits of a year (A year of the 20th century can be stored in the 21st century.) |
| | RRRR | Capable of receiving a year with four digits or two digits. If there are 2 digits, the value is the same as the returned value of RR. If there are 4 digits, the value is the same as YYYY. |
| | • BC or B.C.<br>• AD or A.D. | Era indicator Before Christ (BC) and After Christ (AD) |
| Month | MONTH | Full spelling of a month in uppercase (9 characters are filled in if the value is empty.) |
| | MON | Month in abbreviated format in uppercase (with three characters) |
| | MM | Month (01–12) |
| | RM | Month in Roman numerals (I–XII; I=JAN) and uppercase |

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| Category | Format | Description |
| --- | --- | --- |
| Day | DAY | Full spelling of a date in uppercase (9 characters are filled in if the value is empty.) |
| | DY | Day in abbreviated format in uppercase (with three characters) |
| | DDD | Day in a year (001–366) |
| | DD | Day in a month (01–31) |
| | D | Day in a week (1–7). |
| Week | W | Week in a month (1–5) (The first week starts from the first day of the month.) |
| | WW | Week in a year (1–53) (The first week starts from the first day of the year.) |
| | IW | Week in an ISO year (The first Thursday is in the first week.) |
| Century | CC | Century (with two digits) (The 21st century starts from 2001-01-01.) |
| Julian date | J | Julian date (starting from January 1 of 4712 BC) |
| Quarter | Q | Quarter |

**NOTE**

In the table, the rules for RR to calculate years are as follows:

- If the range of the input two-digit year is between 00 and 49:

  If the last two digits of the current year are between 00 and 49, the first two digits of the returned year are the same as the first two digits of the current year.

  If the last two digits of the current year are between 50 and 99, the first two digits of the returned year equal to the first two digits of the current year plus 1.
- If the range of the input two-digit year is between 50 and 99:

  If the last two digits of the current year are between 00 and 49, the first two digits of the returned year equal to the first two digits of the current year minus 1.

  If the last two digits of the current year are between 50 and 99, the first two digits of the returned year are the same as the first two digits of the current year.

# 12.5.9 Type Conversion Functions

## Type Conversion Functions

- cash_words(money)

  Description: Type conversion function, which converts money into text.

  Example:

```
openGauss=# SELECT cash_words('1.23');
        cash_words
```

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```
-----------------------------------
 One dollar and twenty three cents
(1 row)
```

- cast(x as y)

  Description: Converts x into the type specified by y.

  Example:

```
openGauss=# SELECT cast('22-oct-1997' as timestamp);
      timestamp
---------------------
 1997-10-22 00:00:00
(1 row)
```

- hextoraw(raw)

  Description: Converts a string in hexadecimal format into binary format.

  Return type: raw

  Example:

```
openGauss=# SELECT hextoraw('7D');
 hextoraw
----------
 7D
(1 row)
```

- numtoday(numeric)

  Description: Converts values of the number type into the timestamp of the specified type.

  Return type: timestamp

  Example:

```
openGauss=# SELECT numtoday(2);
 numtoday
----------
 2 days
(1 row)
```

- pg_systimestamp()

  Description: Obtains the system timestamp.

  Return type: timestamp with time zone

  Example:

```
openGauss=# SELECT pg_systimestamp();
        pg_systimestamp
-------------------------------
 2015-10-14 11:21:28.317367+08
(1 row)
```

- rawtohex(string)

  Description: Converts a string in binary format into hexadecimal format.

  The result is the ACSII code of the input characters in hexadecimal format.

  Return type: varchar

  Example:

```
openGauss=# SELECT rawtohex('1234567');
    rawtohex
----------------
 31323334353637
(1 row)
```

- to_bigint(varchar)

  Description: Converts the character type to the bigint type.

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Return type: bigint

Example:

```
openGauss=# SELECT to_bigint('123364545554455');
    to_bigint
----------------
 123364545554455
(1 row)
```

- to_char (datetime/interval [, fmt])

  Description: Converts a DATETIME or INTERVAL value of the DATE/TIMESTAMP/TIMESTAMP WITH TIME ZONE/TIMESTAMP WITH LOCAL TIME ZONE type into the VARCHAR type according to the format specified by **fmt**.

  – The optional parameter **fmt** allows for the following types: date, time, week, quarter, and century. Each type has a unique template. The templates can be combined together. Common templates include: HH, MM, SS, YYYY, MM, and DD.

  – A template may have a modification word. FM is a common modification word and is used to suppress the preceding zero or the following blank spaces.

  Return type: varchar

  Example:

```
openGauss=# SELECT to_char(current_timestamp,'HH12:MI:SS');
 to_char
----------
 10:19:26
(1 row)
openGauss=# SELECT to_char(current_timestamp,'FMHH12:FMMI:FMSS');
 to_char
----------
 10:19:46
(1 row)
```

- to_char(double precision/real, text)

  Description: Converts the values of the floating point type into the strings in the specified format.

  Return type: text

  Example:

```
openGauss=# SELECT to_char(125.8::real, '999D99');
 to_char
---------
  125.80
(1 row)
```

- to_char (numeric/smallint/integer/bigint/double precision/real[, fmt])

  Descriptions: Converts an integer or a value in floating point format into a string in specified format.

  – The optional parameter **fmt** allows for the following types: decimal characters, grouping characters, positive/negative sign and currency sign. Each type has a unique template. The templates can be combined together. Common templates include: 9, 0, millesimal sign (,), and decimal point (.).

  – A template can have a modification word, similar to FM. However, FM does not suppress 0 which is output according to the template.

  – Use the template X or x to convert an integer value into a string in hexadecimal format.

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Return type: varchar

Example:

```
openGauss=# SELECT to_char(1485,'9,999');
 to_char
---------
  1,485
(1 row)
openGauss=# SELECT to_char( 1148.5,'9,999.999');
  to_char
------------
  1,148.500
(1 row)
openGauss=# SELECT to_char(148.5,'990999.909');
   to_char
--------------
    0148.500
(1 row)
openGauss=# SELECT to_char(123,'XXX');
 to_char
---------
   7B
(1 row)
```

- to_char(interval, text)

  Description: Converts the values of the time interval type into the strings in the specified format.

  Return type: text

  Example:

  ```
  openGauss=# SELECT to_char(interval '15h 2m 12s', 'HH24:MI:SS');
   to_char
  ----------
   15:02:12
  (1 row)
  ```

- to_char(integer, text)

  Description: Converts the values of the integer type into the strings in the specified format.

  Return type: text

  Example:

  ```
  openGauss=# SELECT to_char(125, '999');
   to_char
  ---------
   125
  (1 row)
  ```

- to_char(numeric, text)

  Description: Converts the values of the numeric type into the strings in the specified format.

  Return type: text

  Example:

  ```
  openGauss=# SELECT to_char(-125.8, '999D99S');
   to_char
  ---------
   125.80-
  (1 row)
  ```

- to_char (string)

  Description: Converts the CHAR/VARCHAR/VARCHAR2/CLOB type into the VARCHAR type.

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If this function is used to convert data of the CLOB type, and the value to be converted exceeds the value range of the target type, an error is returned.

Return type: varchar

Example:

```
openGauss=# SELECT to_char('01110');
 to_char
---------
 01110
(1 row)
```

- to_nvarchar2

  Description: Converts to the nvarchar2 type.

  Parameter: numeric

  Return type: nvarchar2

- to_char(timestamp, text)

  Description: Converts the values of the timestamp type into the strings in the specified format.

  Return type: text

  Example:

```
openGauss=# SELECT to_char(current_timestamp, 'HH12:MI:SS');
 to_char
----------
 10:55:59
(1 row)
```

- to_clob(char/nchar/varchar/nvarchar/varchar2/nvarchar2/text/raw)

  Description: Converts the RAW type or text character set type CHAR/NCHAR/VARCHAR/VARCHAR2/NVARCHAR2/TEXT into the CLOB type.

  Return type: clob

  Example:

```
openGauss=# SELECT to_clob('ABCDEF'::RAW(10));
 to_clob
---------
 ABCDEF
(1 row)
openGauss=# SELECT to_clob('hello111'::CHAR(15));
 to_clob
----------
 hello111
(1 row)
openGauss=# SELECT to_clob('gauss123'::NCHAR(10));
 to_clob
----------
 gauss123
(1 row)
openGauss=# SELECT to_clob('gauss234'::VARCHAR(10));
 to_clob
----------
 gauss234
(1 row)
openGauss=# SELECT to_clob('gauss345'::VARCHAR2(10));
 to_clob
----------
 gauss345
(1 row)
openGauss=# SELECT to_clob('gauss456'::NVARCHAR2(10));
 to_clob
----------
 gauss456
(1 row)
```

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```
openGauss=# SELECT to_clob('World222!'::TEXT);
 to_clob
-----------
 World222!
(1 row)
```

- to_date(text)

  Description: Converts values of the text type into the timestamp in the specified format.

  Return type: timestamp without time zone

  Example:

```
openGauss=# SELECT to_date('2015-08-14');
      to_date
---------------------
 2015-08-14 00:00:00
(1 row)
```

- to_date(text, text)

  Description: Converts the values of the string type into the dates in the specified format.

  Return type: timestamp without time zone

  Example:

```
openGauss=# SELECT to_date('05 Dec 2000', 'DD Mon YYYY');
      to_date
---------------------
 2000-12-05 00:00:00
(1 row)
```

- to_number ( expr [, fmt])

  Description: Converts **expr** into a value of the NUMBER type according to the specified format.

  For details about the type conversion formats, see **Table 12-33**.

  If a hexadecimal string is converted into a decimal number, the hexadecimal string can include a maximum of 16 bytes if it is to be converted into a sign-free number.

  During the conversion from a hexadecimal string to a decimal digit, the format string cannot have a character other than x or X. Otherwise, an error is reported.

  Return type: number

  Example:

```
openGauss=# SELECT to_number('12,454.8-', '99G999D9S');
 to_number
-----------
  -12454.8
(1 row)
```

- to_number(text, text)

  Description: Converts the values of the string type into the numbers in the specified format.

  Return type: numeric

  Example:

```
openGauss=# SELECT to_number('12,454.8-', '99G999D9S');
 to_number
-----------
  -12454.8
(1 row)
```

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- to_timestamp(double precision)

  Description: Converts a UNIX century into a timestamp.

  Return type: timestamp with time zone

  Example:

```
openGauss=# SELECT to_timestamp(1284352323);
     to_timestamp
------------------------
 2010-09-13 12:32:03+08
(1 row)
```

- to_timestamp(string [,fmt])

  Description: Converts a string into a value of the timestamp type according to the format specified by **fmt**. When **fmt** is not specified, perform the conversion according to the format specified by **nls_timestamp_format**.

  In **to_timestamp** in GaussDB,

  – If the input year *YYYY* is 0, an error will be reported.

  – If the input year *YYYY* is less than 0, specify *SYYYY* in **fmt**. The year with the value of n (an absolute value) BC will be output correctly.

  Characters in the **fmt** must match the schema for formatting the data and time. Otherwise, an error is reported.

  Return type: timestamp without time zone

  Example:

```
openGauss=# SHOW nls_timestamp_format;
    nls_timestamp_format
----------------------------
 DD-Mon-YYYY HH:MI:SS.FF AM
(1 row)

openGauss=# SELECT to_timestamp('12-sep-2014');
    to_timestamp
---------------------
 2014-09-12 00:00:00
(1 row)
openGauss=# SELECT to_timestamp('12-Sep-10 14:10:10.123000','DD-Mon-YY HH24:MI:SS.FF');
      to_timestamp
-------------------------
 2010-09-12 14:10:10.123
(1 row)
openGauss=# SELECT to_timestamp('-1','SYYYY');
      to_timestamp
-----------------------
 0001-01-01 00:00:00 BC
(1 row)
openGauss=# SELECT to_timestamp('98','RR');
    to_timestamp
---------------------
 1998-01-01 00:00:00
(1 row)
openGauss=# SELECT to_timestamp('01','RR');
    to_timestamp
---------------------
 2001-01-01 00:00:00
(1 row)
```

- to_timestamp(text, text)

  Description: Converts values of the string type into the timestamp of the specified type.

  Return type: timestamp

  Example:

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```
openGauss=# SELECT to_timestamp('05 Dec 2000', 'DD Mon YYYY');
   to_timestamp
---------------------
 2000-12-05 00:00:00
(1 row)
```

**Table 12-33** Template patterns for numeric formatting

| Pattern | Description |
| --- | --- |
| 9 | Value with specified digits |
| 0 | Values with leading zeros |
| Period (.) | Decimal point |
| Comma (,) | Group (thousand) separator |
| PR | Negative values in angle brackets |
| S | Sign anchored to number (uses locale) |
| L | Currency symbol (uses locale) |
| D | Decimal point (uses locale) |
| G | Group separator (uses locale) |
| MI | Minus sign in the specified position (if the number is less than 0) |
| PL | Plus sign in the specified position (if the number is greater than 0) |
| SG | Plus or minus sign in the specified position |
| RN | Roman numerals (the input values are between 1 and 3999) |
| TH or th | Ordinal number suffix |
| V | Shifts specified number of digits (decimal) |
| x or X | Hexadecimal-to-decimal conversion identifier |

- abstime_text
  Description: Converts abstime to text.
  Parameter: abstime
  Return type: text
- abstime_to_smalldatetime
  Description: Converts abstime to smalldatatime.
  Parameter: abstime
  Return type: smalldatetime
- bigint_tid
  Description: Converts bigint to tid.

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Parameter: bigint
Return type: tid

- bool_int1
  Description: Converts bool to int1.
  Parameter: Boolean
  Return type: tinyint
- bool_int2
  Description: Converts bool to int2.
  Parameter: Boolean
  Return type: smallint
- bool_int8
  Description: Converts bool to int8.
  Parameter: Boolean
  Return type: bigint
- bpchar_date
  Description: Converts a string to a date.
  Parameter: character
  Return type: date
- bpchar_float4
  Description: Converts a string to float4.
  Parameter: character
  Return type: real
- bpchar_float8
  Description: Converts a string to float8.
  Parameter: character
  Return type: double precision
- bpchar_int4
  Description: Converts a string to int4.
  Parameter: character
  Return type: integer
- bpchar_int8
  Description: Converts a string to int8.
  Parameter: character
  Return type: bigint
- bpchar_numeric
  Description: Converts a string to numeric.
  Parameter: character
  Return type: numeric
- bpchar_timestamp
  Description: Converts a string to a timestamp.
  Parameter: character

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Return type: timestamp without time zone

- bpchar_to_smalldatetime
  Description: Converts a string to smalldatetime.
  Parameter: character
  Return type: smalldatetime
- complex_array_in
  Description: Converts the external complex_array type to the internal anyarray array type.
  Parameter: cstring, oid, int2vector
  Return type: anyarray
- cupointer_bigint
  Description: Converts the column-store CU pointer type to the bigint type.
  Parameter: text
  Return type: bigint
- date_bpchar
  Description: Converts the date type to bpchar.
  Parameter: date
  Return type: character
- date_text
  Description: Converts date to text.
  Parameter: date
  Return type: text
- date_varchar
  Description: Converts date to varchar.
  Parameter: date
  Return type: character varying
- f4toi1
  Description: Forcibly converts float4 to uint8.
  Parameter: real
  Return type: tinyint
- f8toi1
  Description: Forcibly converts float8 to uint8.
  Parameter: double precision
  Return type: tinyint
- float4_bpchar
  Description: Converts float4 to bpchar.
  Parameter: real
  Return type: character
- float4_text
  Description: Converts float4 to text.
  Parameter: real

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Return type: text

- float4_varchar
  Description: Converts float4 to varchar.
  Parameter: real
  Return type: character varying
- float8_bpchar
  Description: Converts float4 to bpchar.
  Parameter: double precision
  Return type: character
- float8_interval
  Description: Converts float4 to interval.
  Parameter: double precision
  Return type: interval
- float8_text
  Description: Converts float8 to text.
  Parameter: double precision
  Return type: text
- float8_varchar
  Description: Converts float8 to varchar.
  Parameter: double precision
  Return type: character varying
- i1tof4
  Description: Converts uint8 to float4.
  Parameter: tinyint
  Return type: real
- i1tof8
  Description: Converts uint8 to float8.
  Parameter: tinyint
  Return type: double precision
- i1toi2
  Description: Converts uint8 to int16.
  Parameter: tinyint
  Return type: smallint
- i1toi4
  Description: Converts uint8 to int32.
  Parameter: tinyint
  Return type: integer
- i1toi8
  Description: Converts uint8 to int64.
  Parameter: tinyint
  Return type: bigint

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- i2toi1

  Description: Converts int16 to uint8.

  Parameter: smallint

  Return type: tinyint
- i4toi1

  Description: Converts int32 to uint8.

  Parameter: integer

  Return type: tinyint
- i8toi1

  Description: Converts int64 to uint8.

  Parameter: bigint

  Return type: tinyint
- int1_avg_accum

  Description: Adds the second parameter of the uint8 type to the first parameter. The first parameter is an array of the bigint type.

  Parameter: bigint[], tinyint

  Return type: bigint[]
- int1_bool

  Description: Converts uint8 to bool.

  Parameter: tinyint

  Return type: Boolean
- int1_bpchar

  Description: Converts uint8 to bpchar.

  Parameter: tinyint

  Return type: character
- int1_mul_cash

  Description: Returns the product of a parameter of the int8 type and a parameter of the cash type. The return type is cash.

  Parameter: tinyint, money

  Return type: money
- int1_numeric

  Description: Converts uint8 to numeric.

  Parameter: tinyint

  Return type: numeric
- int1_nvarchar2

  Description: Converts uint8 to nvarchar2.

  Parameter: tinyint

  Return type: nvarchar2
- int1_text

  Description: Converts uint8 to text.

  Parameter: tinyint

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Return type: text

- int1_varchar
  Description: Converts uint8 to varchar.
  Parameter: tinyint
  Return type: character varying
- int1in
  Description: Converts a string into an unsigned 1-byte integer.
  Parameter: cstring
  Return type: tinyint
- int1out
  Description: Converts an unsigned 1-byte integer into a string.
  Return type: cstring
- int1up
  Description: Converts an input integer to an unsigned 1-byte integer.
  Parameter: tinyint
  Return type: tinyint
- int2_bool
  Description: Converts a signed two-byte integer to the bool type.
  Parameter: smallint
  Return type: Boolean
- int2_bpchar
  Description: Converts a signed two-byte integer to the bpchar type.
  Parameter: smallint
  Return type: character
- int2_text
  Description: Converts a signed two-byte integer to the text type.
  Parameter: smallint
  Return type: text
- int2_varchar
  Description: Converts a signed two-byte integer to the varchar type.
  Parameter: smallint
  Return type: character varying
- int4_bpchar
  Description: Converts a signed four-byte integer to bpchar.
  Parameter: integer
  Return type: character
- int4_text
  Description: Converts a signed four-byte integer to the text type.
  Parameter: integer
  Return type: text

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- int4_varchar
  Description: Converts a signed four-byte integer into varchar.
  Parameter: integer
  Return type: character varying
- int8_bool
  Description: Converts an eight-byte signed integer to a Boolean value.
  Parameter: bigint
  Return type: Boolean
- int8_bpchar
  Description: Converts an 8-byte signed integer to bpchar.
  Parameter: bigint
  Return type: character
- int8_text
  Description: Converts an eight-byte signed integer to the text type.
  Parameter: bigint
  Return type: text
- int8_varchar
  Description: Converts an eight-byte signed integer to varchar.
  Parameter: bigint
  Return type: character varying
- intervaltonum
  Description: Converts the internal dats type date to numeric.
  Parameter: interval
  Return type: numeric
- numeric_bpchar
  Description: Converts numeric to bpchar.
  Parameter: numeric
  Return type: character
- numeric_int1
  Description: Converts numeric to a signed one-byte integer.
  Parameter: numeric
  Return type: tinyint
- numeric_text
  Description: Converts numeric to text.
  Parameter: numeric
  Return type: text
- numeric_varchar
  Description: Converts numeric to varchar.
  Parameter: numeric
  Return type: character varying

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- nvarchar2in
  Description: Converts c string to varchar.
  Parameter: cstring, oid, integer
  Return type: nvarchar2
- nvarchar2out
  Description: Converts text into a c string.
  Parameter: nvarchar2
  Return type: cstring
- nvarchar2send
  Description: Converts varchar to binary.
  Parameter: nvarchar2
  Return type: bytea
- oidvectorin_extend
  Description: Converts a string to oidvector.
  Parameter: cstring
  Return type: oidvector_extend
- oidvectorout_extend
  Description: Converts oidvector to a string.
  Parameter: oidvector_extend
  Return type: cstring
- oidvectorsend_extend
  Description: Converts oidvector to a string.
  Parameter: oidvector_extend
  Return type: bytea
- reltime_text
  Description: Converts reltime to text.
  Parameter: reltime
  Return type: text
- text_date
  Description: Converts the text type to the date type.
  Parameter: text
  Return type: date
- text_float4
  Description: Converts text to float4.
  Parameter: text
  Return type: real
- text_float8
  Description: Converts the text type to float8.
  Parameter: text
  Return type: double precision

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- text_int1
  Description: Converts the text type to int1.
  Parameter: text
  Return type: tinyint
- text_int2
  Description: Converts the text type to the int2 type.
  Parameter: text
  Return type: smallint
- text_int4
  Description: Converts the text type to int4.
  Parameter: text
  Return type: integer
- text_int8
  Description: Converts the text type to the int8 type.
  Parameter: text
  Return type: bigint
- text_numeric
  Description: Converts the text type to the numeric type.
  Parameter: text
  Return type: numeric
- text_timestamp
  Description: Converts the text type to the timestamp type.
  Parameter: text
  Return type: timestamp without time zone
- time_text
  Description: Converts the time type to the text type.
  Parameter: time without time zone
  Return type: text
- timestamp_text
  Description: Converts the timestamp type to the text type.
  Parameter: timestamp without time zone
  Return type: text
- timestamp_to_smalldatetime
  Description: Converts the timestamp type to the smalldatetime type.
  Parameter: timestamp without time zone
  Return type: smalldatetime
- timestamp_varchar
  Description: Converts the timestamp type to varchar.
  Parameter: timestamp without time zone
  Return type: character varying

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- timestamptz_to_smalldatetime
  Description: Converts timestamptz to smalldatetime.
  Parameter: timestamp with time zone
  Return type: smalldatetime
- timestampzone_text
  Description: Converts the timestampzone type to the text type.
  Parameter: timestamp with time zone
  Return type: text
- timetz_text
  Description: Converts the timetz type to the text type.
  Parameter: time with time zone
  Return type: text
- to_integer
  Description: Converts data to the integer type.
  Parameter: character varying
  Return type: integer
- to_interval
  Description: Converts to the interval type.
  Parameter: character varying
  Return type: interval
- to_numeric
  Description: Converts to the numeric type.
  Parameter: character varying
  Return type: numeric
- to_text
  Description: Converts to the text type.
  Parameter: smallint
  Return type: text
- to_ts
  Description: Converts to the ts type.
  Parameter: character varying
  Return type: timestamp without time zone
- to_varchar2
  Description: Converts to the varchar2 type.
  Parameter: timestamp without time zone
  Return type: character varying
- varchar_date
  Description: Converts varchar to date.
  Parameter: character varying
  Return type: date

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- varchar_float4
  Description: Converts varchar to float4.
  Parameter: character varying
  Return type: real
- varchar_float8
  Description: Converts the varchar type to the float8 type.
  Parameter: character varying
  Return type: double precision
- varchar_int4
  Description: Converts the type from varchar to int4.
  Parameter: character varying
  Return type: integer
- varchar_int8
  Description: Converts the varchar type to the int8 type.
  Parameter: character varying
  Return type: bigint
- varchar_numeric
  Description: Converts varchar to numeric.
  Parameter: character varying
  Return type: numeric
- varchar_timestamp
  Description: Converts varchar to timestamp.
  Parameter: character varying
  Return type: timestamp without time zone
- varchar2_to_smlldatetime
  Description: Converts varchar2 to smlldatetime.
  Parameter: character varying
  Return type: smalldatetime
- xidout4
  Description: The xid output is a four-byte number.
  Parameter: xid32
  Return type: cstring
- xidsend4
  Description: Converts xid to the binary format.
  Parameter: xid32
  Return type: bytea

## Encoding Type Conversion

convert_to_nocase(text, text)

Description: Converts a string into a specified encoding type.

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Return type: bytea

Example:

```
openGauss=# SELECT convert_to_nocase('12345', 'GBK');
 convert_to_nocase
-------------------
 \x3132333435
(1 row)
```

# 12.5.10 Geometric Functions and Operators

## Geometric Operators

- +

  Description: Translation

  Example:

  ```
  openGauss=# SELECT box '((0,0),(1,1))' + point '(2.0,0)' AS RESULT;
    result
  -------------
   (3,1),(2,0)
  (1 row)
  ```

- -e

  Description: Translation

  Example:

  ```
  openGauss=# SELECT box '((0,0),(1,1))' - point '(2.0,0)' AS RESULT;
     result
  ---------------
   (-1,1),(-2,0)
  (1 row)
  ```

- *

  Description: Scaling out/Rotation

  Example:

  ```
  openGauss=# SELECT box '((0,0),(1,1))' * point '(2.0,0)' AS RESULT;
    result
  -------------
   (2,2),(0,0)
  (1 row)
  ```

- /

  Description: Scaling in/Rotation

  Example:

  ```
  openGauss=# SELECT box '((0,0),(2,2))' / point '(2.0,0)' AS RESULT;
    result
  -------------
   (1,1),(0,0)
  (1 row)
  ```

- #

  Description: Intersection of two figures

  Example:

  ```
  openGauss=# SELECT box '((1,-1),(-1,1))' # box '((1,1),(-2,-2))' AS RESULT;
   result
  ---------------
   (1,1),(-1,-1)
  (1 row)
  ```

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- #

  Description: Number of paths or polygon vertexes

  Example:

```
openGauss=# SELECT # path'((1,0),(0,1),(-1,0))' AS RESULT;
 result
--------
      3
(1 row)
```

- @-@

  Description: Length or circumference

  Example:

```
openGauss=# SELECT @-@ path '((0,0),(1,0))' AS RESULT;
 result
--------
      2
(1 row)
```

- @@

  Description: Center of box

  Example:

```
openGauss=# SELECT @@ circle '((0,0),10)' AS RESULT;
 result
--------
 (0,0)
(1 row)
```

- <->

  Description: Distance between the two figures

  Example:

```
openGauss=# SELECT circle '((0,0),1)' <-> circle '((5,0),1)' AS RESULT;
 result
--------
      3
(1 row)
```

- &&

  Description: Overlaps? (One point in common makes this true.)

  Example:

```
openGauss=# SELECT box '((0,0),(1,1))' && box '((0,0),(2,2))' AS RESULT;
 result
--------
 t
(1 row)
```

- <<

  Description: Is strictly left of (no common horizontal coordinate)?

  Example:

```
openGauss=# SELECT circle '((0,0),1)' << circle '((5,0),1)' AS RESULT;
 result
--------
 t
(1 row)
```

- >>

  Description: Is strictly right of (no common horizontal coordinate)?

  Example:

```
openGauss=# SELECT circle '((5,0),1)' >> circle '((0,0),1)' AS RESULT;
 result
```

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```
--------
 t
(1 row)
```

- &<

  Description: Does not extend to the right of?

  Example:

```
openGauss=# SELECT box '((0,0),(1,1))' &< box '((0,0),(2,2))' AS RESULT;
 result
--------
 t
(1 row)
```

- &>

  Description: Does not extend to the left of?

  Example:

```
openGauss=# SELECT box '((0,0),(3,3))' &> box '((0,0),(2,2))' AS RESULT;
 result
--------
 t
(1 row)
```

- <<|

  Description: Is strictly below (no common horizontal coordinate)?

  Example:

```
openGauss=# SELECT box '((0,0),(3,3))' <<| box '((3,4),(5,5))' AS RESULT;
 result
--------
 t
(1 row)
```

- |>>

  Description: Is strictly above (no common horizontal coordinate)?

  Example:

```
openGauss=# SELECT box '((3,4),(5,5))' |>> box '((0,0),(3,3))' AS RESULT;
 result
--------
 t
(1 row)
```

- &<|

  Description: Does not extend above?

  Example:

```
openGauss=# SELECT box '((0,0),(1,1))' &<| box '((0,0),(2,2))' AS RESULT;
 result
--------
 t
(1 row)
```

- |&>

  Description: Does not extend below?

  Example:

```
openGauss=# SELECT box '((0,0),(3,3))' |&> box '((0,0),(2,2))' AS RESULT;
 result
--------
 t
(1 row)
```

- <^

  Description: Is below (allows touching)?

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Example:

```
openGauss=# SELECT box '((0,0),(-3,-3))' <^ box '((0,0),(2,2))' AS RESULT;
 result
--------
 t
(1 row)
```

- >^

  Description: Is above (allows touching)?

  Example:

```
openGauss=# SELECT box '((0,0),(2,2))' >^ box '((0,0),(-3,-3))'  AS RESULT;
 result
--------
 t
(1 row)
```

- ?#

  Description: Intersect?

  Example:

```
openGauss=# SELECT lseg '((-1,0),(1,0))' ?# box '((-2,-2),(2,2))' AS RESULT;
 result
--------
 t
(1 row)
```

- ?-

  Description: Is horizontal?

  Example:

```
openGauss=# SELECT ?- lseg '((-1,0),(1,0))' AS RESULT;
 result
--------
 t
(1 row)
```

- ?-

  Description: Are horizontally aligned?

  Example:

```
openGauss=# SELECT point '(1,0)' ?- point '(0,0)' AS RESULT;
 result
--------
 t
(1 row)
```

- ?|

  Description: Is vertical?

  Example:

```
openGauss=# SELECT ?| lseg '((-1,0),(1,0))' AS RESULT;
 result
--------
 f
(1 row)
```

- ?|

  Description: Are vertically aligned?

  Example:

```
openGauss=# SELECT point '(0,1)' ?| point '(0,0)' AS RESULT;
 result
--------
 t
(1 row)
```

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- ?-|

  Description: Are perpendicular?

  Example:

```
openGauss=# SELECT lseg '((0,0),(0,1))' ?-| lseg '((0,0),(1,0))' AS RESULT;
 result
--------
 t
(1 row)
```

- ?||

  Description: Are parallel?

  Example:

```
openGauss=# SELECT lseg '((-1,0),(1,0))' ?|| lseg '((-1,2),(1,2))' AS RESULT;
 result
--------
 t
(1 row)
```

- @>

  Description: Contains?

  Example:

```
openGauss=# SELECT circle '((0,0),2)' @> point '(1,1)' AS RESULT;
 result
--------
 t
(1 row)
```

- <@

  Description: Contained in or on?

  Example:

```
openGauss=# SELECT point '(1,1)' <@ circle '((0,0),2)' AS RESULT;
 result
--------
 t
(1 row)
```

- ~=

  Description: Same as?

  Example:

```
openGauss=# SELECT polygon '((0,0),(1,1))' ~= polygon '((1,1),(0,0))' AS RESULT;
 result
--------
 t
(1 row)
```

## Geometric Functions

- area(object)

  Description: Area calculation

  Return type: double precision

  Example:

```
openGauss=# SELECT area(box '((0,0),(1,1))') AS RESULT;
 result
--------
      1
(1 row)
```

- center(object)

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Description: Figure center calculation

Return type: point

Example:

```
openGauss=# SELECT center(box '((0,0),(1,2))') AS RESULT;
 result
---------
 (0.5,1)
(1 row)
```

- diameter(circle)

  Description: Circle diameter calculation

  Return type: double precision

  Example:

```
openGauss=# SELECT diameter(circle '((0,0),2.0)') AS RESULT;
 result
--------
      4
(1 row)
```

- height(box)

  Description: Vertical size of box

  Return type: double precision

  Example:

```
openGauss=# SELECT height(box '((0,0),(1,1))') AS RESULT;
 result
--------
      1
(1 row)
```

- isclosed(path)

  Description: A closed path?

  Return type: Boolean

  Example:

```
openGauss=# SELECT isclosed(path '((0,0),(1,1),(2,0))') AS RESULT;
 result
--------
 t
(1 row)
```

- isopen(path)

  Description: An open path?

  Return type: Boolean

  Example:

```
openGauss=# SELECT isopen(path '[(0,0),(1,1),(2,0)]') AS RESULT;
 result
--------
 t
(1 row)
```

- length(object)

  Description: Length calculation

  Return type: double precision

  Example:

```
openGauss=# SELECT length(path '((-1,0),(1,0))') AS RESULT;
 result
--------
```

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```
     4
(1 row)
```

- npoints(path)

  Description: Number of points in path

  Return type: int

  Example:

```
openGauss=# SELECT npoints(path '[(0,0),(1,1),(2,0)]') AS RESULT;
 result
--------
      3
(1 row)
```

- npoints(polygon)

  Description: Number of points in polygon

  Return type: int

  Example:

```
openGauss=# SELECT npoints(polygon '((1,1),(0,0))') AS RESULT;
 result
--------
      2
(1 row)
```

- pclose(path)

  Description: Converts path to closed.

  Return type: path

  Example:

```
openGauss=# SELECT pclose(path '[(0,0),(1,1),(2,0)]') AS RESULT;
       result
---------------------
 ((0,0),(1,1),(2,0))
(1 row)
```

- popen(path)

  Description: Converts path to open.

  Return type: path

  Example:

```
openGauss=# SELECT popen(path '((0,0),(1,1),(2,0))') AS RESULT;
       result
---------------------
 [(0,0),(1,1),(2,0)]
(1 row)
```

- radius(circle)

  Description: Circle diameter calculation

  Return type: double precision

  Example:

```
openGauss=# SELECT radius(circle '((0,0),2.0)') AS RESULT;
 result
--------
      2
(1 row)
```

- width(box)

  Description: Horizontal size of box

  Return type: double precision

  Example:

```
openGauss=# SELECT width(box '((0,0),(1,1))') AS RESULT;
 result
--------
      1
(1 row)
```

## Geometric Type Conversion Functions

- box(circle)

  Description: Circle to box

  Return type: box

  Example:

  ```
  openGauss=# SELECT box(circle '((0,0),2.0)') AS RESULT;
                                  result
  ---------------------------------------------------------------------------
   (1.41421356237309,1.41421356237309),(-1.41421356237309,-1.41421356237309)
  (1 row)
  ```

- box(point, point)

  Description: Points to box

  Return type: box

  Example:

  ```
  openGauss=# SELECT box(point '(0,0)', point '(1,1)') AS RESULT;
    result
  -------------
   (1,1),(0,0)
  (1 row)
  ```

- box(polygon)

  Description: Polygon to box

  Return type: box

  Example:

  ```
  openGauss=# SELECT box(polygon '((0,0),(1,1),(2,0))') AS RESULT;
    result
  -------------
   (2,1),(0,0)
  (1 row)
  ```

- circle(box)

  Description: Box to circle

  Return type: circle

  Example:

  ```
  openGauss=# SELECT circle(box '((0,0),(1,1))') AS RESULT;
              result
  -------------------------------
   <(0.5,0.5),0.707106781186548>
  (1 row)
  ```

- circle(point, double precision)

  Description: Center and radius to circle

  Return type: circle

  Example:

  ```
  openGauss=# SELECT circle(point '(0,0)', 2.0) AS RESULT;
    result
  -----------
   <(0,0),2>
  (1 row)
  ```

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- circle(polygon)

  Description: Polygon to circle

  Return type: circle

  Example:

```
openGauss=# SELECT circle(polygon '((0,0),(1,1),(2,0))') AS RESULT;
                result
-----------------------------------------
 <(1,0.333333333333333),0.924950591148529>
(1 row)
```

- lseg(box)

  Description: Box diagonal to line segment

  Return type: lseg

  Example:

```
openGauss=# SELECT lseg(box '((-1,0),(1,0))') AS RESULT;
    result
----------------
 [(1,0),(-1,0)]
(1 row)
```

- lseg(point, point)

  Description: Points to line segment

  Return type: lseg

  Example:

```
openGauss=# SELECT lseg(point '(-1,0)', point '(1,0)') AS RESULT;
    result
----------------
 [(-1,0),(1,0)]
(1 row)
```

- slope(point, point)

  Description: Calculates the slope of a straight line formed by two points.

  Return type: double

  Example:

```
openGauss=# SELECT slope(point '(1,1)', point '(0,0)') AS RESULT;
 result
--------
      1
(1 row)
```

- path(polygon)

  Description: Polygon to path

  Return type: path

  Example:

```
openGauss=# SELECT path(polygon '((0,0),(1,1),(2,0))') AS RESULT;
      result
--------------------
 ((0,0),(1,1),(2,0))
(1 row)
```

- point(double precision, double precision)

  Description: Points

  Return type: point

  Example:

```
openGauss=# SELECT point(23.4, -44.5) AS RESULT;
   result
```

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```
--------------
 (23.4,-44.5)
(1 row)
```

- point(box)

  Description: Center of box

  Return type: point

  Example:

```
openGauss=# SELECT point(box '((-1,0),(1,0))') AS RESULT;
 result
--------
 (0,0)
(1 row)
```

- point(circle)

  Description: Center of circle

  Return type: point

  Example:

```
openGauss=# SELECT point(circle '((0,0),2.0)') AS RESULT;
 result
--------
 (0,0)
(1 row)
```

- point(lseg)

  Description: Center of line segment

  Return type: point

  Example:

```
openGauss=# SELECT point(lseg '((-1,0),(1,0))') AS RESULT;
 result
--------
 (0,0)
(1 row)
```

- point(polygon)

  Description: Center of polygon

  Return type: point

  Example:

```
openGauss=# SELECT point(polygon '((0,0),(1,1),(2,0))') AS RESULT;
       result
-----------------------
 (1,0.333333333333333)
(1 row)
```

- polygon(box)

  Description: Box to 4-point polygon

  Return type: polygon

  Example:

```
openGauss=# SELECT polygon(box '((0,0),(1,1))') AS RESULT;
          result
---------------------------
 ((0,0),(0,1),(1,1),(1,0))
(1 row)
```

- polygon(circle)

  Description: Circle to 12-point polygon

  Return type: polygon

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Example:

```
openGauss=# SELECT polygon(circle '((0,0),2.0)') AS RESULT;

result

------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------
----------
 ((-2,0),(-1.73205080756888,1),(-1,1.73205080756888),(-1.22464679914735e-16,2),
(1,1.73205080756888),(1.73205080756888,1),(2,2.44929359829471e-16),
(1.73205080756888,-0.999999999999999),(1,-1.73205080756888),(3.67394039744206e-16,-2),
(-0.999999999999999,-1.73205080756888),(-1.73205080756888,-1))
(1 row)
```

- polygon(npts, circle)

  Description: Circle to **npts**-point polygon

  Return type: polygon

  Example:

```
openGauss=# SELECT polygon(12, circle '((0,0),2.0)') AS RESULT;

result

------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------
----------
 ((-2,0),(-1.73205080756888,1),(-1,1.73205080756888),(-1.22464679914735e-16,2),
(1,1.73205080756888),(1.73205080756888,1),(2,2.44929359829471e-16),
(1.73205080756888,-0.999999999999999),(1,-1.73205080756888),(3.67394039744206e-16,-2),
(-0.999999999999999,-1.73205080756888),(-1.73205080756888,-1))
(1 row)
```

- polygon(path)

  Description: Path to polygon

  Return type: polygon

  Example:

```
openGauss=# SELECT polygon(path '((0,0),(1,1),(2,0))') AS RESULT;
      result
--------------------
 ((0,0),(1,1),(2,0))
(1 row)
```

# 12.5.11 Network Address Functions and Operators

## cidr and inet Operators

The operators **<<**, **<<=**, **>>**, and **>>=** test for subnet inclusion. They consider only the network parts of the two addresses (ignoring any host part) and determine whether one network is identical to or a subnet of the other.

- <

  Description: Is less than

  Example:

```
openGauss=# SELECT inet '192.168.1.5' < inet '192.168.1.6' AS RESULT;
 result
--------
 t
(1 row)
```

- <=

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Description: Is less than or equals

Example:

```
openGauss=# SELECT inet '192.168.1.5' <= inet '192.168.1.5' AS RESULT;
 result
--------
 t
(1 row)
```

- =

  Description: Equals

  Example:

```
openGauss=# SELECT inet '192.168.1.5' = inet '192.168.1.5' AS RESULT;
 result
--------
 t
(1 row)
```

- >=

  Description: Is greater than or equals

  Example:

```
openGauss=# SELECT inet '192.168.1.5' >= inet '192.168.1.5' AS RESULT;
 result
--------
 t
(1 row)
```

- >

  Description: Is greater than

  Example:

```
openGauss=# SELECT inet '192.168.1.5' > inet '192.168.1.4' AS RESULT;
 result
--------
 t
(1 row)
```

- <>

  Description: Does not equal to

  Example:

```
openGauss=# SELECT inet '192.168.1.5' <> inet '192.168.1.4' AS RESULT;
 result
--------
 t
(1 row)
```

- <<

  Description: Is contained in

  Example:

```
openGauss=# SELECT inet '192.168.1.5' << inet '192.168.1/24' AS RESULT;
 result
--------
 t
(1 row)
```

- <<=

  Description: Is contained in or equals

  Example:

```
openGauss=# SELECT inet '192.168.1/24' <<= inet '192.168.1/24' AS RESULT;
 result
--------
```

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```
 t
(1 row)
```

- >>

  Description: Contains

  Example:

```
openGauss=# SELECT inet '192.168.1/24' >> inet '192.168.1.5' AS RESULT;
 result
--------
 t
(1 row)
```

- >>=

  Description: Contains or equals

  Example:

```
openGauss=# SELECT inet '192.168.1/24' >>= inet '192.168.1/24' AS RESULT;
 result
--------
 t
(1 row)
```

- ~

  Description: Bitwise NOT

  Example:

```
openGauss=# SELECT ~ inet '192.168.1.6' AS RESULT;
    result
---------------
 63.87.254.249
(1 row)
```

- &

  Description: Performs an AND operation on each bit of the two network addresses.

  Example:

```
openGauss=# SELECT inet '192.168.1.6' & inet '10.0.0.0' AS RESULT;
 result
---------
 0.0.0.0
(1 row)
```

- |

  Description: Performs an OR operation on each bit of the two network addresses.

  Example:

```
openGauss=# SELECT inet '192.168.1.6' | inet '10.0.0.0' AS RESULT;
   result
-------------
 202.168.1.6
(1 row)
```

- +

  Description: Addition

  Example:

```
openGauss=# SELECT inet '192.168.1.6' + 25 AS RESULT;
    result
--------------
 192.168.1.31
(1 row)
```

- -

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Description: Subtraction

Example:

```
openGauss=# SELECT inet '192.168.1.43' - 36 AS RESULT;
   result
-------------
 192.168.1.7
(1 row)
```

- -

  Description: Subtraction

  Example:

```
openGauss=# SELECT inet '192.168.1.43' - inet '192.168.1.19' AS RESULT;
 result
--------
     24
(1 row)
```

## cidr and inet Functions

The **abbrev**, **host**, and **text** functions are primarily intended to offer alternative display formats.

- abbrev(inet)

  Description: Abbreviated display format as text

  Return type: text

  Example:

```
openGauss=# SELECT abbrev(inet '10.1.0.0/16') AS RESULT;
   result
-------------
 10.1.0.0/16
(1 row)
```

- abbrev(cidr)

  Description: Abbreviated display format as text

  Return type: text

  Example:

```
openGauss=# SELECT abbrev(cidr '10.1.0.0/16') AS RESULT;
 result
---------
 10.1/16
(1 row)
```

- broadcast(inet)

  Description: Broadcast address for networks

  Return type: inet

  Example:

```
openGauss=# SELECT broadcast('192.168.1.5/24') AS RESULT;
      result
------------------
 192.168.1.255/24
(1 row)
```

- family(inet)

  Description: Extracts family of addresses, **4** for IPv4.

  Return type: int

  Example:

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```
openGauss=# SELECT family('127.0.01') AS RESULT;
 result
--------
      4
(1 row)
```

- host(inet)

  Description: Extracts IP addresses as text.

  Return type: text

  Example:

```
openGauss=# SELECT host('192.168.1.5/24') AS RESULT;
   result
-------------
 192.168.1.5
(1 row)
```

- hostmask(inet)

  Description: Constructs the host mask for a network.

  Return type: inet

  Example:

```
openGauss=# SELECT hostmask('192.168.23.20/30') AS RESULT;
 result
---------
 0.0.0.3
(1 row)
```

- masklen(inet)

  Description: Extracts subnet mask length.

  Return type: int

  Example:

```
openGauss=# SELECT masklen('192.168.1.5/24') AS RESULT;
 result
--------
     24
(1 row)
```

- netmask(inet)

  Description: Constructs the subnet mask for a network.

  Return type: inet

  Example:

```
openGauss=# SELECT netmask('192.168.1.5/24') AS RESULT;
    result
---------------
 255.255.255.0
(1 row)
```

- network(inet)

  Description: Extracts the network part of an address.

  Return type: cidr

  Example:

```
openGauss=# SELECT network('192.168.1.5/24') AS RESULT;
     result
----------------
 192.168.1.0/24
(1 row)
```

- set_masklen(inet, int)

  Description: Sets subnet mask length for the **inet** value.

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Return type: inet

Example:

```
openGauss=# SELECT set_masklen('192.168.1.5/24', 16) AS RESULT;
    result
----------------
 192.168.1.5/16
(1 row)
```

- set_masklen(cidr, int)

  Description: Sets subnet mask length for the **cidr** value.

  Return type: cidr

  Example:

  ```
  openGauss=# SELECT set_masklen('192.168.1.0/24'::cidr, 16) AS RESULT;
      result
  ----------------
   192.168.0.0/16
  (1 row)
  ```

- text(inet)

  Description: Extracts IP addresses and subnet mask length as text.

  Return type: text

  Example:

  ```
  openGauss=# SELECT text(inet '192.168.1.5') AS RESULT;
      result
  ----------------
   192.168.1.5/32
  (1 row)
  ```

Any **cidr** value can be cast to **inet** implicitly or explicitly; therefore, the functions shown above as operating on **inet** also work on **cidr** values. An **inet** value can be cast to **cidr**. After the conversion, any bits to the right of the subnet mask are silently zeroed to create a valid **cidr** value. In addition, you can cast a text string to **inet** or **cidr** using normal casting syntax. For example, **inet(expression)** or **colname::cidr**.

## macaddr Functions

The function **trunc(macaddr)** returns a MAC address with the last 3 bytes set to zero.

trunc(macaddr)

Description: Sets last 3 bytes to zero.

Return type: macaddr

Example:

```
openGauss=# SELECT trunc(macaddr '12:34:56:78:90:ab') AS RESULT;
     result
-------------------
 12:34:56:00:00:00
(1 row)
```

The **macaddr** type also supports the standard relational operators (such as **>** and **<=**) for lexicographical ordering, and the bitwise arithmetic operators (**~**, **&** and **|**) for NOT, AND and OR.

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# 12.5.12 Text Search Functions and Operators

## Text Search Operators

- @@

  Description: Specifies whether the **tsvector**-typed words match the **tsquery**-typed words.

  Example:

```
openGauss=# SELECT to_tsvector('fat cats ate rats') @@ to_tsquery('cat & rat') AS RESULT;
 result
--------
 t
(1 row)
```

- @@@

  Description: Synonym for @@

  Example:

```
openGauss=# SELECT to_tsvector('fat cats ate rats') @@@ to_tsquery('cat & rat') AS RESULT;
 result
--------
 t
(1 row)
```

- ||

  Description: Connects two **tsvector**-typed words.

  Example:

```
openGauss=# SELECT 'a:1 b:2'::tsvector || 'c:1 d:2 b:3'::tsvector AS RESULT;
          result
----------------------------
 'a':1 'b':2,5 'c':3 'd':4
(1 row)
```

- &&

  Description: Performs the AND operation on two **tsquery**-typed words.

  Example:

```
openGauss=# SELECT 'fat | rat'::tsquery && 'cat'::tsquery AS RESULT;
          result
----------------------------
 ( 'fat' | 'rat' ) & 'cat'
(1 row)
```

- ||

  Description: Performs the OR operation on two **tsquery**-typed words.

  Example:

```
openGauss=# SELECT 'fat | rat'::tsquery || 'cat'::tsquery AS RESULT;
          result
----------------------------
 ( 'fat' | 'rat' ) | 'cat'
(1 row)
```

- !!

  Description: **NOT** a **tsquery**

  Example:

```
openGauss=# SELECT !! 'cat'::tsquery AS RESULT;
 result
--------
 !'cat'
(1 row)
```

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- @>

  Description: Specifies whether a **tsquery**-typed word contains another **tsquery**-typed word.

  Example:

```
openGauss=# SELECT 'cat'::tsquery @> 'cat & rat'::tsquery AS RESULT;
 result
--------
 f
(1 row)
```

- <@

  Description: Specifies whether a **tsquery**-typed word is contained in another **tsquery**-typed word.

  Example:

```
openGauss=# SELECT 'cat'::tsquery <@ 'cat & rat'::tsquery AS RESULT;
 result
--------
 t
(1 row)
```

In addition to the preceding operators, the ordinary B-tree comparison operators (including = and <) are defined for types **tsvector** and **tsquery**.

## Text Search Functions

- get_current_ts_config()

  Description: Obtains default text search configurations.

  Return type: regconfig

  Example:

```
openGauss=# SELECT get_current_ts_config();
 get_current_ts_config
-----------------------
 english
(1 row)
```

- length(tsvector)

  Description: Specifies the number of lexemes in a **tsvector**-typed word.

  Return type: integer

  Example:

```
openGauss=# SELECT length('fat:2,4 cat:3 rat:5A'::tsvector);
 length
--------
      3
(1 row)
```

- numnode(tsquery)

  Description: Specifies the number of lexemes plus **tsquery** operators.

  Return type: integer

  Example:

```
openGauss=# SELECT numnode('(fat & rat) | cat'::tsquery);
 numnode
---------
       5
(1 row)
```

- plainto_tsquery([ config regconfig , ] query text)

  Description: Generates **tsquery** lexemes without punctuation.

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Return type: tsquery

Example:

```
openGauss=# SELECT plainto_tsquery('english', 'The Fat Rats');
 plainto_tsquery
-----------------
 'fat' & 'rat'
(1 row)
```

- querytree(query tsquery)

  Description: Obtains the indexable part of a **tsquery**.

  Return type: text

  Example:

```
openGauss=# SELECT querytree('foo & ! bar'::tsquery);
 querytree
-----------
 'foo'
(1 row)
```

- setweight(tsvector, "char")

  Description: Assigns weight to each element of **tsvector**.

  Return type: tsvector

  Example:

```
openGauss=# SELECT setweight('fat:2,4 cat:3 rat:5B'::tsvector, 'A');
           setweight
-------------------------------
 'cat':3A 'fat':2A,4A 'rat':5A
(1 row)
```

- strip(tsvector)

  Description: Removes positions and weights from **tsvector**.

  Return type: tsvector

  Example:

```
openGauss=# SELECT strip('fat:2,4 cat:3 rat:5A'::tsvector);
       strip
--------------------
 'cat' 'fat' 'rat'
(1 row)
```

- to_tsquery([ config regconfig , ] query text)

  Description: Normalizes words and converts them to **tsquery**.

  Return type: tsquery

  Example:

```
openGauss=# SELECT to_tsquery('english', 'The & Fat & Rats');
  to_tsquery
---------------
 'fat' & 'rat'
(1 row)
```

- to_tsvector([ config regconfig , ] document text)

  Description: Reduces document text to **tsvector**.

  Return type: tsvector

  Example:

```
openGauss=# SELECT to_tsvector('english', 'The Fat Rats');
   to_tsvector
-----------------
 'fat':2 'rat':3
(1 row)
```

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- to_tsvector_for_batch([ config regconfig , ] document text)

  Description: Reduces document text to **tsvector**.

  Return type: tsvector

  Example:

```
openGauss=# SELECT to_tsvector_for_batch('english', 'The Fat Rats');
   to_tsvector
-----------------
 'fat':2 'rat':3
(1 row)
```

- ts_headline([ config regconfig, ] document text, query tsquery [, options text ])

  Description: Highlights a query match.

  Return type: text

  Example:

```
openGauss=# SELECT ts_headline('x y z', 'z'::tsquery);
 ts_headline
--------------
 x y <b>z</b>
(1 row)
```

- ts_rank([ weights float4[], ] vector tsvector, query tsquery [, normalization integer ])

  Description: Ranks document for query.

  Return type: float4

  Example:

```
openGauss=# SELECT ts_rank('hello world'::tsvector, 'world'::tsquery);
 ts_rank
----------
 .0607927
(1 row)
```

- ts_rank_cd([ weights float4[], ] vector tsvector, query tsquery [, normalization integer ])

  Description: Ranks document for query using cover density.

  Return type: float4

  Example:

```
openGauss=# SELECT ts_rank_cd('hello world'::tsvector, 'world'::tsquery);
 ts_rank_cd
------------
          .0
(1 row)
```

- ts_rewrite(query tsquery, target tsquery, substitute tsquery)

  Description: Replaces **tsquery**-typed word.

  Return type: tsquery

  Example:

```
openGauss=# SELECT ts_rewrite('a & b'::tsquery, 'a'::tsquery, 'foo|bar'::tsquery);
       ts_rewrite
-------------------------
 'b' & ( 'foo' | 'bar' )
(1 row)
```

- ts_rewrite(query tsquery, select text)

  Description: Replaces **tsquery** data in the target with the result of a **SELECT** command.

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Return type: tsquery

Example:

```
openGauss=# SELECT ts_rewrite('world'::tsquery, 'select ''world''::tsquery, ''hello''::tsquery');
 ts_rewrite
------------
 'hello'
(1 row)
```

## Text Search Debugging Functions

- ts_debug([ config regconfig, ] document text, OUT alias text, OUT description text, OUT token text, OUT dictionaries regdictionary[], OUT dictionary regdictionary, OUT lexemes text[])

  Description: Tests a configuration.

  Return type: SETOF record

  Example:

  ```
  openGauss=# SELECT ts_debug('english', 'The Brightest supernovaes');
                                  ts_debug
  -------------------------------------------------------------------------------
   (asciiword,"Word, all ASCII",The,{english_stem},english_stem,{})
   (blank,"Space symbols"," ",{},,)
   (asciiword,"Word, all ASCII",Brightest,{english_stem},english_stem,{brightest})
   (blank,"Space symbols"," ",{},,)
   (asciiword,"Word, all ASCII",supernovaes,{english_stem},english_stem,{supernova})
  (5 rows)
  ```

- ts_lexize(dict regdictionary, token text)

  Description: Tests a data dictionary.

  Return type: text[]

  Example:

  ```
  openGauss=# SELECT ts_lexize('english_stem', 'stars');
   ts_lexize
  -----------
   {star}
  (1 row)
  ```

- ts_parse(parser_name text, document text, OUT tokid integer, OUT token text)

  Description: Tests a parser.

  Return type: SETOF record

  Example:

  ```
  openGauss=# SELECT ts_parse('default', 'foo - bar');
   ts_parse
  -----------
   (1,foo)
   (12," ")
   (12,"- ")
   (1,bar)
  (4 rows)
  ```

- ts_parse(parser_oid oid, document text, OUT tokid integer, OUT token text)

  Description: Tests a parser.

  Return type: SETOF record

  Example:

  ```
  openGauss=# SELECT ts_parse(3722, 'foo - bar');
   ts_parse
  -----------
  ```

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```
 (1,foo)
 (12," ")
 (12,"- ")
 (1,bar)
(4 rows)
```

- ts_token_type(parser_name text, OUT tokid integer, OUT alias text, OUT description text)

  Description: Obtains token types defined by a parser.

  Return type: SETOF record

  Example:

```
openGauss=# SELECT ts_token_type('default');
                      ts_token_type
------------------------------------------------------------
 (1,asciiword,"Word, all ASCII")
 (2,word,"Word, all letters")
 (3,numword,"Word, letters and digits")
 (4,email,"Email address")
 (5,url,URL)
 (6,host,Host)
 (7,sfloat,"Scientific notation")
 (8,version,"Version number")
 (9,hword_numpart,"Hyphenated word part, letters and digits")
 (10,hword_part,"Hyphenated word part, all letters")
 (11,hword_asciipart,"Hyphenated word part, all ASCII")
 (12,blank,"Space symbols")
 (13,tag,"XML tag")
 (14,protocol,"Protocol head")
 (15,numhword,"Hyphenated word, letters and digits")
 (16,asciihword,"Hyphenated word, all ASCII")
 (17,hword,"Hyphenated word, all letters")
 (18,url_path,"URL path")
 (19,file,"File or path name")
 (20,float,"Decimal notation")
 (21,int,"Signed integer")
 (22,uint,"Unsigned integer")
 (23,entity,"XML entity")
(23 rows)
```

- ts_token_type(parser_oid oid, OUT tokid integer, OUT alias text, OUT description text)

  Description: Obtains token types defined by a parser.

  Return type: SETOF record

  Example:

```
openGauss=# SELECT ts_token_type(3722);
                      ts_token_type
------------------------------------------------------------
 (1,asciiword,"Word, all ASCII")
 (2,word,"Word, all letters")
 (3,numword,"Word, letters and digits")
 (4,email,"Email address")
 (5,url,URL)
 (6,host,Host)
 (7,sfloat,"Scientific notation")
 (8,version,"Version number")
 (9,hword_numpart,"Hyphenated word part, letters and digits")
 (10,hword_part,"Hyphenated word part, all letters")
 (11,hword_asciipart,"Hyphenated word part, all ASCII")
 (12,blank,"Space symbols")
 (13,tag,"XML tag")
 (14,protocol,"Protocol head")
 (15,numhword,"Hyphenated word, letters and digits")
 (16,asciihword,"Hyphenated word, all ASCII")
 (17,hword,"Hyphenated word, all letters")
 (18,url_path,"URL path")
```

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```
 (19,file,"File or path name")
 (20,float,"Decimal notation")
 (21,int,"Signed integer")
 (22,uint,"Unsigned integer")
 (23,entity,"XML entity")
(23 rows)
```

- ts_stat(sqlquery text, [ weights text, ] OUT word text, OUT ndoc integer, OUT nentry integer)

  Description: Obtains statistics of a **tsvector** column.

  Return type: SETOF record

  Example:

```
openGauss=# SELECT ts_stat('select ''hello world''::tsvector');
   ts_stat
-------------
 (world,1,1)
 (hello,1,1)
(2 rows)
```

## 12.5.13 JSON/JSONB Functions and Operators

For details about the JSON/JSONB data type, see **12.3.12 JSON/JSONB Types**.

**Table 12-34** JSON/JSONB common operators

| Operators | Left Operand Type | Right Operand Type | Return Type | Description | Example | Example Result |
| --- | --- | --- | --- | --- | --- | --- |
| -> | Array-json(b) | int | json(b) | Obtains the **array-json** element. If the subscript does not exist, **NULL** is returned. | '[{"a":"foo"}, {"b":"bar"}, {"c":"baz"}]'::json->2 | {"c":"baz"} |
| -> | object-json(b) | text | json(b) | Obtains the value by a key. If no record is found, **NULL** is returned. | '{"a": {"b":"foo"}}'::json->'a' | {"b":"foo"} |

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| Operators | Left Operand Type | Right Operand Type | Return Type | Description | Example | Example Result |
| --- | --- | --- | --- | --- | --- | --- |
| ->> | Array-json(b) | int | text | Obtains the JSON array element. If the subscript does not exist, **NULL** is returned. | '[1,2,3]'::json->>2 | 3 |
| ->> | object-json(b) | text | text | Obtains the value by a key. If no record is found, **NULL** is returned. | '{"a":1,"b":2}'::json->>'b' | 2 |
| #> | container-json (b) | text[] | json(b) | Obtains the JSON object in the specified path. If the path does not exist, **NULL** is returned. | '{"a": {"b":{"c": "foo"}}}'::json #>'{a,b}' | {"c": "foo"} |
| #>> | container-json (b) | text[] | text | Obtains the JSON object in the specified path. If the path does not exist, **NULL** is returned. | '{"a": [1,2,3],"b": [4,5,6]}'::json #>>'{a,2}' | 3 |

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**CAUTION**

For the **#>** and **#>>** operators, if no data can be found in the specified path, no error is reported and a **NULL** value is returned.

**Table 12-35** Additional JSONB support for operators

| Operators | Right Operand Type | Description | Example |
| --- | --- | --- | --- |
| @> | jsonb | Whether the top layer of the JSON on the left contains all items of the top layer of the JSON on the right. | '{"a":1, "b":2}'::jsonb @> '{"b":2}'::jsonb |
| <@ | jsonb | Whether all items in the JSON file on the left exist at the top layer of the JSON file on the right. | '{"b":2}'::jsonb <@ '{"a":1, "b":2}'::jsonb |
| ? | text | Whether the string of the key or element exists at the top layer of the JSON value. | '{"a":1, "b":2}'::jsonb ? 'b' |
| ?\| | text[] | Whether any of these array strings exists as top-layer keys. | '{"a":1, "b":2, "c":3}'::jsonb ?\| array['b', 'c'] |
| ?& | text[] | Whether all these array strings exist as top-layer keys. | '["a", "b"]'::jsonb ?& array['a', 'b'] |
| = | jsonb | Determines the size between two **JSONB** files, which is the same as the **jsonb_eq** function. | / |
| <> | jsonb | Determines the size between two **JSONB** files, which is the same as the **jsonb_ne** function. | / |

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| Operators | Right Operand Type | Description | Example |
| --- | --- | --- | --- |
| < | jsonb | Determines the size between two **JSONB** files, which is the same as the **jsonb_lt** function. | / |
| > | jsonb | Determines the size between two **JSONB** files, which is the same as the **jsonb_gt** function. | / |
| <= | jsonb | Determines the size between two **JSONB** files, which is the same as the **jsonb_le** function. | / |
| >= | jsonb | Determines the size between two **JSONB** files, which is the same as the **jsonb_ge** function. | / |

## Functions Supported by JSON/JSONB

- array_to_json\(anyarray \[, pretty_bool\]\)

  Description: Returns the array as JSON. A multi-dimensional array becomes a JSON array of arrays. If the value of **pretty_bool** is **true**, a newline character is added between one-dimensional elements.

  Return type: json

  Example:

  ```
  openGauss=# SELECT array_to_json('{{1,5},{99,100}}'::int[]);
    array_to_json
    ------------------
    [[1,5],[99,100]]
    (1 row)
  ```

- row_to_json\(record \[, pretty_bool\]\)

  Description: Returns the row as JSON. If the value of **preretty_bool** is **true**, a newline character is added between one-dimensional elements.

  Return type: json

  Example:

  ```
  openGauss=# SELECT row_to_json(row(1,'foo'));
        row_to_json
  ```

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```
 ---------------------
  {"f1":1,"f2":"foo"}    (1 row)
```

- json_array_element(array-json, integer), jsonb_array_element(array-jsonb, integer)

  Description: Same as the operator **`->`**, which returns the element with the specified subscript in the array.

  Return type: json, jsonb

  Example:

```
openGauss=# select json_array_element('[1,true,[1,[2,3
]],null]',2);
 json_array_element
 --------------------
 [1,[2,3]]
 (1 row)
```

- json_array_element_text(array-json, integer), jsonb_array_element_text(array-jsonb, integer)

  Description: Same as the operator **`->>`**, which returns the element with the specified subscript in the array.

  Return type: text, text

  Example:

```
openGauss=# select json_array_element_text('[1,true,[1,[2,3]],null]',2);
json_array_element_text
------------------------
 [1,[2,3]]
 (1 row)
```

- json_object_field(object-json, text), jsonb_object_field(object-jsonb, text)

  Description: Same as the operator **`->`**, which returns the value of a specified key in an object.

  Return type: json, json

  Example:

```
 openGauss=# select json_object_field('{"a": {"b":"foo"}}','a');
 json_object_field
 -------------------
 {"b":"foo"}
 (1 row)
```

- json_object_field_text(object-json, text), jsonb_object_field_text(object-jsonb, text)

  Description: Same as the operator **`->`**, which returns the value of a specified key in an object.

  Return type: text, text

  Example:

```
 openGauss=# select json_object_field_text('{"a": {"b":"foo"}}','a');
 json_object_field_text
 ------------------------
 {"b":"foo"}
 (1 row)
```

- json_extract_path(json, VARIADIC text[]), jsonb_extract_path((jsonb, VARIADIC text[])

  Description: Equivalent to the operator **`#>`** searches for JSON based on the path specified by *$2* and returns the result.

  Return type: json, jsonb

  Example:

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```
openGauss=# select json_extract_path('{"f2":{"f3":1},"f4":{"f5":99,"f6":"stringy"}}', 'f4','f6');
 json_extract_path
-------------------
 "stringy"
(1 row)
```

- json_extract_path_op(json, text[]), jsonb_extract_path_op(jsonb, text[])

  Description: Same as the operator **`#>`**, searches for JSON based on the path specified by *$2* and returns the result.

  Return type: json, jsonb

  Example:

```
 openGauss=# select json_extract_path_op('{"f2":{"f3":1},"f4":{"f5":99,"f6":"stringy"}}',
ARRAY['f4','f6']);
  json_extract_path_op
----------------------
 "stringy"
(1 row)
```

- json_extract_path_text(json, VARIADIC text[]), jsonb_extract_path_text((jsonb, VARIADIC text[])

  Description: Equivalent to the operator **`#>`**, searches for JSON based on the path specified by $2 and return the result.

  Return type: text, text

  Example:

```
openGauss=# select json_extract_path_text('{"f2":{"f3":1},"f4":{"f5":99,"f6":"stringy"}}', 'f4','f6');
  json_extract_path_text
------------------------
 "stringy"
(1 row)
```

- json_extract_path_text_op(json, text[]), jsonb_extract_path_text_op(jsonb, text[])

  Description: Same as the operator **`#>`**, searches for JSON based on the path specified by $2 and return the result.

  Return type: text, text

  Example:

```
 openGauss=# select json_extract_path_text_op('{"f2":{"f3":1},"f4":{"f5":99,"f6":"stringy"}}',
ARRAY['f4','f6']);
  json_extract_path_text_op
---------------------------
 "stringy"
(1 row)
```

- json_array_elements(array-json), jsonb_array_elements(array-jsonb)

  Description: Splits an array. Each element returns a row.

  Return type: json, jsonb

  Example:

```
openGauss=# select json_array_elements('[1,true,[1,[2,3]],null]');
  json_array_elements
----------------------
 1
 true
 [1,[2,3]]
 null
(4 rows)
```

- json_array_elements_text(array-json), jsonb_array_elements_text(array-jsonb)

  Description: Splits an array. Each element returns a row.

  Return type: text, text

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Example:

```
openGauss=# select * from  json_array_elements_text('[1,true,[1,[2,3]],null]');
    value
-----------
 1
 true
 [1,[2,3]]

 (4 rows)
```

- json_array_length(array-json), jsonb_array_length(array-jsonb)

  Description: Returns the array length.

  Return type: integer

  Example:

  ```
  openGauss=# SELECT json_array_length('[1,2,3,{"f1":1,"f2":[5,6]},4,null]');
   json_array_length
  -------------------
                   6
  (1 row)
  ```

- json_each(object-json), jsonb_each(object-jsonb)

  Description: Splits each key-value pair of an object into one row and two columns.

  Return type: setof(key text, value json), setof(key text, value jsonb)

  Example:

  ```
  openGauss=# select * from  json_each('{"f1":[1,2,3],"f2":{"f3":1},"f4":null}');
   key |  value
  -----+----------
   f1  | [1,2,3]
   f2  | {"f3":1}
   f4  | null
  (3 rows)
  ```

- json_each_text(object-json), jsonb_each_text(object-jsonb)

  Description: Splits each key-value pair of an object into one row and two columns.

  Return type: setof(key text, value text), setof(key text, value text)

  Example:

  ```
  openGauss=# select * from  json_each_text('{"f1":[1,2,3],"f2":{"f3":1},"f4":null}');
   key |  value
  -----+----------
   f1  | [1,2,3]
   f2  | {"f3":1}
   f4  |
  (3 rows)
  ```

- json_object_keys(object-json), jsonb_object_keys(object-jsonb)

  Description: Returns all keys at the top layer of the object.

  Return type: SETOF text

  Example:

  ```
  openGauss=# select json_object_keys('{"f1":"abc","f2":{"f3":"a", "f4":"b"}, "f1":"abcd"}');
   json_object_keys
  ------------------
   f1
   f2
   f1
  (3 rows)
  ```

- JSONB deduplication operations:

  ```
  openGauss=# select jsonb_object_keys('{"f1":"abc","f2":{"f3":"a", "f4":"b"}, "f1":"abcd"}');
   jsonb_object_keys
  -------------------
  ```

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```
 f1
 f2
(2 rows)
```

- json_populate_record(anyelement, object-json [, bool]), jsonb_populate_record(anyelement, object-jsonb [, bool])

  Description: *$1* must be a compound parameter. Each key-value in the **object-json** file is split. The key is used as the column name to match the column name in *$1* and fill in the *$1* format.

  Return type: anyelement, anyelement

  Example:

```
openGauss=# create type jpop as (a text, b int, c bool);
CREATE TYPE
postgres=# select * from json_populate_record(null::jpop,'{"a":"blurfl","x":43.2}');
   a    | b | c
--------+---+---
 blurfl |   |
(1 row)
```

```
openGauss=# select * from json_populate_record((1,1,null)::jpop,'{"a":"blurfl","x":43.2}');
   a    | b | c
--------+---+---
 blurfl | 1 |
(1 row)
```

- json_populate_record_set(anyelement, array-json [, bool]), jsonb_populate_record_set(anyelement, array-jsonb [, bool])

  Description: Performs the preceding operations on each element in the *$2* array by referring to the **json_populate_record** and **jsonb_populate_record** functions. Therefore, each element in the *$2* array must be of the **object-json** type.

  Return type: setof anyelement, setof anyelement

  Example:

```
openGauss=# create type jpop as (a text, b int, c bool);
CREATE TYPE
postgres=# select * from json_populate_recordset(null::jpop, '[{"a":1,"b":2},{"a":3,"b":4}]');
 a | b | c
---+---+---
 1 | 2 |
 3 | 4 |
(2 rows)
```

- json_typeof(json), jsonb_typeof(jsonb)

  Description: Checks the JSON type.

  Return type: text, text

  Example:

```
openGauss=# select value, json_typeof(value)
 postgres-# from (values (json '123.4'), (json '"foo"'), (json 'true'), (json 'null'), (json '[1, 2, 3]'), (json
'{"x":"foo", "y":123}'), (NULL::json))  as data(value);
         value          | json_typeof
------------------------+-------------
 123.4                  | number
 "foo"                  | string
 true                   | boolean
 null                   | null
 [1, 2, 3]              | array
 {"x":"foo", "y":123} | object
                        |
(7 rows)
```

- json_build_array( [VARIADIC "any"] )

  Description: Constructs a JSON array from a variable parameter list.

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Return type: array-json

Example:

```
openGauss=# select json_build_array('a',1,'b',1.2,'c',true,'d',null,'e',json '{"x": 3, "y": [1,2,3]}','');
                      json_build_array
------------------------------------------------------------------------------
 ["a", 1, "b", 1.2, "c", true, "d", null, "e", {"x": 3, "y": [1,2,3]}, ""]
(1 row)
```

- json_build_object( [VARIADIC "any"] )

  Description: Constructs a JSON object from a variable parameter list. The number of input parameters must be an even number. Every two input parameters form a key-value pair. Note that the value of a key cannot be null.

  Return type: object-json

  Example:

  ```
  openGauss=# select json_build_object(1,2);
    json_build_object
  --------------------
   {"1" : 2}
  (1 row)
  ```

- json_to_record(object-json, bool)

  Description: Like all functions that return **record**, the caller must explicitly define the structure of the record with an AS clause. The key-value pair of **object-json** is split and reassembled. The key is used as a column name to match and fill in the structure of the specified record.

  Return type: record

  Example:

  ```
  openGauss=# select * from json_to_record('{"a":1,"b":"foo","c":"bar"}',true) as x(a int, b text, d text);
    a |  b  | d
  ---+-----+---
    1 | foo |
  (1 row)
  ```

- json_to_recordset(array-json, bool)

  Description: Executes the preceding function on each element in the array by referring to the **json_to_record** function. Therefore, each element in the array must be **object-json**.

  Return type: SETOF record

  Example:

  ```
  openGauss=# select * from json_to_recordset(
   openGauss(#    '[{"a":1,"b":"foo","d":false},{"a":2,"b":"bar","c":true}]',
  openGauss(#    false
  openGauss(# ) as x(a int, b text, c boolean);
    a |  b  | c
  ---+-----+---
    1 | foo |
    2 | bar | t
  (2 rows)
  ```

- json_object(text[]), json_object(text[], text[])

  Description: Constructs an **object-json** from a text array. This is an overloaded function. When the input parameter is a text array, the array length must be an even number, and members are considered as alternate key-value pairs. When two text arrays are used, the first array is considered as a key, and the second array a value. The lengths of the two arrays must be the same. Note that the value of a key cannot be null.

  Return type: object-json

  Example:

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```
openGauss=# select json_object('{a,1,b,2,3,NULL,"d e f","a b c"}');
                       json_object
-----------------------------------------------------
 {"a" : "1", "b" : "2", "3" : null, "d e f" : "a b c"}
(1 row)
postgres=# select json_object('{a,b,"a b c"}', '{a,1,1}');
              json_object
---------------------------------------
 {"a" : "a", "b" : "1", "a b c" : "1"}
(1 row)
```

- json_agg(any)

  Description: Aggregates values into a JSON array.

  Return type: array-json

  Example:

```
openGauss=# select * from classes;
 name | score
------+-------
A    |     2
A    |     3
D    |     5
D    |
(4 rows)
openGauss=# select name, json_agg(score) score from classes group by name order by name;
name |      score
-----+-----------------
A    | [2, 3]
D    | [5, null]
     | [null]
(3 rows)
```

- json_object_agg(any, any)

  Description: Aggregates values into a JSON object.

  Return type: object-json

  Example:

```
openGauss=# select * from classes;
name | score
-----+-------
A    |     2
A    |     3
D    |     5
D    |
(4 rows)
```

```
openGauss=# select json_object_agg(name, score) from classes group by name order by name;
    json_object_agg
-------------------------
 { "A" : 2, "A" : 3 }
 { "D" : 5, "D" : null }
(2 rows)
```

- - jsonb_contained(jsonb, jsonb)

  Description: Same as the operator **`<@`**, determines whether all elements in *$1* exist at the top layer of *$2*.

  Return type: Boolean

  Example:

```
openGauss=# select jsonb_contained('[1,2,3]', '[1,2,3,4]');
 jsonb_contained
-----------------
 t
(1 row)
```

- - jsonb_contains(jsonb, jsonb)

  Description: Same as the operator **`@>`**, checks whether all top-layer elements in *$1* are contained in *$2*.

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Return type: Boolean

Example:

```
openGauss=# select jsonb_contains('[1,2,3,4]', '[1,2,3]');
 jsonb_contains
----------------
 t
(1 row)
```

- - jsonb_exists(jsonb, text)

  Description: Same as the operator **`?`**, determines whether all elements in the string array *$2* exist at the top layer of *$1* in the form of **key\elem\scalar**.

  Return type: Boolean

  Example:

  ```
  openGauss=# select jsonb_exists('["1",2,3]', '1');
   jsonb_exists
  --------------
   t
  (1 row)
  ```

- - jsonb_exists_all(jsonb, text[])

  Description: Same as the operator **`?&`**, checks whether all elements in the string array *$2* exist at the top layer of *$1* in the form of **key\elem\scalar**.

  Return type: Boolean

  Example:

  ```
  openGauss=# select jsonb_exists_all('["1","2",3]', '{1, 2}');
   jsonb_exists_all
  ------------------
   t
  (1 row)
  ```

- - jsonb_exists_any(jsonb, text[])

  Description: Same as the operator **`?|`**, checks whether all elements in the string array *$2* exist at the top layer of *$1* in the form of **key\elem\scalar**.

  Return type: Boolean

  Example:

  ```
  openGauss=# select jsonb_exists_any('["1","2",3]', '{1, 2, 4}');
   jsonb_exists_any
  ------------------
   t
  (1 row)
  ```

- - jsonb_cmp(jsonb, jsonb)

  Description: Compares values. A positive value indicates greater than, a negative value indicates less than, and **0** indicates equal.

  Return type: integer

  Example:

  ```
  openGauss=# select jsonb_cmp('["a", "b"]', '{"a":1, "b":2}');
   jsonb_cmp
  -----------
          -1
  (1 row)
  ```

- - jsonb_eq(jsonb, jsonb)

  Description: Same as the operator **`=`**, compares two values.

  Return type: Boolean

  Example:

  ```
  openGauss=# select jsonb_eq('["a", "b"]', '{"a":1, "b":2}');
   jsonb_eq
  ```

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```
----------
 f
(1 row)
```

- - jsonb_ne(jsonb, jsonb)

  Description: Same as the operator **`<>`**, compares two values.

  Return type: Boolean

  Example:

```
openGauss=# select jsonb_ne('["a", "b"]', '{"a":1, "b":2}');
 jsonb_ne
----------
 t
(1 row)
```

- - jsonb_gt(jsonb, jsonb)

  Description: Same as the operator **`>`**, compares two values.

  Return type: Boolean

  Example:

```
openGauss=# select jsonb_gt('["a", "b"]', '{"a":1, "b":2}');
 jsonb_gt
----------
 f
(1 row)
```

- - jsonb_ge(jsonb, jsonb)

  Description: Same as the operator **`>=`**, compares two values.

  Return type: Boolean

  Example:

```
openGauss=# select jsonb_ge('["a", "b"]', '{"a":1, "b":2}');
 jsonb_ge
----------
 f
(1 row)
```

- - jsonb_lt(jsonb, jsonb)

  Description: Same as the operator **`<`**, compares two values.

  Return type: Boolean

  Example:

```
openGauss=# select jsonb_lt('["a", "b"]', '{"a":1, "b":2}');
 jsonb_lt
----------
 t
(1 row)
```

- - jsonb_le(jsonb, jsonb)

  Description: Same as the operator **`<=`**, compares two values.

  Return type: Boolean

  Example:

```
openGauss=# select jsonb_le('["a", "b"]', '{"a":1, "b":2}');
 jsonb_le
----------
 t
(1 row)
```

- - to_json(anyelement)

  Description: Converts parameters to **`json`**.

  Return type: json

  Example:

```
openGauss=# select to_json('{1,5}'::text[]);
   to_json
 -----------
  ["1","5"]
 (1 row)
```

- - jsonb_hash(jsonb)

  Description: Performs the hash operation on JSONB.

  Return type: integer

  Example:

```
openGauss=# select jsonb_hash('[1,2,3]');
   josnb_hash
 --------------
  -55996848
 (1 row)
```

- Other functions

  Description: Internal functions used by GIN indexes and JSON and JSONB aggregate functions.

```
gin_compare_jsonb
gin_consistent_jsonb
gin_consistent_jsonb_hash
gin_extract_jsonb
gin_extract_jsonb_hash
gin_extract_jsonb_query
gin_extract_jsonb_query_hash
gin_triconsistent_jsonb
gin_triconsistent_jsonb_hash
json_agg_transfn
json_agg_finalfn
json_object_agg_transfn
json_object_agg_finalfn
```

# 12.5.14 HLL Functions and Operators

## Hash Functions

- hll_hash_boolean(bool)

  Description: Hashes data of the bool type.

  Return type: hll_hashval

  Example:

```
openGauss=# SELECT hll_hash_boolean(FALSE);
  hll_hash_boolean
----------------------
 -5451962507482445012
(1 row)
```

- hll_hash_boolean(bool, int32)

  Description: Configures a hash seed (that is, change the hash policy) and hashes data of the bool type.

  Return type: hll_hashval

  Example:

```
openGauss=# SELECT hll_hash_boolean(FALSE, 10);
  hll_hash_boolean
--------------------
 -1169037589280886076
(1 row)
```

- hll_hash_smallint(smallint)

  Description: Hashes data of the smallint type.

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Return type: hll_hashval

Example:

```
openGauss=# SELECT hll_hash_smallint(100::smallint);
 hll_hash_smallint
---------------------
 962727970174027904
(1 row)
```

NOTE

If parameters with the same numeric value are hashed using different data types, the data will differ, because hash functions select different calculation policies for each type.

- hll_hash_smallint(smallint, int32)

  Description: Configures a hash seed (that is, change the hash policy) and hashes data of the smallint type.

  Return type: hll_hashval

  Example:

  ```
  openGauss=# SELECT hll_hash_smallint(100::smallint, 10);
   hll_hash_smallint
  ---------------------
   -9056177146160443041
  (1 row)
  ```

- hll_hash_integer(integer)

  Description: Hashes data of the integer type.

  Return type: hll_hashval

  Example:

  ```
  openGauss=# SELECT hll_hash_integer(0);
    hll_hash_integer
  ----------------------
   5156626420896634997
  (1 row)
  ```

- hll_hash_integer(integer, int32)

  Description: Hashes data of the integer type and configures a hash seed (that is, change the hash policy).

  Return type: hll_hashval

  Example:

  ```
  openGauss=# SELECT hll_hash_integer(0, 10);
   hll_hash_integer
  ---------------------
   -5035020264353794276
  (1 row)
  ```

- hll_hash_bigint(bigint)

  Description: Hashes data of the bigint type.

  Return type: hll_hashval

  Example:

  ```
  openGauss=# SELECT hll_hash_bigint(100::bigint);
    hll_hash_bigint
  ---------------------
   -2401963681423227794
  (1 row)
  ```

- hll_hash_bigint(bigint, int32)

  Description: Hashes data of the bigint type and configures a hash seed (that is, change the hash policy).

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Return type: hll_hashval

Example:

```
openGauss=# SELECT hll_hash_bigint(100::bigint, 10);
  hll_hash_bigint
---------------------
 -2305749404374433531
(1 row)
```

- hll_hash_bytea(bytea)

  Description: Hashes data of the bytea type.

  Return type: hll_hashval

  Example:

  ```
  openGauss=# SELECT hll_hash_bytea(E'\\x');
   hll_hash_bytea
  ----------------
   0
  (1 row)
  ```

- hll_hash_bytea(bytea, int32)

  Description: Hashes data of the bytea type and configures a hash seed (that is, change the hash policy).

  Return type: hll_hashval

  Example:

  ```
  openGauss=# SELECT hll_hash_bytea(E'\\x', 10);
    hll_hash_bytea
  ---------------------
   7233188113542599437
  (1 row)
  ```

- hll_hash_text(text)

  Description: Hashes data of the text type.

  Return type: hll_hashval

  Example:

  ```
  openGauss=# SELECT hll_hash_text('AB');
     hll_hash_text
  ---------------------
   -5666002586880275174
  (1 row)
  ```

- hll_hash_text(text, int32)

  Description: Hashes data of the text type and configures a hash seed (that is, change the hash policy).

  Return type: hll_hashval

  Example:

  ```
  openGauss=# SELECT hll_hash_text('AB', 10);
  hll_hash_text
  ---------------------
  -2215507121143724132
  (1 row)
  ```

- hll_hash_any(anytype)

  Description: Hashes data of any type.

  Return type: hll_hashval

  Example:

  ```
  openGauss=# select hll_hash_any(1);
     hll_hash_any
  ```

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```
----------------------
 -1316670585935156930
(1 row)

openGauss=# select hll_hash_any('08:00:2b:01:02:03'::macaddr);
     hll_hash_any
----------------------
 -3719950434455589360
(1 row)
```

- hll_hash_any(anytype, int32)

  Description: Hashes data of any type and configures a hash seed (that is, change the hash policy).

  Return type: hll_hashval

  Example:

```
openGauss=# select hll_hash_any(1, 10);
     hll_hash_any
----------------------
 7048553517657992351
(1 row)
```

- hll_hashval_eq(hll_hashval, hll_hashval)

  Description: Compares two pieces of data of the hll_hashval type to check whether they are the same.

  Return type: Boolean

  Example:

```
openGauss=# select hll_hashval_eq(hll_hash_integer(1), hll_hash_integer(1));
 hll_hashval_eq
----------------
 t
(1 row)
```

- hll_hashval_ne(hll_hashval, hll_hashval)

  Description: Compares two pieces of data of the hll_hashval type to check whether they are different.

  Return type: Boolean

  Example:

```
openGauss=# select hll_hashval_ne(hll_hash_integer(1), hll_hash_integer(1));
 hll_hashval_ne
----------------
 f
(1 row)
```

## HLL Functions

There are three HLL modes: explicit, sparse, and full. When the data size is small, the explicit mode is used. In this mode, distinct values are calculated without errors. As the number of distinct values increases, the HLL mode is switched to the sparse and full modes in sequence. The two modes have no difference in the calculation result, but vary in the calculation efficiency of HLL functions and the storage space of HLL objects. The following functions can be used to view some HLL parameters:

- hll_print(hll)

  Description: Prints some debugging parameters of an HLL.

  Example:

```
openGauss=# select hll_print(hll_empty());
                                hll_print
```

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```
--------------------------------------------------------------------------------
 type=1(HLL_EMPTY), log2m=14, log2explicit=10, log2sparse=12, duplicatecheck=0
(1 row)
```

- hll_type(hll)

  Description: Checks the type of the current HLL. The return values are described as follows: **0** indicates **HLL_UNINIT**, an HLL object that is not initialized. **1** indicates **HLL_EMPTY**, an empty HLL object. **2** indicates **HLL_EXPLICIT**, an HLL object in explicit mode. **3** indicates **HLL_SPARSE**, an HLL object in sparse mode. **4** indicates **HLL_FULL**, an HLL object in full mode. **5** indicates **HLL_UNDEFINED**, an invalid HLL object.

  Example:

```
openGauss=# select hll_type(hll_empty());
 hll_type
----------
        1
(1 row)
```

- hll_log2m(hll)

  Description: Checks the value of **log2m** in the current HLL data structure. **log2m** is the logarithm of the number of buckets. This value affects the error rate of calculating distinct values by HLL. The error rate = ±1.04/√(2^log2m). If the value of **log2m** ranges from 10 to 16, HLL sets the number of buckets to $2^{log2m}$. When the value of **log2explicit** is explicitly set to **–1**, the built-in default value is used.

  Example:

```
openGauss=# select hll_log2m(hll_empty());
 hll_log2m
-----------
        14
(1 row)

openGauss=# select hll_log2m(hll_empty(10));
 hll_log2m
-----------
        10
(1 row)

openGauss=# select hll_log2m(hll_empty(-1));
 hll_log2m
-----------
        14
(1 row)
```

- hll_log2explicit(hll)

  Description: Queries the value of **log2explicit** in the current HLL data structure. Generally, the HLL changes from the explicit mode to the sparse mode and then to the full mode. This process is called the promotion hierarchy policy. You can change the value of **log2explicit** to change the policy. For example, if the value of **log2explicit** is **0**, the HLL will skip the **explicit** mode and directly enter the **sparse** mode. When the value of **log2explicit** is explicitly set to a value ranging from 1 to 12, the HLL will switch to the sparse mode when the length of the data segment exceeds $2^{log2explicit}$. When the value of **log2explicit** is explicitly set to **–1**, the built-in default value is used.

  Example:

```
openGauss=# select hll_log2explicit(hll_empty());
 hll_log2explicit
------------------
```

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```
           10
(1 row)

openGauss=# select hll_log2explicit(hll_empty(12, 8));
 hll_log2explicit
------------------
            8
(1 row)

openGauss=# select hll_log2explicit(hll_empty(12, -1));
 hll_log2explicit
------------------
           10
(1 row)
```

- hll_log2sparse(hll)

  Description: Queries the value of **log2sparse** in the current HLL data structure. Generally, the HLL changes from the explicit mode to the sparse mode and then to the full mode. This process is called the promotion hierarchy policy. You can adjust the value of **log2sparse** to change the policy. For example, if the value of **log2sparse** is **0**, the system skips the sparse mode and directly enters the full mode. If the value of **log2sparse** is explicitly set to a value ranging from 1 to 14, the HLL will switch to the full mode when the length of the data segment exceeds $2^{log2sparse}$. When the value of **log2sparse** is explicitly set to **–1**, the built-in default value is used.

  Example:

```
openGauss=# select hll_log2sparse(hll_empty());
 hll_log2sparse
----------------
          12
(1 row)

openGauss=# select hll_log2sparse(hll_empty(12, 8, 10));
 hll_log2sparse
----------------
          10
(1 row)

openGauss=# select hll_log2sparse(hll_empty(12, 8, -1));
 hll_log2sparse
----------------
          12
(1 row)
```

- hll_duplicatecheck(hll)

  Description: Specifies whether duplicate check is enabled. **0**: disable; **1**: enable. This function is disabled by default. If there are many duplicate values, you can enable this function to improve efficiency. When the value of **duplicatecheck** is explicitly set to **–1**, the built-in default value is used.

  Example:

```
openGauss=# select hll_duplicatecheck(hll_empty());
 hll_duplicatecheck
--------------------
                 0
(1 row)

openGauss=# select hll_duplicatecheck(hll_empty(12, 8, 10, 1));
 hll_duplicatecheck
--------------------
                 1
(1 row)

openGauss=# select hll_duplicatecheck(hll_empty(12, 8, 10, -1));
```

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```
 hll_duplicatecheck
--------------------
                  0
(1 row)
```

## Functional Functions

- hll_empty()

  Description: Creates an empty HLL.

  Return type: hll

  Example:

  ```
  openGauss=# select hll_empty();
                                hll_empty
  ------------------------------------------------------------
   \x484c4c00000000002b050000000000000000000000000000000000000000
  (1 row)
  ```

- hll_empty(int32 log2m)

  Description: Creates an empty HLL and sets the **log2m** parameter. The parameter value ranges from 10 to 16. If the input is **–1**, the built-in default value is used.

  Return type: HLL

  Example:

  ```
  openGauss=# select hll_empty(10);
                                hll_empty
  ------------------------------------------------------------
   \x484c4c00000000002b040000000000000000000000000000000000000000
  (1 row)

  openGauss=# select hll_empty(-1);
                                hll_empty
  ------------------------------------------------------------
   \x484c4c00000000002b050000000000000000000000000000000000000000
  (1 row)
  ```

- hll_empty(int32 log2m, int32 log2explicit)

  Description: Creates an empty HLL and sets the **log2m** and **log2explicit** parameters in sequence. The value of **log2explicit** ranges from 0 to 12. The value **0** indicates that the explicit mode is skipped. This parameter is used to set the threshold of the explicit mode. When the length of the data segment reaches $2^{log2explicit}$, the mode is switched to the sparse or full mode. If the input is **–1**, the built-in default value of **log2explicit** is used.

  Return type: HLL

  Example:

  ```
  openGauss=# select hll_empty(10, 4);
                                hll_empty
  ------------------------------------------------------------
   \x484c4c0000000000130400000000000000000000000000000000000000
  (1 row)

  openGauss=# select hll_empty(10, -1);
                                hll_empty
  ------------------------------------------------------------
   \x484c4c00000000002b040000000000000000000000000000000000000000
  (1 row)
  ```

- hll_empty(int32 log2m, int32 log2explicit, int64 log2sparse)

  Description: Creates an empty HLL and sets the **log2m**, **log2explicit** and **log2sparse** parameters in sequence. The value of **log2sparse** ranges from 0

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to 14. The value **0** indicates that the sparse mode is skipped. This parameter is used to set the threshold of the sparse mode. When the length of the data segment reaches $2^{log2sparse}$, the mode is switched to the full mode. If the input is **–1**, the built-in default value of **log2sparse** is used.

Return type: HLL

Example:

```
openGauss=# select hll_empty(10, 4, 8);
                      hll_empty
------------------------------------------------------------
 \x484c4c0000000000120400000000000000000000000000000000000000
(1 row)

openGauss=# select hll_empty(10, 4, -1);
                      hll_empty
------------------------------------------------------------
 \x484c4c0000000000130400000000000000000000000000000000000000
(1 row)
```

- hll_empty(int32 log2m, int32 log2explicit, int64 log2sparse, int32 duplicatecheck)

  Description: Creates an empty HLL and sets the **log2m**, **log2explicit**, **log2sparse**, and **duplicatecheck** parameters in sequence. The value of **duplicatecheck** is **0** or **1**, indicating whether the duplicate check mode is enabled. By default, this mode is disabled. If the input is **–1**, the built-in default value of **duplicatecheck** is used.

  Return type: HLL

  Example:

```
openGauss=# select hll_empty(10, 4, 8, 0);
                      hll_empty
------------------------------------------------------------
 \x484c4c0000000000120400000000000000000000000000000000000000
(1 row)

openGauss=# select hll_empty(10, 4, 8, -1);
                      hll_empty
------------------------------------------------------------
 \x484c4c0000000000120400000000000000000000000000000000000000
(1 row)
```

- hll_add(hll, hll_hashval)

  Description: Adds hll_hashval to an HLL.

  Return type: HLL

  Example:

```
openGauss=# select hll_add(hll_empty(), hll_hash_integer(1));
                                hll_add
------------------------------------------------------------------------------
 \x484c4c08000002002b0900000000000000f03f3e2921ff133fbaed3e2921ff133fbaed00
(1 row)
```

- hll_add_rev(hll_hashval, hll)

  Description: Adds **hll_hashval** to an HLL. This function works the same as **hll_add**, except that the positions of parameters are switched.

  Return type: HLL

  Example:

```
openGauss=# select hll_add_rev(hll_hash_integer(1), hll_empty());
                              hll_add_rev
------------------------------------------------------------------------------
```

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```
 \x484c4c08000002002b0900000000000000f03f3e2921ff133fbaed3e2921ff133fbaed00
(1 row)
```

- hll_eq(hll, hll)

  Description: Compares two HLLs to check whether they are the same.

  Return type: Boolean

  Example:

```
openGauss=# select hll_eq(hll_add(hll_empty(), hll_hash_integer(1)), hll_add(hll_empty(),
hll_hash_integer(2)));
 hll_eq
--------
 f
(1 row)
```

- hll_ne(hll, hll)

  Description: Compares two HLLs to check whether they are different.

  Return type: Boolean

  Example:

```
openGauss=# select hll_ne(hll_add(hll_empty(), hll_hash_integer(1)), hll_add(hll_empty(),
hll_hash_integer(2)));
 hll_ne
--------
 t
(1 row)
```

- hll_cardinality(hll)

  Description: Calculates the number of distinct values of an HLL.

  Return type: int

  Example:

```
openGauss=# select hll_cardinality(hll_empty() || hll_hash_integer(1));
 hll_cardinality
-----------------
               1
(1 row)
```

- hll_union(hll, hll)

  Description: Performs the UNION operation on two HLL data structures to obtain one HLL.

  Return type: HLL

  Example:

```
openGauss=# select hll_union(hll_add(hll_empty(), hll_hash_integer(1)), hll_add(hll_empty(),
hll_hash_integer(2)));
                                    hll_union
------------------------------------------------------------------------------------------------

\x484c4c10002000002b0900000000000000004000000000000000000b3ccc49320cca1ae3e2921ff133fba
ed00
(1 row)
```

## Aggregate Functions

- hll_add_agg(hll_hashval)

  Description: Groups hashed data into HLL.

  Return type: HLL

  Example:

```
-- Prepare data:
openGauss=# create table t_id(id int);
```

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```
openGauss=# insert into t_id values(generate_series(1,500));
openGauss=# create table t_data(a int, c text);
openGauss=# insert into t_data select mod(id,2), id from t_id;

-- Create a table and specify an HLL column:
openGauss=# create table t_a_c_hll(a int, c hll);

-- Use GROUP BY on column a to group data, and insert the data to the HLL:
openGauss=# insert into t_a_c_hll select a, hll_add_agg(hll_hash_text(c)) from t_data group by a;

-- Calculate the number of distinct values for each group in the HLL:
openGauss=# select a, #c as cardinality from t_a_c_hll order by a;
 a |   cardinality
---+------------------
 0 | 247.862354346299
 1 | 250.908710610377
(2 rows)
```

- hll_add_agg(hll_hashval, int32 log2m)

  Description: Groups hashed data into HLL and specifies the **log2m** parameter. The value ranges from 10 to 16. If the input is **–1** or **NULL**, the built-in default value is used.

  Return type: HLL

  Example:

  ```
  openGauss=# select hll_cardinality(hll_add_agg(hll_hash_text(c), 12)) from t_data;
   hll_cardinality
  ------------------
   497.965240179228
  (1 row)
  ```

- hll_add_agg(hll_hashval, int32 log2m, int32 log2explicit)

  Description: Groups hashed data into HLL and specifies the **log2m** and **log2explicit** parameters in sequence. The value of **log2explicit** ranges from 0 to 12. The value **0** indicates that the explicit mode is skipped. This parameter is used to set the threshold of the explicit mode. When the length of the data segment reaches $2^{log2explicit}$, the mode is switched to the sparse or full mode. If the input is **–1** or **NULL**, the built-in default value of **log2explicit** is used.

  Return type: HLL

  Example:

  ```
  openGauss=# select hll_cardinality(hll_add_agg(hll_hash_text(c), NULL, 1)) from t_data;
   hll_cardinality
  ------------------
   498.496062953313
  (1 row)
  ```

- hll_add_agg(hll_hashval, int32 log2m, int32 log2explicit, int64 log2sparse)

  Description: Groups hashed data into HLL and sets the **log2m**, **log2explicit**, and **log2sparse** parameters in sequence. The value of **log2sparse** ranges from 0 to 14. The value **0** indicates that the sparse mode is skipped. This parameter is used to set the threshold of the sparse mode. When the length of the data segment reaches $2^{log2sparse}$, the mode is switched to the full mode. If the input is **–1** or **NULL**, the built-in default value of **log2sparse** is used.

  Return type: HLL

  Example:

  ```
  openGauss=# select hll_cardinality(hll_add_agg(hll_hash_text(c), NULL, 6, 10)) from t_data;
   hll_cardinality
  ------------------
   498.496062953313
  (1 row)
  ```

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- hll_add_agg(hll_hashval, int32 log2m, int32 log2explicit, int64 log2sparse, int32 duplicatecheck)

  Description: Groups hashed data into HLL and sets the **log2m**, **log2explicit**, **log2sparse**, and **duplicatecheck** parameters. The value of **duplicatecheck** can be **0** or **1**, indicating whether to enable this mode. By default, this mode is disabled. If the input is **–1** or **NULL**, the built-in default value of **duplicatecheck** is used.

  Return type: HLL

  Example:

```
openGauss=# select hll_cardinality(hll_add_agg(hll_hash_text(c), NULL, 6, 10, -1)) from t_data;
 hll_cardinality
------------------
 498.496062953313
(1 row)
```

- hll_union_agg(hll)

  Description: Performs the UNION operation on multiple pieces of data of the HLL type to obtain one HLL.

  Return type: HLL

  Example:

```
-- Perform the UNION operation on data of the HLL type in each group to obtain one HLL, and calculate the number of distinct values:
openGauss=# select #hll_union_agg(c) as cardinality from t_a_c_hll;
   cardinality
------------------
 498.496062953313
(1 row)
```

  NOTE

  To perform the UNION operation on data in multiple HLLs, ensure that the HLLs have the same precision. Otherwise, **UNION** cannot be performed. This constraint also applies to the **hll_union(hll, hll)** function.

## Obsolete Functions

Some old HLL functions are discarded due to version upgrade. You can replace them with similar functions.

- hll_schema_version(hll)

  Description: Checks the schema version in the current HLL. In earlier versions, the schema version is fixed at **1**, which is used to verify the header of the HLL field. After refactoring, the HLL field is added to the header for verification. The schema version is no longer used.

- hll_regwidth(hll)

  Description: Queries the bucket size in the HLL data structure. In earlier versions, the value of **regwidth** ranges from 1 to 5, which has a large error and limits the upper limit of the cardinality estimation. After refactoring, the value of *regwidth* is fixed at **6** and the variable is not used.

- hll_expthresh(hll)

  Description: Obtains the value of **expthresh** in the current HLL. The **hll_log2explicit(hll)** function is used to replace similar functions.

- hll_sparseon(hll)

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Description: Specifies whether the sparse mode is enabled. Use **hll_log2sparse(hll)** to replace similar functions. The value **0** indicates that the sparse mode is disabled.

## Built-In Functions

HLL has a series of built-in functions for internal data processing. Generally, users do not need to know how to use these functions. For details, see **Table 12-36**.

**Table 12-36** Built-in functions

| Function | Description |
| --- | --- |
| hll_in | Receives hll data in string format. |
| hll_out | Sends hll data in string format. |
| hll_recv | Receives hll data in bytea format. |
| hll_send | Sends hll data in bytea format. |
| hll_trans_in | Receives hll_trans_type data in string format. |
| hll_trans_out | Sends hll_trans_type data in string format. |
| hll_trans_recv | Receives hll_trans_type data in bytea format. |
| hll_trans_send | Sends hll_trans_type data in bytea format. |
| hll_typmod_in | Receives typmod data. |
| hll_typmod_out | Sends typmod data. |
| hll_hashval_in | Receives hll_hashval data. |
| hll_hashval_out | Sends hll_hashval data. |
| hll_add_trans0 | Works similar to **hll_add**. No input parameter is specified during initialization. It is usually used in the first phase of DNs in distributed aggregation operations. |
| hll_add_trans1 | Works similar to **hll_add**. An input parameter is specified during initialization. It is usually used in the first phase of DNs in distributed aggregation operations. |
| hll_add_trans2 | Works similar to **hll_add**. Two input parameters are specified during initialization. It is usually used in the first phase of DNs in distributed aggregation operations. |
| hll_add_trans3 | Works similar to **hll_add**. Three input parameters are specified during initialization. It is usually used in the first phase of DNs in distributed aggregation operations. |
| hll_add_trans4 | Works similar to **hll_add**. Four input parameters are specified during initialization. It is usually used in the first phase of DNs in distributed aggregation operations. |

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| Function | Description |
| --- | --- |
| hll_union_trans | Works similar to **hll_union** and is used on the first phase of DNs in distributed aggregation operations. |
| hll_union_collect | Works similar to **hll_union** and is used on the second phase of CNs in distributed aggregation operations to summarize the results of each DN. |
| hll_pack | Is used on the third phase of CNs in distributed aggregation operations to convert a user-defined type hll_trans_type to the hll type. |
| hll | Converts a hll type to another hll type. Input parameters can be specified. |
| hll_hashval | Converts the bigint type to the hll_hashval type. |
| hll_hashval_int4 | Converts the int4 type to the hll_hashval type. |

## Operators

- =

  Description: Compares the values of the hll or hll_hashval type to check whether they are the same.

  Return type: Boolean

  Example:

```
--hll
openGauss=# select (hll_empty() || hll_hash_integer(1)) = (hll_empty() || hll_hash_integer(1));
column
----------
 t
(1 row)

--hll_hashval
openGauss=# select hll_hash_integer(1) = hll_hash_integer(1);
 ?column?
----------
 t
(1 row)
```

- <> or !=

  Description: Compares the values of the hll or hll_hashval type to check whether they are different.

  Return type: Boolean

  Example:

```
--hll
openGauss=# select (hll_empty() || hll_hash_integer(1)) <> (hll_empty() || hll_hash_integer(2));
 ?column?
----------
 t
(1 row)

--hll_hashval
openGauss=# select hll_hash_integer(1) <> hll_hash_integer(2);
 ?column?
----------
```

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```
 t
(1 row)
```

- ||

  Description: Represents the functions of **hll_add**, **hll_union**, and **hll_add_rev**.

  Return type: HLL

  Example:

```
--hll_add
openGauss=# select hll_empty() || hll_hash_integer(1);
                                ?column?
--------------------------------------------------------------------------------
 \x484c4c08000002002b0900000000000000f03f3e2921ff133fbaed3e2921ff133fbaed00
(1 row)

--hll_add_rev
openGauss=# select hll_hash_integer(1) || hll_empty();
                                ?column?
--------------------------------------------------------------------------------
 \x484c4c08000002002b0900000000000000f03f3e2921ff133fbaed3e2921ff133fbaed00
(1 row)

--hll_union
openGauss=# select (hll_empty() || hll_hash_integer(1)) || (hll_empty() || hll_hash_integer(2));
                                      ?column?
-----------------------------------------------------------------------------------------------

\x484c4c10002000002b0900000000000000004000000000000000000b3ccc49320cca1ae3e2921ff133fba
ed00
(1 row)
```

- #

  Description: Calculates the number of distinct values of an HLL. It works the same as the **hll_cardinality** function.

  Return type: int

  Example:

```
openGauss=# select #(hll_empty() || hll_hash_integer(1));
 ?column?
----------
        1
(1 row)
```

## 12.5.15 SEQUENCE Functions

The sequence functions provide a simple method to ensure security of multiple users for users to obtain sequence values from sequence objects.

- nextval(regclass)

  Description: Specifies an increasing sequence and returns a new value.

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NOTE

- To avoid blocking of concurrent transactions that obtain numbers from the same sequence, a nextval operation is never rolled back; that is, once a value has been fetched it is considered used, even if the transaction that did the nextval later aborts. This means that aborted transactions may leave unused "holes" in the sequence of assigned values. Therefore, sequences in GaussDB cannot be used to obtain sequence without gaps.
- If the nextval function is pushed to DNs, each DN will automatically connect to the GTM and requests the next value. For example, in the **insert into t1 select xxx** statement, a column in table **t1** needs to invoke the nextval function. If maximum number of connections on the GTM is 8192, this type of pushed statements occupies too many GTM connections. Therefore, the number of concurrent connections for these statements is limited to 7000 divided by the number of cluster DNs. The other 1192 connections are reserved for other statements.

Return type: numeric

The **nextval** function can be invoked in either of the following ways: (In example 2, the Oracle syntax is supported. Currently, the sequence name cannot contain a dot.)

Example 1:

```
openGauss=# select nextval('seqDemo');
 nextval
---------
       2
(1 row)
```

Example 2:

```
openGauss=# select seqDemo.nextval;
 nextval
---------
       2
(1 row)
```

- currval(regclass)

  Returns the last value of **nextval** for a specified sequence in the current session. If **nextval** has not been invoked for the specified sequence in the current session, an error is reported when **currval** is invoked. By default, **currval** is disabled. To enable it, set **enable_beta_features** to **true**. After **enable_beta_features** is set to **true**, **nextval** will not be pushed down.

  Return type: numeric

  The **currval** function can be invoked in either of the following ways: (In example 2, the Oracle syntax is supported. Currently, the sequence name cannot contain a dot.)

  Example 1:

```
openGauss=# select currval('seq1');
 currval
---------
       2
(1 row)
```

  Example 2:

```
openGauss=# select seq1.currval seq1;
 currval
---------
       2
(1 row)
```

- lastval()

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Description: Returns the last value of **nextval** in the current session. This function is equivalent to **currval**, but **lastval** does not have a parameter. If **nextval** has not been invoked in the current session, invoking **lastval** will report an error.

By default, **lastval** is disabled. To enable it, set **enable_beta_features** or **lastval_supported** to **true**. After **lastval** is enabled, **nextval** will not be pushed down.

Return type: numeric

Example:

```
openGauss=# select lastval();
 lastval
---------
       2
(1 row)
```

- setval(regclass, bigint)

  Sets the current value of a sequence.

  Return type: numeric

  Example:

  ```
  openGauss=# select setval('seqDemo',1);
   setval
  --------
       1
  (1 row)
  ```

- setval(regclass, numeric, Boolean)

  Sets the current value of a sequence and the is_called sign.

  Return type: numeric

  Example:

  ```
  openGauss=# select setval('seqDemo',1,true);
   setval
  --------
       1
  (1 row)
  ```

  **NOTE**

  The current session and GTM will take effect immediately after **setval** is performed. If other sessions have buffered sequence values, **setval** will take effect only after the values are used up. Therefore, to prevent sequence value conflicts, you are advised to use **setval** with caution.

  Because the sequence is non-transactional, changes made by **setval** will not be canceled when a transaction rolled back.

- pg_sequence_last_value(sequence_oid oid, OUT cache_value int16, OUT last_value int16)

  Description: Obtains the parameters of a specified sequence, including the cache value and current value.

  Return type: int16, int16

# 12.5.16 Array Functions and Operators

## Array Operators

- =

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Description: Specifies whether two arrays are equal.

Example:

```
openGauss=# SELECT ARRAY[1.1,2.1,3.1]::int[] = ARRAY[1,2,3] AS RESULT ;
 result
--------
 t
(1 row)
```

- <>

  Description: Specifies whether two arrays are not equal.

  Example:

  ```
  openGauss=# SELECT ARRAY[1,2,3] <> ARRAY[1,2,4] AS RESULT;
   result
  --------
   t
  (1 row)
  ```

- <

  Description: Specifies whether an array is less than another.

  Example:

  ```
  openGauss=# SELECT ARRAY[1,2,3] < ARRAY[1,2,4] AS RESULT;
   result
  --------
   t
  (1 row)
  ```

- >

  Description: Specifies whether an array is greater than another.

  Example:

  ```
  openGauss=# SELECT ARRAY[1,4,3] > ARRAY[1,2,4] AS RESULT;
   result
  --------
   t
  (1 row)
  ```

- <=

  Description: Specifies whether an array is less than or equal to another.

  Example:

  ```
  openGauss=# SELECT ARRAY[1,2,3] <= ARRAY[1,2,3] AS RESULT;
   result
  --------
   t
  (1 row)
  ```

- >=

  Description: Specifies whether an array is greater than or equal to another.

  Example:

  ```
  openGauss=# SELECT ARRAY[1,4,3] >= ARRAY[1,4,3] AS RESULT;
   result
  --------
   t
  (1 row)
  ```

- @>

  Description: Specifies whether an array contains another.

  Example:

  ```
  openGauss=# SELECT ARRAY[1,4,3] @> ARRAY[3,1] AS RESULT;
   result
  --------
  ```

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```
 t
(1 row)
```

- <@

  Description: Specifies whether an array is contained in another.

  Example:

```
openGauss=# SELECT ARRAY[2,7] <@ ARRAY[1,7,4,2,6] AS RESULT;
 result
--------
 t
(1 row)
```

- &&

  Description: Specifies whether an array overlaps another (have common elements).

  Example:

```
openGauss=# SELECT ARRAY[1,4,3] && ARRAY[2,1] AS RESULT;
 result
--------
 t
(1 row)
```

- ||

  Description: Specifies array-to-array concatenation.

  Example:

```
openGauss=# SELECT ARRAY[1,2,3] || ARRAY[4,5,6] AS RESULT;
    result
---------------
 {1,2,3,4,5,6}
(1 row)
openGauss=# SELECT ARRAY[1,2,3] || ARRAY[[4,5,6],[7,8,9]] AS RESULT;
          result
---------------------------
 {{1,2,3},{4,5,6},{7,8,9}}
(1 row)
```

- ||

  Description: Specifies element-to-array concatenation.

  Example:

```
openGauss=# SELECT 3 || ARRAY[4,5,6] AS RESULT;
  result
-----------
 {3,4,5,6}
(1 row)
```

- ||

  Description: Specifies array-to-element concatenation.

  Example:

```
openGauss=# SELECT ARRAY[4,5,6] || 7 AS RESULT;
  result
-----------
 {4,5,6,7}
(1 row)
```

Array comparisons compare the array contents element-by-element, using the default B-tree comparison function for the element data type. In multidimensional arrays, the elements are accessed in row-major order. If the contents of two arrays are equal but the number of dimensions is different, the first difference in the dimensionality information determines the sort order.

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## Array Functions

- array_append(anyarray, anyelement)

  Description: Appends an element to the end of an array. Only one-dimensional arrays are supported.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_append(ARRAY[1,2], 3) AS RESULT;
 result
---------
 {1,2,3}
(1 row)
```

- array_prepend(anyelement, anyarray)

  Description: Appends an element to the beginning of an array. Only one-dimensional arrays are supported.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_prepend(1, ARRAY[2,3]) AS RESULT;
 result
---------
 {1,2,3}
(1 row)
```

- array_cat(anyarray, anyarray)

  Description: Concatenates two arrays, and supports multi-dimensional arrays.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_cat(ARRAY[1,2,3], ARRAY[4,5]) AS RESULT;
   result
-------------
 {1,2,3,4,5}
(1 row)

openGauss=# SELECT array_cat(ARRAY[[1,2],[4,5]], ARRAY[6,7]) AS RESULT;
       result
---------------------
 {{1,2},{4,5},{6,7}}
(1 row)
```

- array_union(anyarray, anyarray)

  Description: Concatenates two arrays. Only one-dimensional arrays are supported.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_union(ARRAY[1,2,3], ARRAY[3,4,5]) AS RESULT;
   result
-------------
 {1,2,3,3,4,5}
(1 row)
```

- array_union_distinct(anyarray, anyarray)

  Description: Concatenates two arrays and deduplicates them. Only one-dimensional arrays are supported.

  Return type: anyarray

  Example:

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```
openGauss=# SELECT array_union_distinct(ARRAY[1,2,3], ARRAY[3,4,5]) AS RESULT;
  result
-------------
 {1,2,3,4,5}
(1 row)
```

- array_intersect(anyarray, anyarray)

  Description: Intersects two arrays. Only one-dimensional arrays are supported.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_intersect(ARRAY[1,2,3], ARRAY[3,4,5]) AS RESULT;
  result
-------------
 {3}
(1 row)
```

- array_intersect_distinct(anyarray, anyarray)

  Description: Intersects two arrays and deduplicates them. Only one-dimensional arrays are supported.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_intersect_distinct(ARRAY[1,2,2], ARRAY[2,2,4,5]) AS RESULT;
  result
-------------
 {2}
(1 row)
```

- array_except(anyarray, anyarray)

  Description: Calculates the difference between two arrays. Only one-dimensional arrays are supported.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_except(ARRAY[1,2,3], ARRAY[3,4,5]) AS RESULT;
  result
-------------
 {1,2}
(1 row)
```

- array_except_distinct(anyarray, anyarray)

  Description: Calculates the difference between two arrays and deduplicates them. Only one-dimensional arrays are supported.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_except_distinct(ARRAY[1,2,2,3], ARRAY[3,4,5]) AS RESULT;
  result
-------------
 {1,2}
(1 row)
```

- array_ndims(anyarray)

  Description: Returns the number of dimensions of an array.

  Return type: int

  Example:

```
openGauss=# SELECT array_ndims(ARRAY[[1,2,3], [4,5,6]]) AS RESULT;
 result
--------
      2
(1 row)
```

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- array_dims(anyarray)

  Description: Returns a text representation of array dimensions.

  Return type: text

  Example:

```
openGauss=# SELECT array_dims(ARRAY[[1,2,3], [4,5,6]]) AS RESULT;
   result
------------
 [1:2][1:3]
(1 row)
```

- array_length(anyarray, int)

  Description: Returns the length of the array dimensions.

  Return type: int

  Example:

```
openGauss=# SELECT array_length(array[1,2,3], 1) AS RESULT;
 result
--------
      3
(1 row)
```

- array_lower(anyarray, int)

  Description: Returns lower bound of the array dimensions.

  Return type: int

  Example:

```
openGauss=# SELECT array_lower('[0:2]={1,2,3}'::int[], 1) AS RESULT;
 result
--------
      0
(1 row)
```

- array_sort(anyarray)

  Description: Returns an array in ascending order.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_sort(ARRAY[5,1,3,6,2,7]) AS RESULT;
 result
-------------
{1,2,3,5,6,7}
(1 row)
```

- array_upper(anyarray, int)

  Description: Returns upper bound of the array dimensions.

  Return type: int

  Example:

```
openGauss=# SELECT array_upper(ARRAY[1,8,3,7], 1) AS RESULT;
 result
--------
      4
(1 row)
```

- array_to_string(anyarray, text [, text])

  Description: Uses the first **text** as the new delimiter and the second **text** to replace **NULL** values.

  Return type: text

  Example:

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```
openGauss=# SELECT array_to_string(ARRAY[1, 2, 3, NULL, 5], ',', '*') AS RESULT;
 result
-----------
 1,2,3,*,5
(1 row)
```

- array_delete(anyarray)

  Description: Clears elements in an array and returns an empty array of the same type.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_delete(ARRAY[1,8,3,7]) AS RESULT;
 result
--------
 {}
(1 row)
```

- array_deleteidx(anyarray, int)

  Description: Deletes specified subscript elements from an array and returns an array consisting of the remaining elements.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_deleteidx(ARRAY[1,2,3,4,5], 1) AS RESULT;
 result
-----------
 {2,3,4,5}
(1 row)
```

- array_extendnull(anyarray, int)

  Description: Adds a specified number of null elements to the end of an array.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_extend(ARRAY[1,8,3,7],1) AS RESULT;
   result
--------------
{1,8,3,7,null}
(1 row)
```

- array_trim(anyarray, int)

  Description: Deletes a specified number of elements from the end of an array.

  Return type: anyarray

  Example:

```
openGauss=# SELECT array_trim(ARRAY[1,8,3,7],1) AS RESULT;
 result
---------
 {1,8,3}
(1 row)
```

- array_exists(anyarray, int)

  Description: Checks whether the second parameter is a valid subscript of an array.

  Return type: Boolean

  Example:

```
openGauss=# SELECT array_exists(ARRAY[1,8,3,7],1) AS RESULT;
 result
--------
 t
(1 row)
```

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- array_next(anyarray, int)

  Description: Returns the subscript of the element following a specified subscript in an array based on the second input parameter.

  Return type: int

  Example:

```
openGauss=# SELECT array_next(ARRAY[1,8,3,7],1) AS RESULT;
 result
--------
      2
(1 row)
```

- array_prior(anyarray, int)

  Description: Returns the subscript of the element followed by a specified subscript in an array based on the second input parameter.

  Return type: int

  Example:

```
openGauss=# SELECT array_prior(ARRAY[1,8,3,7],2) AS RESULT;
 result
--------
  1
(1 row)
```

- string_to_array(text, text [, text])

  Description: Uses the second **text** as the new delimiter and the third **text** as the substring to be replaced by **NULL** values. A substring can be replaced by **NULL** values only when it is the same as the third **text**.

  Return type: text[]

  Example:

```
openGauss=# SELECT string_to_array('xx~^~yy~^~zz', '~^~', 'yy') AS RESULT;
    result
--------------
 {xx,NULL,zz}
(1 row)
openGauss=# SELECT string_to_array('xx~^~yy~^~zz', '~^~', 'y') AS RESULT;
   result
------------
 {xx,yy,zz}
(1 row)
```

- unnest(anyarray)

  Description: Expands an array to a set of rows.

  Return type: setof anyelement

  Example:

```
openGauss=# SELECT unnest(ARRAY[1,2]) AS RESULT;
 result
--------
      1
      2
(2 rows)
```

In **string_to_array**, if the delimiter parameter is NULL, each character in the input string will become a separate element in the resulting array. If the delimiter is an empty string, then the entire input string is returned as a one-element array. Otherwise the input string is split at each occurrence of the delimiter string.

In **string_to_array**, if the null-string parameter is omitted or NULL, none of the substrings of the input will be replaced by NULL.

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In **array_to_string**, if the null-string parameter is omitted or NULL, any null elements in the array are simply skipped and not represented in the output string.

- _pg_keysequal

  Description: Checks whether two smallint arrays are the same.

  Parameter: smallint[], smallint[]

  Return type: Boolean

# 12.5.17 Range Functions and Operators

## Range Operators

- =

  Description: Equals

  Example:

```
openGauss=# SELECT int4range(1,5) = '[1,4]'::int4range AS RESULT;
 result
--------
 t
(1 row)
```

- <>

  Description: Does not equal to

  Example:

```
openGauss=# SELECT numrange(1.1,2.2) <> numrange(1.1,2.3) AS RESULT;
 result
--------
 t
(1 row)
```

- <

  Description: Is less than

  Example:

```
openGauss=# SELECT int4range(1,10) < int4range(2,3) AS RESULT;
 result
--------
 t
(1 row)
```

- >

  Description: Is greater than

  Example:

```
openGauss=# SELECT int4range(1,10) > int4range(1,5) AS RESULT;
 result
--------
 t
(1 row)
```

- <=

  Description: Is less than or equals

  Example:

```
openGauss=# SELECT numrange(1.1,2.2) <= numrange(1.1,2.2) AS RESULT;
 result
--------
 t
(1 row)
```

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- >=

  Description: Is greater than or equals

  Example:

```
openGauss=# SELECT numrange(1.1,2.2) >= numrange(1.1,2.0) AS RESULT;
 result
--------
 t
(1 row)
```

- @>

  Description: Contains range

  Example:

```
openGauss=# SELECT int4range(2,4) @> int4range(2,3) AS RESULT;
 result
--------
 t
(1 row)
```

- @>

  Description: Contains element

  Example:

```
openGauss=# SELECT '[2011-01-01,2011-03-01)'::tsrange @> '2011-01-10'::timestamp AS RESULT;
 result
--------
 t
(1 row)
```

- <@

  Description: Range is contained by

  Example:

```
openGauss=# SELECT int4range(2,4) <@ int4range(1,7) AS RESULT;
 result
--------
 t
(1 row)
```

- <@

  Description: Element is contained by

  Example:

```
openGauss=# SELECT 42 <@ int4range(1,7) AS RESULT;
 result
--------
 f
(1 row)
```

- &&

  Description: Overlap (have points in common)

  Example:

```
openGauss=# SELECT int8range(3,7) && int8range(4,12) AS RESULT;
 result
--------
 t
(1 row)
```

- <<

  Description: Strictly left of

  Example:

```
openGauss=# SELECT int8range(1,10) << int8range(100,110) AS RESULT;
 result
```

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```
--------
 t
(1 row)
```

- >>

  Description: Strictly right of

  Example:

```
openGauss=# SELECT int8range(50,60) >> int8range(20,30) AS RESULT;
 result
--------
 t
(1 row)
```

- &<

  Description: Does not extend to the right of

  Example:

```
openGauss=# SELECT int8range(1,20) &< int8range(18,20) AS RESULT;
 result
--------
 t
(1 row)
```

- &>

  Description: Does not extend to the left of

  Example:

```
openGauss=# SELECT int8range(7,20) &> int8range(5,10) AS RESULT;
 result
--------
 t
(1 row)
```

- -|-

  Description: Is adjacent to

  Example:

```
openGauss=# SELECT numrange(1.1,2.2) -|- numrange(2.2,3.3) AS RESULT;
 result
--------
 t
(1 row)
```

- +

  Description: Union

  Example:

```
openGauss=# SELECT numrange(5,15) + numrange(10,20) AS RESULT;
 result
--------
 [5,20)
(1 row)
```

- *

  Description: Intersection

  Example:

```
openGauss=# SELECT int8range(5,15) * int8range(10,20) AS RESULT;
 result
---------
 [10,15)
(1 row)
```

- -

  Description: Difference

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Example:

```
openGauss=# SELECT int8range(5,15) - int8range(10,20) AS RESULT;
 result
--------
 [5,10)
(1 row)
```

The simple comparison operators **<**, **>**, **<=**, and **>=** compare the lower bounds first, and only if those are equal, compare the upper bounds.

The **<<**, **>>**, and **-|-** operators always return false when an empty range is involved; that is, an empty range is not considered to be either before or after any other range.

The union and difference operators will fail if the resulting range would need to contain two disjoint sub-ranges.

## Range Functions

- numrange(numeric, numeric, [text])

  Description: Specifies a range.

  Return type: Range's element type

  Example:

  ```
  openGauss=# SELECT numrange(1.1,2.2) AS RESULT;
   result
  --------
  [1.1,2.2)
  (1 row)
  openGauss=# SELECT numrange(1.1,2.2, '()') AS RESULT;
   result
  --------
  (1.1,2.2)
  (1 row)
  ```

- lower(anyrange)

  Description: Lower bound of range

  Return type: Range's element type

  Example:

  ```
  openGauss=# SELECT lower(numrange(1.1,2.2)) AS RESULT;
   result
  --------
     1.1
  (1 row)
  ```

- upper(anyrange)

  Description: Upper bound of range

  Return type: Range's element type

  Example:

  ```
  openGauss=# SELECT upper(numrange(1.1,2.2)) AS RESULT;
   result
  --------
     2.2
  (1 row)
  ```

- isempty(anyrange)

  Description: Is the range empty?

  Return type: Boolean

  Example:

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```
openGauss=# SELECT isempty(numrange(1.1,2.2)) AS RESULT;
 result
--------
 f
(1 row)
```

- lower_inc(anyrange)

  Description: Is the lower bound inclusive?

  Return type: Boolean

  Example:

```
openGauss=# SELECT lower_inc(numrange(1.1,2.2)) AS RESULT;
 result
--------
 t
(1 row)
```

- upper_inc(anyrange)

  Description: Is the upper bound inclusive?

  Return type: Boolean

  Example:

```
openGauss=# SELECT upper_inc(numrange(1.1,2.2)) AS RESULT;
 result
--------
 f
(1 row)
```

- lower_inf(anyrange)

  Description: Is the lower bound infinite?

  Return type: Boolean

  Example:

```
openGauss=# SELECT lower_inf('(,)'::daterange) AS RESULT;
 result
--------
 t
(1 row)
```

- upper_inf(anyrange)

  Description: Is the upper bound infinite?

  Return type: Boolean

  Example:

```
openGauss=# SELECT upper_inf('(,)'::daterange) AS RESULT;
 result
--------
 t
(1 row)
```

The **lower** and **upper** functions return null if the range is empty or the requested bound is infinite. The **lower_inc**, **upper_inc**, **lower_inf**, and **upper_inf** functions all return false for an empty range.

- elem_contained_by_range(anyelement, anyrange)

  Description: Determines whether an element is within the range.

  Return type: Boolean

  Example:

```
openGauss=# SELECT elem_contained_by_range('2', numrange(1.1,2.2));
 elem_contained_by_range
-------------------------
```

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```
 t
(1 row)
```

# 12.5.18 Aggregate Functions

## Aggregate Functions

- sum(expression)

  Description: Sum of expression across all input values

  Return type:

  Generally, same as the argument data type. In the following cases, type conversion occurs:

  – **BIGINT** for **SMALLINT** or **INT** arguments

  – **NUMBER** for **BIGINT** arguments

  – **DOUBLE PRECISION** for floating-point arguments

  Example:

  ```
  openGauss=# SELECT SUM(ss_ext_tax) FROM tpcds.STORE_SALES;
    sum
  --------------
   213267594.69
  (1 row)
  ```

- max(expression)

  Description: Specifies the maximum value of expression across all input values.

  Parameter type: any array, numeric, string, or date/time type

  Return type: same as the parameter type

  Example:

  ```
  openGauss=# SELECT MAX(inv_quantity_on_hand) FROM tpcds.inventory;
  ```

- min(expression)

  Description: Minimum value of expression across all input values

  Parameter type: any array, numeric, string, or date/time type

  Return type: same as the parameter type

  Example:

  ```
  openGauss=# SELECT MIN(inv_quantity_on_hand) FROM tpcds.inventory;
   min
  -----
    0
  (1 row)
  ```

- avg(expression)

  Description: Average (arithmetic mean) of all input values

  Return type:

  **NUMBER** for any integer-type argument.

  **DOUBLE PRECISION** for floating-point parameters.

  otherwise the same as the argument data type.

  Example:

  ```
  openGauss=# SELECT AVG(inv_quantity_on_hand) FROM tpcds.inventory;
          avg
  ----------------------
  ```

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```
 500.0387129084044604
(1 row)
```

- count(expression)

  Description: Returns the number of input rows for which the value of expression is not null.

  Return type: bigint

  Example:

```
openGauss=# SELECT COUNT(inv_quantity_on_hand) FROM tpcds.inventory;
  count
----------
 11158087
(1 row)
```

- count(*)

  Description: Returns the number of input rows.

  Return type: bigint

  Example:

```
openGauss=# SELECT COUNT(*) FROM tpcds.inventory;
  count
----------
 11745000
(1 row)
```

- array_agg(expression)

  Description: Input values, including nulls, concatenated into an array

  Return type: array of the parameter type

  Example:

```
openGauss=# SELECT ARRAY_AGG(sr_fee) FROM tpcds.store_returns WHERE sr_customer_sk = 2;
   array_agg
---------------
 {22.18,63.21}
(1 row)
```

- string_agg(expression, delimiter)

  Description: Input values concatenated into a string, separated by delimiter

  Return type: same as the parameter data type.

  Example:

```
openGauss=# SELECT string_agg(sr_item_sk, ',') FROM tpcds.store_returns where sr_item_sk < 3;
        string_agg
--------------------------------------------------------------------------------
--------------------------------
 1,2,1,2,2,1,1,2,2,1,2,1,2,1,1,1,2,1,1,1,1,1,2,1,1,1,1,1,2,2,1,1,1,1,1,1,1,1,2,
2,1,1,1,1,1,1,2,2,1,1,2,1,1,1
(1 row)
```

- listagg(expression [, delimiter]) WITHIN GROUP(ORDER BY order-list)

  Description: Aggregation column data sorted according to the mode specified by **WITHIN GROUP**, and concatenated to a string using the specified delimiter

  - **expression**: Mandatory. It specifies an aggregation column name or a column-based, valid expression. It does not support the **DISTINCT** keyword and the **VARIADIC** parameter.
  - **delimiter**: Optional. It specifies a delimiter, which can be a string constant or a deterministic expression based on a group of columns. The default value is empty.

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– **order-list**: Mandatory. It specifies the sorting mode in a group.

Return type: text

> **NOTE**
>
> **listagg** is a column-to-row aggregation function, compatible with Oracle Database 11g Release 2. You can specify the **OVER** clause as a window function. When **listagg** is used as a window function, the **OVER** clause does not support the window sorting or framework of **ORDER BY**, to avoid ambiguity in **listagg** and **ORDER BY** of the **WITHIN GROUP** clause.

Example:

The aggregation column is of the text character set type.

```
openGauss=# SELECT deptno, listagg(ename, ',') WITHIN GROUP(ORDER BY ename) AS employees
FROM emp GROUP BY deptno;
 deptno |              employees
--------+---------------------------------------
     10 | CLARK,KING,MILLER
     20 | ADAMS,FORD,JONES,SCOTT,SMITH
     30 | ALLEN,BLAKE,JAMES,MARTIN,TURNER,WARD
(3 rows)
```

The aggregation column is of the integer type.

```
openGauss=# SELECT deptno, listagg(mgrno, ',') WITHIN GROUP(ORDER BY mgrno NULLS FIRST) AS
mgrnos FROM emp GROUP BY deptno;
 deptno |            mgrnos
--------+------------------------------
     10 | 7782,7839
     20 | 7566,7566,7788,7839,7902
     30 | 7698,7698,7698,7698,7698,7839
(3 rows)
```

The aggregation column is of the floating point type.

```
openGauss=# SELECT job, listagg(bonus, '($); ') WITHIN GROUP(ORDER BY bonus DESC) || '($)' AS
bonus FROM emp GROUP BY job;
    job     |                    bonus
------------+-----------------------------------------------
 CLERK      | 10234.21($); 2000.80($); 1100.00($); 1000.22($)
 PRESIDENT  | 23011.88($)
 ANALYST    | 2002.12($); 1001.01($)
 MANAGER    | 10000.01($); 2399.50($); 999.10($)
 SALESMAN   | 1000.01($); 899.00($); 99.99($); 9.00($)
(5 rows)
```

The aggregation column is of the time type.

```
openGauss=# SELECT deptno, listagg(hiredate, ', ') WITHIN GROUP(ORDER BY hiredate DESC) AS
hiredates FROM emp GROUP BY deptno;
 deptno |                                                hiredates
--------
+-----------------------------------------------------------------------------------------------------------------------
---------
     10 | 1982-01-23 00:00:00, 1981-11-17 00:00:00, 1981-06-09 00:00:00
     20 | 2001-04-02 00:00:00, 1999-12-17 00:00:00, 1987-05-23 00:00:00, 1987-04-19 00:00:00,
1981-12-03 00:00:00
     30 | 2015-02-20 00:00:00, 2010-02-22 00:00:00, 1997-09-28 00:00:00, 1981-12-03 00:00:00,
1981-09-08 00:00:00, 1981-05-01 00:00:00
(3 rows)
```

The aggregation column is of the time interval type.

```
openGauss=# SELECT deptno, listagg(vacationTime, '; ') WITHIN GROUP(ORDER BY vacationTime
DESC) AS vacationTime FROM emp GROUP BY deptno;
 deptno |                              vacationtime
--------+-------------------------------------------------------------------------------
     10 | 1 year 30 days; 40 days; 10 days
     20 | 70 days; 36 days; 9 days; 5 days
     30 | 1 year 1 mon; 2 mons 10 days; 30 days; 12 days 12:00:00; 4 days 06:00:00; 24:00:00
(3 rows)
```

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By default, the delimiter is empty.

```
openGauss=# SELECT deptno, listagg(job) WITHIN GROUP(ORDER BY job) AS jobs FROM emp
GROUP BY deptno;
 deptno |                  jobs
--------+-----------------------------------------------
     10 | CLERKMANAGERPRESIDENT
     20 | ANALYSTANALYSTCLERKCLERKMANAGER
     30 | CLERKMANAGERSALESMANSALESMANSALESMANSALESMAN
(3 rows)
```

When **listagg** is used as a window function, the **OVER** clause does not support the window sorting of **ORDER BY**, and the **listagg** column is an ordered aggregation of the corresponding groups.

```
openGauss=# SELECT deptno, mgrno, bonus, listagg(ename,'; ') WITHIN GROUP(ORDER BY hiredate)
OVER(PARTITION BY deptno) AS employees FROM emp;
 deptno | mgrno |  bonus   |                 employees
--------+-------+----------+-------------------------------------------
     10 |  7839 | 10000.01 | CLARK; KING; MILLER
     10 |       | 23011.88 | CLARK; KING; MILLER
     10 |  7782 | 10234.21 | CLARK; KING; MILLER
     20 |  7566 |  2002.12 | FORD; SCOTT; ADAMS; SMITH; JONES
     20 |  7566 |  1001.01 | FORD; SCOTT; ADAMS; SMITH; JONES
     20 |  7788 |  1100.00 | FORD; SCOTT; ADAMS; SMITH; JONES
     20 |  7902 |  2000.80 | FORD; SCOTT; ADAMS; SMITH; JONES
     20 |  7839 |   999.10 | FORD; SCOTT; ADAMS; SMITH; JONES
     30 |  7839 |  2399.50 | BLAKE; TURNER; JAMES; MARTIN; WARD; ALLEN
     30 |  7698 |     9.00 | BLAKE; TURNER; JAMES; MARTIN; WARD; ALLEN
     30 |  7698 |  1000.22 | BLAKE; TURNER; JAMES; MARTIN; WARD; ALLEN
     30 |  7698 |    99.99 | BLAKE; TURNER; JAMES; MARTIN; WARD; ALLEN
     30 |  7698 |  1000.01 | BLAKE; TURNER; JAMES; MARTIN; WARD; ALLEN
     30 |  7698 |   899.00 | BLAKE; TURNER; JAMES; MARTIN; WARD; ALLEN
(14 rows)
```

- covar_pop(Y, X)

  Description: Overall covariance

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT COVAR_POP(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE
  sr_customer_sk < 1000;
     covar_pop
  ------------------
   829.749627587403
  (1 row)
  ```

- covar_samp(Y, X)

  Description: Sample covariance

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT COVAR_SAMP(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE
  sr_customer_sk < 1000;
     covar_samp
  ------------------
   830.052235037289
  (1 row)
  ```

- stddev_pop(expression)

  Description: Overall standard difference

  Return type: **double precision** for floating-point arguments, otherwise **numeric**

  Example:

  ```
  openGauss=# SELECT STDDEV_POP(inv_quantity_on_hand) FROM tpcds.inventory WHERE
  inv_warehouse_sk = 1;
  ```

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```
   stddev_pop
------------------
 289.224294957556
(1 row)
```

- stddev_samp(expression)

  Description: Sample standard deviation of the input values

  Return type: **double precision** for floating-point arguments, otherwise **numeric**

  Example:

```
openGauss=# SELECT STDDEV_SAMP(inv_quantity_on_hand) FROM tpcds.inventory WHERE
inv_warehouse_sk = 1;
  stddev_samp
------------------
 289.224359757315
(1 row)
```

- var_pop(expression)

  Description: Population variance of the input values (square of the population standard deviation)

  Return type: **double precision** for floating-point arguments, otherwise **numeric**

  Example:

```
openGauss=# SELECT VAR_POP(inv_quantity_on_hand) FROM tpcds.inventory WHERE
inv_warehouse_sk = 1;
      var_pop
--------------------
 83650.692793695475
(1 row)
```

- var_samp(expression)

  Description: Sample variance of the input values (square of the sample standard deviation)

  Return type: **double precision** for floating-point arguments, otherwise **numeric**

  Example:

```
openGauss=# SELECT VAR_SAMP(inv_quantity_on_hand) FROM tpcds.inventory WHERE
inv_warehouse_sk = 1;
      var_samp
--------------------
 83650.730277028768
(1 row)
```

- bit_and(expression)

  Description: The bitwise AND of all non-null input values, or null if none

  Return type: same as the parameter data type.

  Example:

```
openGauss=# SELECT BIT_AND(inv_quantity_on_hand) FROM tpcds.inventory WHERE
inv_warehouse_sk = 1;
 bit_and
---------
       0
(1 row)
```

- bit_or(expression)

  Description: The bitwise OR of all non-null input values, or null if none

  Return type: same as the parameter data type.

  Example:

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```
openGauss=# SELECT BIT_OR(inv_quantity_on_hand) FROM tpcds.inventory WHERE
inv_warehouse_sk = 1;
 bit_or
--------
   1023
(1 row)
```

- bool_and(expression)

  Description: Its value is **true** if all input values are **true**, otherwise **false**.

  Return type: Boolean

  Example:

```
openGauss=# SELECT bool_and(100 <2500);
 bool_and
----------
 t
(1 row)
```

- bool_or(expression)

  Description: Its value is **true** if at least one input value is **true**, otherwise **false**.

  Return type: Boolean

  Example:

```
openGauss=# SELECT bool_or(100 <2500);
 bool_or
----------
 t
(1 row)
```

- corr(Y, X)

  Description: Correlation coefficient

  Return type: double precision

  Example:

```
openGauss=# SELECT CORR(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE sr_customer_sk <
1000;
       corr
--------------------
 .0381383624904186
(1 row)
```

- every(expression)

  Description: Equivalent to **bool_and**

  Return type: Boolean

  Example:

```
openGauss=# SELECT every(100 <2500);
 every
-------
 t
(1 row)
```

- rank(expression)

  Description: The tuples in different groups are sorted non-consecutively by **expression**.

  Return type: bigint

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, rank() OVER(PARTITION BY d_moy ORDER BY
d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY 1,2;
  d_moy | d_fy_week_seq | rank
-------+---------------+------
```

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```
   1 |           1 |   1
   1 |           1 |   1
   1 |           1 |   1
   1 |           1 |   1
   1 |           1 |   1
   1 |           1 |   1
   1 |           1 |   1
   1 |           2 |   8
   1 |           2 |   8
   1 |           2 |   8
   1 |           2 |   8
   1 |           2 |   8
   1 |           2 |   8
   1 |           2 |   8
   1 |           3 |  15
   1 |           3 |  15
   1 |           3 |  15
   1 |           3 |  15
   1 |           3 |  15
   1 |           3 |  15
   1 |           3 |  15
   1 |           4 |  22
   1 |           4 |  22
   1 |           4 |  22
   1 |           4 |  22
   1 |           4 |  22
   1 |           4 |  22
   1 |           4 |  22
   1 |           5 |  29
   1 |           5 |  29
   2 |           5 |   1
   2 |           5 |   1
   2 |           5 |   1
   2 |           5 |   1
   2 |           5 |   1
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
(42 rows)
```

- regr_avgx(Y, X)

  Description: Average of the independent variable (**sum(X)/N**)

  Return type: double precision

  Example:

```
openGauss=# SELECT REGR_AVGX(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE
sr_customer_sk < 1000;
    regr_avgx
------------------
 578.606576740795
(1 row)
```

- regr_avgy(Y, X)

  Description: Average of the dependent variable (**sum(Y)/N**)

  Return type: double precision

  Example:

```
openGauss=# SELECT REGR_AVGY(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE
sr_customer_sk < 1000;
    regr_avgy
------------------
 50.0136711629602
(1 row)
```

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- regr_count(Y, X)

  Description: Specifies the number of input rows in which both expressions are non-null.

  Return type: bigint

  Example:

```
openGauss=# SELECT REGR_COUNT(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE
sr_customer_sk < 1000;
 regr_count
------------
       2743
(1 row)
```

- regr_intercept(Y, X)

  Description: y-intercept of the least-squares-fit linear equation determined by the (X, Y) pairs

  Return type: double precision

  Example:

```
openGauss=# SELECT REGR_INTERCEPT(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE
sr_customer_sk < 1000;
  regr_intercept
------------------
 49.2040847848607
(1 row)
```

- regr_r2(Y, X)

  Description: Square of the correlation coefficient

  Return type: double precision

  Example:

```
openGauss=# SELECT REGR_R2(sr_fee, sr_net_loss) FROM store_returns WHERE sr_customer_sk <
1000;
      regr_r2
--------------------
 .00145453469345058
(1 row)
```

- regr_slope(Y, X)

  Description: Slope of the least-squares-fit linear equation determined by the (X, Y) pairs

  Return type: double precision

  Example:

```
openGauss=# SELECT REGR_SLOPE(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE
sr_customer_sk < 1000;
     regr_slope
--------------------
 .00139920009665259
(1 row)
```

- regr_sxx(Y, X)

  Description: **sum(X^2) - sum(X)^2/N** (sum of squares of the independent variables)

  Return type: double precision

  Example:

```
openGauss=# SELECT REGR_SXX(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE sr_customer_sk
< 1000;
     regr_sxx
------------------
```

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```
 1626645991.46135
(1 row)
```

- regr_sxy(Y, X)

  Description: **sum(X*Y) - sum(X) * sum(Y)/N** ("sum of products" of independent times dependent variable)

  Return type: double precision

  Example:

```
openGauss=# SELECT REGR_SXY(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE sr_customer_sk
< 1000;
     regr_sxy
------------------
 2276003.22847225
(1 row)
```

- regr_syy(Y, X)

  Description: **sum(Y^2) - sum(Y)^2/N** ("sum of squares" of the dependent variable)

  Return type: double precision

  Example:

```
openGauss=# SELECT REGR_SYY(sr_fee, sr_net_loss) FROM tpcds.store_returns WHERE sr_customer_sk
< 1000;
    regr_syy
-----------------
 2189417.6547314
(1 row)
```

- stddev(expression)

  Description: Alias of **stddev_samp**

  Return type: **double precision** for floating-point arguments, otherwise **numeric**

  Example:

```
openGauss=# SELECT STDDEV(inv_quantity_on_hand) FROM tpcds.inventory WHERE
inv_warehouse_sk = 1;
      stddev
------------------
 289.224359757315
(1 row)
```

- variance(expexpression,ression)

  Description: Alias of **var_samp**

  Return type: **double precision** for floating-point arguments, otherwise **numeric**

  Example:

```
openGauss=# SELECT VARIANCE(inv_quantity_on_hand) FROM tpcds.inventory WHERE
inv_warehouse_sk = 1;
      variance
--------------------
 83650.730277028768
(1 row)
```

- spread

  Description: Calculates the difference between the maximum value and minimum value in a certain period.

  Parameter: real

  Return type: real

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- checksum(expression)

  Description: Returns the CHECKSUM value of all input values. This function can be used to check whether the data in the tables is the same before and after the backup, restoration, or migration of the GaussDB database (databases other than GaussDB are not supported). Before and after database backup, database restoration, or data migration, you need to manually run SQL commands to obtain the execution results. Compare the obtained execution results to check whether the data in the tables before and after the backup or migration is the same.

  NOTE

  - For large tables, the execution of CHECKSUM function may take a long time.
  - If the CHECKSUM values of two tables are different, it indicates that the contents of the two tables are different. Using the hash function in the CHECKSUM function may incur conflicts. There is low possibility that two tables with different contents may have the same CHECKSUM value. The same problem may occur when CHECKSUM is used for columns.
  - If the time type is timestamp, timestamptz, or smalldatetime, ensure that the time zone settings are the same when calculating the CHECKSUM value.

  – If the CHECKSUM value of a column is calculated and the column type can be changed to TEXT by default, set *expression* to the column name.
  – If the CHECKSUM value of a column is calculated and the column type cannot be converted to TEXT by default, set *expression* to *Column name*::**TEXT**.
  – If the CHECKSUM value of all columns is calculated, set *expression* to *Table name*::**TEXT**.

  The following types of data can be converted into TEXT types by default: char, name, int8, int2, int1, int4, raw, pg_node_tree, float4, float8, bpchar, varchar, nvarchar2, date, timestamp, timestamptz, numeric, and smalldatetime. Other types need to be forcibly converted to TEXT.

  Return type: numeric

  Example:

  The following shows the CHECKSUM value of a column that can be converted to the TEXT type by default:

  ```
  openGauss=# SELECT CHECKSUM(inv_quantity_on_hand) FROM tpcds.inventory;
      checksum
  -------------------
   24417258945265247
  (1 row)
  ```

  The following shows the CHECKSUM value of a column that cannot be converted to the TEXT type by default. Note that the CHECKSUM parameter is set to *Column name*::**TEXT**.

  ```
  openGauss=# SELECT CHECKSUM(inv_quantity_on_hand::TEXT) FROM tpcds.inventory;
      checksum
  -------------------
   24417258945265247
  (1 row)
  ```

  The following shows the CHECKSUM value of all columns in a table. Note that the CHECKSUM parameter is set to *Table name*::**TEXT**. The table name is not modified by its schema.

  ```
  openGauss=# SELECT CHECKSUM(inventory::TEXT) FROM tpcds.inventory;
      checksum
  ```

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```
-------------------
 25223696246875800
(1 row)
```

# 12.5.19 Window Functions

## Window Functions

Currently, column-store tables only support **rank(expression)** and **row_number(expression)** functions.

This statement is used together with the window function. The **OVER** clause is used for grouping data and sorting the elements in a group. Window functions are used for generating sequence numbers for the values in the group.

NOTE

**order by** in a window function must be followed by a column name. If it is followed by a number, the number is processed as a constant value and the target column is not ranked.

- RANK()

  Description: The **RANK** function is used for generating non-consecutive sequence numbers for the values in each group. The same values have the same sequence number.

  Return type: bigint

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, rank() OVER(PARTITION BY d_moy ORDER BY
d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY 1,2;
  d_moy | d_fy_week_seq | rank
-------+---------------+------
     1 |             1 |    1
     1 |             1 |    1
     1 |             1 |    1
     1 |             1 |    1
     1 |             1 |    1
     1 |             1 |    1
     1 |             1 |    1
     1 |             2 |    8
     1 |             2 |    8
     1 |             2 |    8
     1 |             2 |    8
     1 |             2 |    8
     1 |             2 |    8
     1 |             2 |    8
     1 |             3 |   15
     1 |             3 |   15
     1 |             3 |   15
     1 |             3 |   15
     1 |             3 |   15
     1 |             3 |   15
     1 |             3 |   15
     1 |             4 |   22
     1 |             4 |   22
     1 |             4 |   22
     1 |             4 |   22
     1 |             4 |   22
     1 |             4 |   22
     1 |             4 |   22
     1 |             5 |   29
     1 |             5 |   29
     2 |             5 |    1
     2 |             5 |    1
     2 |             5 |    1
```

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```
   2 |           5 |   1
   2 |           5 |   1
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
   2 |           6 |   6
(42 rows)
```

- ROW_NUMBER()

  Description: The **ROW_NUMBER** function is used for generating consecutive sequence numbers for the values in each group. The same values have different sequence numbers.

  Return type: bigint

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, Row_number() OVER(PARTITION BY d_moy ORDER BY d_fy_week_seq) FROM tpcds.date_dim  WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY 1,2;
 d_moy | d_fy_week_seq | row_number
-------+---------------+------------
   1 |           1 |         1
   1 |           1 |         2
   1 |           1 |         3
   1 |           1 |         4
   1 |           1 |         5
   1 |           1 |         6
   1 |           1 |         7
   1 |           2 |         8
   1 |           2 |         9
   1 |           2 |        10
   1 |           2 |        11
   1 |           2 |        12
   1 |           2 |        13
   1 |           2 |        14
   1 |           3 |        15
   1 |           3 |        16
   1 |           3 |        17
   1 |           3 |        18
   1 |           3 |        19
   1 |           3 |        20
   1 |           3 |        21
   1 |           4 |        22
   1 |           4 |        23
   1 |           4 |        24
   1 |           4 |        25
   1 |           4 |        26
   1 |           4 |        27
   1 |           4 |        28
   1 |           5 |        29
   1 |           5 |        30
   2 |           5 |         1
   2 |           5 |         2
   2 |           5 |         3
   2 |           5 |         4
   2 |           5 |         5
   2 |           6 |         6
   2 |           6 |         7
   2 |           6 |         8
   2 |           6 |         9
   2 |           6 |        10
   2 |           6 |        11
   2 |           6 |        12
(42 rows)
```

- DENSE_RANK()

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Description: The **DENSE_RANK** function is used for generating consecutive sequence numbers for the values in each group. The same values have the same sequence number.

Return type: bigint

Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, dense_rank() OVER(PARTITION BY d_moy ORDER BY
d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY 1,2;
 d_moy | d_fy_week_seq | dense_rank
-------+---------------+------------
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             2 |          2
     1 |             2 |          2
     1 |             2 |          2
     1 |             2 |          2
     1 |             2 |          2
     1 |             2 |          2
     1 |             2 |          2
     1 |             3 |          3
     1 |             3 |          3
     1 |             3 |          3
     1 |             3 |          3
     1 |             3 |          3
     1 |             3 |          3
     1 |             3 |          3
     1 |             4 |          4
     1 |             4 |          4
     1 |             4 |          4
     1 |             4 |          4
     1 |             4 |          4
     1 |             4 |          4
     1 |             4 |          4
     1 |             5 |          5
     1 |             5 |          5
     2 |             5 |          1
     2 |             5 |          1
     2 |             5 |          1
     2 |             5 |          1
     2 |             5 |          1
     2 |             6 |          2
     2 |             6 |          2
     2 |             6 |          2
     2 |             6 |          2
     2 |             6 |          2
     2 |             6 |          2
     2 |             6 |          2
(42 rows)
```

- PERCENT_RANK()

  Description: The **PERCENT_RANK** function is used for generating corresponding sequence numbers for the values in each group. That is, the function calculates the value according to the formula Sequence number = (**rank** - 1) / (**total rows** - 1). **rank** is the corresponding sequence number generated based on the **RANK** function for the value and **totalrows** is the total number of elements in a group.

  Return type: double precision

  Example:

  ```
  openGauss=# SELECT d_moy, d_fy_week_seq, percent_rank() OVER(PARTITION BY d_moy ORDER BY
  d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY 1,2;
  ```

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```
 d_moy | d_fy_week_seq |   percent_rank
-------+---------------+------------------
     1 |             1 |                0
     1 |             1 |                0
     1 |             1 |                0
     1 |             1 |                0
     1 |             1 |                0
     1 |             1 |                0
     1 |             1 |                0
     1 |             2 | .241379310344828
     1 |             2 | .241379310344828
     1 |             2 | .241379310344828
     1 |             2 | .241379310344828
     1 |             2 | .241379310344828
     1 |             2 | .241379310344828
     1 |             2 | .241379310344828
     1 |             3 | .482758620689655
     1 |             3 | .482758620689655
     1 |             3 | .482758620689655
     1 |             3 | .482758620689655
     1 |             3 | .482758620689655
     1 |             3 | .482758620689655
     1 |             3 | .482758620689655
     1 |             4 | .724137931034483
     1 |             4 | .724137931034483
     1 |             4 | .724137931034483
     1 |             4 | .724137931034483
     1 |             4 | .724137931034483
     1 |             4 | .724137931034483
     1 |             4 | .724137931034483
     1 |             5 |  .96551724137931
     1 |             5 |  .96551724137931
     2 |             5 |                0
     2 |             5 |                0
     2 |             5 |                0
     2 |             5 |                0
     2 |             5 |                0
     2 |             6 | .454545454545455
     2 |             6 | .454545454545455
     2 |             6 | .454545454545455
     2 |             6 | .454545454545455
     2 |             6 | .454545454545455
     2 |             6 | .454545454545455
     2 |             6 | .454545454545455
(42 rows)
```

- CUME_DIST()

  Description: The **CUME_DIST** function is used for generating accumulative distribution sequence numbers for the values in each group. That is, the function calculates the value according to the following formula: Sequence number = Number of rows preceding or peer with current row/Total rows.

  Return type: double precision

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, cume_dist() OVER(PARTITION BY d_moy ORDER BY
d_fy_week_seq) FROM tpcds.date_dim e_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY
1,2;
 d_moy | d_fy_week_seq |    cume_dist
-------+---------------+------------------
     1 |             1 | .233333333333333
     1 |             1 | .233333333333333
     1 |             1 | .233333333333333
     1 |             1 | .233333333333333
     1 |             1 | .233333333333333
     1 |             1 | .233333333333333
     1 |             1 | .233333333333333
     1 |             2 | .466666666666667
     1 |             2 | .466666666666667
```

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```
    1 |           2 | .466666666666667
    1 |           2 | .466666666666667
    1 |           2 | .466666666666667
    1 |           2 | .466666666666667
    1 |           2 | .466666666666667
    1 |           3 |               .7
    1 |           3 |               .7
    1 |           3 |               .7
    1 |           3 |               .7
    1 |           3 |               .7
    1 |           3 |               .7
    1 |           3 |               .7
    1 |           4 | .933333333333333
    1 |           4 | .933333333333333
    1 |           4 | .933333333333333
    1 |           4 | .933333333333333
    1 |           4 | .933333333333333
    1 |           4 | .933333333333333
    1 |           4 | .933333333333333
    1 |           5 |                1
    1 |           5 |                1
    2 |           5 | .416666666666667
    2 |           5 | .416666666666667
    2 |           5 | .416666666666667
    2 |           5 | .416666666666667
    2 |           5 | .416666666666667
    2 |           6 |                1
    2 |           6 |                1
    2 |           6 |                1
    2 |           6 |                1
    2 |           6 |                1
    2 |           6 |                1
    2 |           6 |                1
(42 rows)
```

- NTILE(num_buckets integer)

  Description: The **NTILE** function is used for equally allocating sequential data sets to the buckets whose quantity is specified by **num_buckets** according to **num_buckets integer** and allocating the bucket number to each row. Divide the partition as evenly as possible.

  Return type: integer

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, ntile(3) OVER(PARTITION BY d_moy ORDER BY
d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY 1,2;
 d_moy | d_fy_week_seq | ntile
-------+---------------+-------
    1 |           1 |     1
    1 |           1 |     1
    1 |           1 |     1
    1 |           1 |     1
    1 |           1 |     1
    1 |           1 |     1
    1 |           1 |     1
    1 |           1 |     1
    1 |           2 |     1
    1 |           2 |     1
    1 |           2 |     1
    1 |           2 |     2
    1 |           2 |     2
    1 |           2 |     2
    1 |           2 |     2
    1 |           3 |     2
    1 |           3 |     2
    1 |           3 |     2
    1 |           3 |     2
    1 |           3 |     2
    1 |           3 |     2
    1 |           3 |     3
```

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```
   1 |          4 |    3
   1 |          4 |    3
   1 |          4 |    3
   1 |          4 |    3
   1 |          4 |    3
   1 |          4 |    3
   1 |          4 |    3
   1 |          5 |    3
   1 |          5 |    3
   2 |          5 |    1
   2 |          5 |    1
   2 |          5 |    1
   2 |          5 |    1
   2 |          5 |    2
   2 |          6 |    2
   2 |          6 |    2
   2 |          6 |    2
   2 |          6 |    3
   2 |          6 |    3
   2 |          6 |    3
   2 |          6 |    3
(42 rows)
```

- LAG(value any [, offset integer [, default any ]])

  Description: The **LAG** function is used for generating lag values for the corresponding values in each group. That is, the value of the row obtained by moving forward the row corresponding to the current value by **offset** (integer) is the sequence number. If the row does not exist after the moving, the result value is the default value. If omitted, **offset** defaults to **1** and **default** to **NULL**. The type of the **default** value must be the same as that of **value**.

  Return type: same as the parameter type

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, lag(d_moy,3,null) OVER(PARTITION BY d_moy ORDER BY d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY 1,2;
 d_moy | d_fy_week_seq | lag
-------+---------------+-----
   1 |          1 |
   1 |          1 |
   1 |          1 |
   1 |          1 |   1
   1 |          1 |   1
   1 |          1 |   1
   1 |          1 |   1
   1 |          2 |   1
   1 |          2 |   1
   1 |          2 |   1
   1 |          2 |   1
   1 |          2 |   1
   1 |          2 |   1
   1 |          2 |   1
   1 |          3 |   1
   1 |          3 |   1
   1 |          3 |   1
   1 |          3 |   1
   1 |          3 |   1
   1 |          3 |   1
   1 |          3 |   1
   1 |          4 |   1
   1 |          4 |   1
   1 |          4 |   1
   1 |          4 |   1
   1 |          4 |   1
   1 |          4 |   1
   1 |          4 |   1
   1 |          5 |   1
```

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```
   1 |          5 |  1
   2 |          5 |
   2 |          5 |
   2 |          5 |
   2 |          5 |  2
   2 |          5 |  2
   2 |          6 |  2
   2 |          6 |  2
   2 |          6 |  2
   2 |          6 |  2
   2 |          6 |  2
   2 |          6 |  2
   2 |          6 |  2
(42 rows)
```

- LEAD(value any [, offset integer [, default any ]])

  Description: The **LEAD** function is used for generating leading values for the corresponding values in each group. That is, the value of the row obtained by moving backward the row corresponding to the current value by **offset** (integer) is the sequence number. If the row after the moving exceeds the total number of rows for the current group, the result value is the default value. If omitted, **offset** defaults to **1** and **default** to **NULL**. The type of the **default** value must be the same as that of **value**.

  Return type: same as the parameter type

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, lead(d_fy_week_seq,2) OVER(PARTITION BY d_moy
ORDER BY d_fy_week_seq) FROM  tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER
BY 1,2;                d_moy | d_fy_week_seq | lead
-------+---------------+------
   1 |          1 |  1
   1 |          1 |  1
   1 |          1 |  1
   1 |          1 |  1
   1 |          1 |  1
   1 |          1 |  2
   1 |          1 |  2
   1 |          2 |  2
   1 |          2 |  2
   1 |          2 |  2
   1 |          2 |  2
   1 |          2 |  2
   1 |          2 |  3
   1 |          2 |  3
   1 |          3 |  3
   1 |          3 |  3
   1 |          3 |  3
   1 |          3 |  3
   1 |          3 |  3
   1 |          3 |  4
   1 |          3 |  4
   1 |          4 |  4
   1 |          4 |  4
   1 |          4 |  4
   1 |          4 |  4
   1 |          4 |  4
   1 |          4 |  5
   1 |          4 |  5
   1 |          5 |
   1 |          5 |
   2 |          5 |  5
   2 |          5 |  5
   2 |          5 |  5
   2 |          5 |  6
   2 |          5 |  6
   2 |          6 |  6
   2 |          6 |  6
```

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```
   2 |          6 |   6
   2 |          6 |   6
   2 |          6 |   6
   2 |          6 |
   2 |          6 |
(42 rows)
```

- FIRST_VALUE(value any)

  Description: Returns the first value of each group.

  Return type: same as the parameter type

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, first_value(d_fy_week_seq) OVER(PARTITION BY d_moy ORDER BY d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 7 ORDER BY 1,2;
 d_moy | d_fy_week_seq | first_value
-------+---------------+-------------
     1 |             1 |           1
     1 |             1 |           1
     1 |             1 |           1
     1 |             1 |           1
     1 |             1 |           1
     1 |             1 |           1
     1 |             1 |           1
     1 |             2 |           1
     1 |             2 |           1
     1 |             2 |           1
     1 |             2 |           1
     1 |             2 |           1
     1 |             2 |           1
     1 |             2 |           1
     1 |             2 |           1
     1 |             3 |           1
     1 |             3 |           1
     1 |             3 |           1
     1 |             3 |           1
     1 |             3 |           1
     1 |             3 |           1
     1 |             3 |           1
     1 |             4 |           1
     1 |             4 |           1
     1 |             4 |           1
     1 |             4 |           1
     1 |             4 |           1
     1 |             4 |           1
     1 |             4 |           1
     1 |             5 |           1
     1 |             5 |           1
     2 |             5 |           5
     2 |             5 |           5
     2 |             5 |           5
     2 |             5 |           5
     2 |             5 |           5
     2 |             6 |           5
     2 |             6 |           5
     2 |             6 |           5
     2 |             6 |           5
     2 |             6 |           5
     2 |             6 |           5
     2 |             6 |           5
(42 rows)
```

- LAST_VALUE(value any)

  Description: Returns the last value of each group.

  Return type: same as the parameter type

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, last_value(d_moy) OVER(PARTITION BY d_moy ORDER BY d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 6 ORDER BY 1,2;
```

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```
 d_moy | d_fy_week_seq | last_value
-------+---------------+------------
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             1 |          1
     1 |             2 |          1
     1 |             2 |          1
     1 |             2 |          1
     1 |             2 |          1
     1 |             2 |          1
     1 |             2 |          1
     1 |             2 |          1
     1 |             2 |          1
     1 |             3 |          1
     1 |             3 |          1
     1 |             3 |          1
     1 |             3 |          1
     1 |             3 |          1
     1 |             3 |          1
     1 |             3 |          1
     1 |             4 |          1
     1 |             4 |          1
     1 |             4 |          1
     1 |             4 |          1
     1 |             4 |          1
     1 |             4 |          1
     1 |             4 |          1
     1 |             5 |          1
     1 |             5 |          1
     2 |             5 |          2
     2 |             5 |          2
     2 |             5 |          2
     2 |             5 |          2
     2 |             5 |          2
(35 rows)
```

- NTH_VALUE(value any, nth integer)

  Description: The *n*th row for a group is the returned value. If the row does not exist, **NULL** is returned by default.

  Return type: same as the parameter type

  Example:

```
openGauss=# SELECT d_moy, d_fy_week_seq, nth_value(d_fy_week_seq,6) OVER(PARTITION BY
d_moy ORDER BY d_fy_week_seq) FROM tpcds.date_dim WHERE d_moy < 4 AND d_fy_week_seq < 6
ORDER BY 1,2;
 d_moy | d_fy_week_seq | nth_value
-------+---------------+-----------
     1 |             1 |         1
     1 |             1 |         1
     1 |             1 |         1
     1 |             1 |         1
     1 |             1 |         1
     1 |             1 |         1
     1 |             1 |         1
     1 |             2 |         1
     1 |             2 |         1
     1 |             2 |         1
     1 |             2 |         1
     1 |             2 |         1
     1 |             2 |         1
     1 |             2 |         1
     1 |             2 |         1
     1 |             3 |         1
     1 |             3 |         1
     1 |             3 |         1
```

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```
   1 |           3 |       1
   1 |           3 |       1
   1 |           3 |       1
   1 |           3 |       1
   1 |           4 |       1
   1 |           4 |       1
   1 |           4 |       1
   1 |           4 |       1
   1 |           4 |       1
   1 |           4 |       1
   1 |           4 |       1
   1 |           5 |       1
   1 |           5 |       1
   2 |           5 |
   2 |           5 |
   2 |           5 |
   2 |           5 |
   2 |           5 |
(35 rows)
```

- delta

  Description: Returns the difference between the current row and the previous row.

  Parameter: numeric

  Return type: numeric

- spread

  Description: Calculates the difference between the maximum value and minimum value in a certain period.

  Parameter: real

  Return type: real

# 12.5.20 Security Functions

## Security Functions

- gs_encrypt_aes128(encryptstr,keystr)

  Description: Encrypts **encryptstr** strings using the key derived from **keystr** and returns encrypted strings. The value of **keystr** ranges from 8 to 16 bytes and contains at least three types of the following characters: uppercase letters, lowercase letters, digits, and special characters. Currently, the following types of data can be encrypted: numerals supported in the database; character type; RAW in binary type; and DATE, TIMESTAMP, and SMALLDATETIME in date/time type.

  Return type: text

  Length of the return value: At least 92 bytes and no more than (4*[*Len*/3]+68) bytes, where *Len* indicates the length of the data before encryption (unit: byte).

  Example:

```
openGauss=# SELECT gs_encrypt_aes128('MPPDB','1234@abc');
                                gs_encrypt_aes128
-----------------------------------------------------------------------------------
 OF1g3+70oeqFfyKiWlpxfYxPnpeitNc6+7nAe02Ttt37fZF8Q+bbEYhdw/YG+0c9tHKRWM6OcTzlB3HnqvX
+1d8Bflo=
(1 row)
```

> **NOTE**
>
> A password is required during the execution of this function. For security purposes, the gsql tool does not record the SQL statements containing the function name in the execution history. That is, the execution history of this function cannot be found in gsql by paging up and down.

- gs_decrypt_aes128(decryptstr,keystr)

  Description: Decrypts **decrypt** strings using the key derived from **keystr** and returns decrypted strings. The **keystr** used for decryption must be consistent with that used for encryption. **keystr** cannot be empty.

  > **NOTE**
  >
  > This function needs to be used with the **gs_encrypt_aes128** encryption function.

  Return type: text

  Example:

  ```
  openGauss=# SELECT gs_decrypt_aes128('OF1g3+70oeqFfyKiWlpxfYxPnpeitNc6+7nAe02Ttt37fZF8Q
  +bbEYhdw/YG+0c9tHKRWM6OcTzlB3HnqvX+1d8Bflo=','1234@abc');
   gs_decrypt_aes128
  -------------------
   MPPDB
  (1 row)
  ```

  > **NOTE**
  >
  > A password is required during the execution of this function. For security purposes, the gsql tool does not record the SQL statements containing the function name in the execution history. That is, the execution history of this function cannot be found in gsql by paging up and down.

- gs_password_deadline()

  Description: Indicates the number of remaining days before the password of the current user expires.

  Return type: interval

  Example:

  ```
  openGauss=# SELECT gs_password_deadline();
    gs_password_deadline
  -------------------------
   83 days 17:44:32.196094
  (1 row)
  ```

- gs_password_notifytime()

  Description: Specifies the number of days prior to password expiration that a user will receive a reminder.

  Return type: int32

- login_audit_messages(BOOLEAN)

  Description: Queries login information about a login user.

  Return type: tuple

  Example:

  – Check the date, time, and IP address of the last successful login.

    ```
    openGauss=> select * from login_audit_messages(true);
     username | database |       logintime        |    mytype     | result | client_conninfo
    ----------+----------+------------------------+---------------+--------+-----------------
     omm      | postgres | 2020-06-29 21:56:40+08 | login_success | ok     | gsql@[local]
    (1 row)
    ```

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  - Check the number, date, and time of failed attempts since the previous successful login.

```
openGauss=>  select * from login_audit_messages(false);
 username | database |       logintime        |    mytype    | result |  client_conninfo
----------+----------+------------------------+--------------+--------+-------------------
 omm      | postgres | 2020-06-29 21:57:55+08 | login_failed | failed | [unknown]@[local]
 omm      | postgres | 2020-06-29 21:57:53+08 | login_failed | failed | [unknown]@[local]
(2 rows)
```

- login_audit_messages_pid(BOOLEAN)

  Description: Queries login information about a login user. Different from **login_audit_messages**, this function queries login information based on **backendid**. Information about subsequent logins of the same user does not alter the query result of previous logins and cannot be found using this function.

  Return type: tuple

  NOTE

  When the thread pool is enabled, the **backendid** obtained in the same session may change due to thread switchover. As a result, the return values are different when the function is called for multiple times. You are not advised to call this function when the thread pool is enabled.

  Example:

  - Check the date, time, and IP address of the last successful login.

```
openGauss=> SELECT * FROM login_audit_messages_pid(true);
 username | database |       logintime        |    mytype     | result | client_conninfo |    backendid
----------+----------+------------------------+---------------+--------+-----------------+-----------------
 omm      | postgres | 2020-06-29 21:56:40+08 | login_success | ok     | gsql@[local]    |
139823109633792
(1 row)
```

  - Check the number, date, and time of failed attempts since the previous successful login.

```
openGauss=> SELECT * FROM login_audit_messages_pid(false);
 username | database |       logintime        |    mytype    | result |  client_conninfo  |    backendid
----------+----------+------------------------+--------------+--------+-------------------+-----------------
 omm      | postgres | 2020-06-29 21:57:55+08 | login_failed | failed | [unknown]@[local] |
139823109633792
 omm      | postgres | 2020-06-29 21:57:53+08 | login_failed | failed | [unknown]@[local] |
139823109633792
(2 rows)
```

- inet_server_addr()

  Description: Displays the server IP address.

  Return type: inet

  Example:

```
openGauss=# SELECT inet_server_addr();
 inet_server_addr
------------------
 10.10.0.13
(1 row)
```

  NOTE

  - The client IP address 10.10.0.50 and server IP address 10.10.0.13 are used as an example.
  - If the database is connected to the local PC, the value is empty.

- inet_client_addr()

  Description: Displays the client IP address.

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Return type: inet

Example:

```
openGauss=# SELECT inet_client_addr();
 inet_client_addr
------------------
 10.10.0.50
(1 row)
```

NOTE

- The client IP address 10.10.0.50 and server IP address 10.10.0.13 are used as an example.
- If the database is connected to the local PC, the value is empty.

- pg_query_audit**(timestamptz** *startime*,**timestamptz** *endtime*,*audit_log*)

  Description: Displays audit logs of the current CN.

  Return type: record

  The following table describes return fields.

| Name | Type | Description |
| --- | --- | --- |
| time | timestamp with time zone | Operation time |
| type | text | Operation |
| result | text | Operation result |
| userid | oid | User ID |
| username | text | Name of the user who performs the operation |
| database | text | Database name |
| client_conninfo | text | Client connection information |
| object_name | text | Object name |
| detail_info | text | Operation details |
| node_name | text | Node name |
| thread_id | text | Thread ID |
| local_port | text | Local port |
| remote_port | text | Remote port |

  For details about how to use the function and details about function examples, see **7.3.2 Querying Audit Results**.

- pgxc_query_audit**(timestamptz** *startime*,**timestamptz** *endtime*)

  Description: Displays audit logs of all CNs.

  Return type: record

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The return fields of this function are the same as those of the **pg_query_audit** function.

For details about how to use the function and details about function examples, see **7.3.2 Querying Audit Results**.

- pg_delete_audit**(timestamp** *startime*,**timestamp** *endtime***)**Description: Deletes audit logs in a specified period. Return type: void For details about how to use the function and details about function examples, see 7.3.3 Maintaining Audit Logs.
- alldigitsmasking

  Description: Specifies the internal function of the masking policy, which is used to anonymize all characters.

  Parameter: col text, letter character default '0'

  Return type: text
- creditcardmasking

  Description: Specifies the internal function of the masking policy, which is used to anonymize all credit card information.

  Parameter: col text, letter character default 'x'

  Return type: text
- randommasking

  Description: Specifies the internal function of the masking policy. The random policy is used.

  Parameter: col text

  Return type: text
- fullemailmasking

  Description: Specifies the internal function of the masking policy, which is used to anonymize the text (except **@**) before the last period (.).

  Parameter: col text, letter character default 'x'

  Return type: text
- basicemailmasking

  Description: Specifies the internal function of the masking policy, which is used to anonymize the text before the first at sign (@).

  Parameter: col text, letter character default 'x'

  Return type: text
- shufflemasking

  Description: Specifies the internal function of the masking policy, which is used to sort characters out of order.

  Parameter: col text

  Return type: text
- regexpmasking

  Description: Specifies the internal function of the masking policy, which is used to replace characters using a regular expression.

  Parameter: col text, reg text, replace_text text, pos INTEGER default 0, reg_len INTEGER default -1

  Return type: text

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- gs_encrypt(encryptstr,keystr, encrypttype)

  Description: Encrypts **encryptstr** strings using **keystr** as the key and returns encrypted strings based on **encrypttype**. The value of **keystr** contains 8 to 16 bytes and at least three types of the following characters: uppercase letters, lowercase letters, digits, and special characters. The value of **encrypttype** can be **aes128** or **sm4**.

  Return type: text

  Example:

```
openGauss=#  SELECT gs_encrypt('MPPDB','Asdf1234','sm4');
       gs_encrypt
 ------------------------------
 ZBzOmaGA4Bb+coyucJ0B8AkIShqc
(1 row)
```

  NOTE

  A decryption password is required during the execution of this function. For security purposes, the gsql tool does not record the SQL statements containing the function name in the execution history. That is, the execution history of this function cannot be found in gsql by paging up and down.

- gs_decrypt(decryptstr, keystr, decrypttype)

  Description: Decrypts **decrypt** strings using **keystr** as the key and returns decrypted strings based on **decrypttype**. The **decrypttype** and **keystr** used for decryption must be consistent with **encrypttype** and **keystr** used for encryption. The value of **keystr** cannot be empty. The value of **decrypttype** can be **aes128** or **sm4**.

  This function needs to be used with the **gs_encrypt** encryption function.

  Return type: text

  Example:

```
openGauss=# select gs_decrypt('ZBzOmaGA4Bb+coyucJ0B8AkIShqc','Asdf1234','sm4');
 gs_decrypt
------------
 MPPDB
(1 row)
```

  NOTE

  A decryption password is required during the execution of this function. For security purposes, the gsql tool does not record the SQL statements containing the function name in the execution history. That is, the execution history of this function cannot be found in gsql by paging up and down.

## 12.5.21 Ledger Database Functions

The current feature is a lab feature. Contact Huawei technical support before using it.

- get_dn_hist_relhash(text, text)

  Description: Returns the hash value of table-level data in a specified tamper-proof user table. This function can be invoked only between distributed nodes. A message indicating insufficient permission is displayed when all users invoke this function.

  Parameter type: text

  Return type: hash16

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- ledger_hist_check(text, text)

  Description: Verifies the consistency between the hash value of table-level data in a specified tamper-proof user table and that in the corresponding history table.

  Parameter type: text

  Return type: Boolean

- ledger_hist_repair(text, text)

  Description: Restores the hash value of the history table corresponding to the specified tamper-proof user table to be the same as that of the user table, and returns the hash difference.

  Parameter type: text

  Return type: hash16

- ledger_hist_archive(text, text)

  Description: Archives the history table corresponding to a specified tamper-proof user table to the **hist_back** folder in the audit log directory.

  Parameter type: text

  Return type: Boolean

- ledger_gchain_check(text, text)

  Description: Verifies the consistency between the history table hash corresponding to the specified tamper-proof user table and the **relhash** corresponding to the global history table.

  Parameter type: text

  Return type: Boolean

- ledger_gchain_repair(text, text)

  Description: Restores **relhash** of a specified tamper-proof user table in the global history table so that the hash is the same as that in the history table, and returns the hash difference.

  Parameter type: text

  Return type: hash16

- ledger_gchain_archive(void)

  Description: Archives global history tables to the **hist_back** folder in the audit log directory.

  Parameter type: void

  Return type: Boolean

- hash16in(cstring)

  Description: Converts the input hexadecimal string into the internal hash16 format.

  Parameter type: cstring

  Return type: hash16

- hash16out(uint64)

  Description: Converts internal hash16 data to hexadecimal cstring data.

  Parameter type: hash16

  Return type: cstring

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- hash32in(cstring)

  Description: Converts the input hexadecimal string (32 characters) into the internal type hash32.

  Parameter type: cstring

  Return type: hash32
- hash32out(hash32)

  Description: Converts internal hash32 data to hexadecimal cstring data.

  Parameter type: cstring

  Return type: hash32

## 12.5.22 Encrypted Equality Functions

- byteawithoutorderwithequalcolin(cstring)

  Description: Converts input data to the internal byteawithoutorderwithequalcol format.

  Parameter type: cstring

  Return type: byteawithoutorderwithequalcol
- byteawithoutorderwithequalcolout(byteawithoutorderwithequalcol)

  Description: Converts internal data of the byteawithoutorderwithequalcol type to data of the cstring type.

  Parameter type: byteawithoutorderwithequalcol

  Return type: cstring
- byteawithoutorderwithequalcolsend(byteawithoutorderwithequalcol)

  Description: Converts data of the byteawithoutorderwithequalcol type to data of the bytea type.

  Parameter type: byteawithoutorderwithequalcol

  Return type: bytea
- byteawithoutorderwithequalcolrecv(internal)

  Description: Converts data of the byteawithoutorderwithequalcol type to data of the byteawithoutorderwithequalcol type.

  Parameter type: internal

  Return type: byteawithoutorderwithequalcol
- byteawithoutorderwithequalcoltypmodin(_cstring)

  Description: Converts data of the byteawithoutorderwithequalcol type to data of the byteawithoutorderwithequalcol type.

  Parameter type: _cstring

  Return type: int4
- byteawithoutorderwithequalcoltypmodout(int4)

  Description: Converts data of the int4 type into data of the cstring type.

  Parameter type: int4

  Return type: cstring
- byteawithoutordercolin(cstring)

  Description: Converts input data to the internal byteawithoutordercolin format.

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Parameter type: cstring

Return type: byteawithoutordercol

- byteawithoutordercolout(byteawithoutordercol)

  Description: Converts internal data of the byteawithoutordercol type to data of the cstring type.

  Parameter type: byteawithoutordercol

  Return type: cstring

- byteawithoutordercolsend(byteawithoutordercol)

  Description: Converts data of the byteawithoutordercol type to data of the bytea type.

  Parameter type: byteawithoutordercol

  Return type: bytea

- byteawithoutordercolrecv(internal)

  Description: Converts data of the byteawithoutordercol type to data of the byteawithoutordercol type.

  Parameter type: internal

  Return type: byteawithoutordercol

- byteawithoutorderwithequalcolcmp(byteawithoutorderwithequalcol, byteawithoutorderwithequalcol)

  Description: Compares two byteawithoutorderwithequalcol data sizes. If the first data size is smaller than the second one, **–1** is returned. If the first data size is equal to the second one, **0** is returned. If the first data size is larger than the second one, **1** is returned.

  Parameter type: byteawithoutorderwithequalcol, byteawithoutorderwithequalcol

  Return type: int4

- byteawithoutorderwithequalcolcmpbytear(byteawithoutorderwithequalcol, bytea)

  Description: Compares the byteawithoutorderwithequalcol and bytea data sizes. If the first data size is smaller than the second one, **–1** is returned. If the first data size is equal to the second one, **0** is returned. If the first data size is larger than the second one, **1** is returned.

  Parameter type: byteawithoutorderwithequalcol or bytea

  Return type: int4

- byteawithoutorderwithequalcolcmpbyteal(bytea, byteawithoutorderwithequalcol)

  Description: Compares the bytea and byteawithoutorderwithequalcol data sizes. If the first data size is smaller than the second one, **–1** is returned. If the first data size is equal to the second one, **0** is returned. If the first data size is larger than the second one, **1** is returned.

  Parameter type: byteawithoutorderwithequalcol or bytea

  Return type: int4

- byteawithoutorderwithequalcoleq(byteawithoutorderwithequalcol, byteawithoutorderwithequalcol)

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Description: Compares two byteawithoutorderwithequalcol data records. If they are the same, **true** is returned. Otherwise, **false** is returned.

Parameter type: byteawithoutorderwithequalcol or bytea

Return type: Boolean

- byteawithoutorderwithequalcoleqbyteal(bytea, byteawithoutorderwithequalcol)

  Description: Compares the bytea and byteawithoutorderwithequalcol data records. If they are the same, **true** is returned. Otherwise, **false** is returned.

  Parameter type: bytea or byteawithoutorderwithequalcol

  Return type: Boolean

- byteawithoutorderwithequalcoleqbytear(byteawithoutorderwithequalcol, bytea)

  Description: Compares the byteawithoutorderwithequalcol and bytea data records. If they are the same, **true** is returned. Otherwise, **false** is returned.

  Parameter type: byteawithoutorderwithequalcol, bytea

  Return type: Boolean

- byteawithoutorderwithequalcolne(byteawithoutorderwithequalcol, byteawithoutorderwithequalcol)

  Description: Compares two byteawithoutorderwithequalcol data records. If they are different, **true** is returned. Otherwise, **false** is returned.

  Parameter type: byteawithoutorderwithequalcol, byteawithoutorderwithequalcol

  Return type: Boolean

- byteawithoutorderwithequalcolnebyteal(bytea, byteawithoutorderwithequalcol)

  Description: Compares the bytea and byteawithoutorderwithequalcol data records. If they are the same, **true** is returned. Otherwise, **false** is returned.

  Parameter type: bytea, byteawithoutorderwithequalcol

  Return type: Boolean

- byteawithoutorderwithequalcolnebytear(byteawithoutorderwithequalcol, bytea)

  Description: Compares the byteawithoutorderwithequalcol and bytea data records. If they are the same, **true** is returned. Otherwise, **false** is returned.

  Parameter type: byteawithoutorderwithequalcol, bytea

  Return type: Boolean

- hll_hash_byteawithoutorderwithequalcol(byteawithoutorderwithequalcol)

  Description: Returns the hll hash value of byteawithoutorderwithequalcol.

  Parameter type: byteawithoutorderwithequalcol

  Return type: hll_hashval

## Example

Functions such as byteawithoutorderwithequalcolin and byteawithoutorderwithequalcolout are read/write format conversion functions such as in, out, send, and recv specified by the data type

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byteawithoutorderwithequalcol in the database kernel. For details, see the byteain and byteaout functions of the bytea type. However, the local CEK must be verified, and the function can be successfully executed only when the encrypted column contains a CEK OID that can be found on the local host.

```
-- In this example, there is an encrypted table int_type, and int_col2 is the encrypted column.

-- Use a non-encrypted client to connect to the database and query the ciphertext of the encrypted column.
openGauss=# select int_col2 from int_type;
                                                
```

Parameter type: int, bigint, numeric

Return type: setof int, setof bigint, setof numeric (same as the parameter type)

- generate_series(start, stop, step)

  Description: Generates a series of values, from **start** to **stop** with a step size of **step**.

  Parameter type: int, bigint, numeric

  Return type: setof int, setof bigint, setof numeric (same as the parameter type)

- generate_series(start, stop, step interval)

  Description: Generates a series of values, from **start** to **stop** with a step size of **step**.

  Parameter type: timestamp or timestamp with time zone

  Return type: setof timestamp or setof timestamp with time zone (same as parameter type)

When **step** is positive, zero rows are returned if **start** is greater than **stop**. Conversely, when **step** is negative, zero rows are returned if **start** is less than **stop**. Zero rows are also returned for **NULL** inputs. It is an error for **step** to be zero.

Example:

```
openGauss=# SELECT * FROM generate_series(2,4);
 generate_series
-----------------
               2
               3
               4
(3 rows)

openGauss=# SELECT * FROM generate_series(5,1,-2);
 generate_series
-----------------
               5
               3
               1
(3 rows)

openGauss=# SELECT * FROM generate_series(4,3);
 generate_series
-----------------
(0 rows)

-- This example applies to the date-plus-integer operator.
openGauss=# SELECT current_date + s.a AS dates FROM generate_series(0,14,7) AS s(a);
   dates
------------
 2017-06-02
 2017-06-09
 2017-06-16
(3 rows)

openGauss=# SELECT * FROM generate_series('2008-03-01 00:00'::timestamp, '2008-03-04 12:00', '10
hours');
   generate_series
---------------------
 2008-03-01 00:00:00
 2008-03-01 10:00:00
 2008-03-01 20:00:00
 2008-03-02 06:00:00
 2008-03-02 16:00:00
```

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```
 2008-03-03 02:00:00
 2008-03-03 12:00:00
 2008-03-03 22:00:00
 2008-03-04 08:00:00
(9 rows)
```

### Subscript Generating Functions

- generate_subscripts(array anyarray, dim int)

  Description: Generates a series comprising the given array's subscripts.

  Return type: setof int

- generate_subscripts(array anyarray, dim int, reverse boolean)

  Description: Generates a series comprising the given array's subscripts. When **reverse** is true, the series is returned in reverse order.

  Return type: setof int

**generate_subscripts** is a function that generates the set of valid subscripts for the specified dimension of the given array. Zero rows are returned for arrays that do not have the requested dimension, or for NULL arrays (but valid subscripts are returned for NULL array elements). Example:

```
-- Basic usage
openGauss=# SELECT generate_subscripts('{NULL,1,NULL,2}'::int[], 1) AS s;
 s
---
 1
 2
 3
 4
(4 rows)
-- Unnest a 2D array.
openGauss=# CREATE OR REPLACE FUNCTION unnest2(anyarray)
RETURNS SETOF anyelement AS $$
SELECT $1[i][j]
   FROM generate_subscripts($1,1) g1(i),
        generate_subscripts($1,2) g2(j);
$$ LANGUAGE sql IMMUTABLE;

openGauss=# SELECT * FROM unnest2(ARRAY[[1,2],[3,4]]);
 unnest2
---------
       1
       2
       3
       4
(4 rows)

-- Delete the function.
openGauss=# DROP FUNCTION unnest2;
```

## 12.5.24 Conditional Expression Functions

### Conditional Expression Functions

- coalesce(expr1, expr2, ..., exprn)

  Description:

  Returns the first of its arguments that are not null.

  **COALESCE(expr1, expr2)** is equivalent to **CASE WHEN expr1 IS NOT NULL THEN expr1 ELSE expr2 END**.

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Example:

```
openGauss=# SELECT coalesce(NULL,'hello');
 coalesce
----------
 hello
(1 row)
```

Note:

- Null is returned only if all parameters are null.
- This value is replaced by the default value when data is displayed.
- Like a **CASE** expression, **COALESCE** only evaluates the parameters that are needed to determine the result. That is, parameters to the right of the first not-**NULL** parameter are not evaluated.

- decode(base_expr, compare1, value1, Compare2,value2, ... default)

  Description: Compares **base_expr** with each **compare(n)** and **returns value(n)** if they are matched. If **base_expr** does not match each **compare(n)**, the default value is returned.

  Example:

  ```
  openGauss=# SELECT decode('A','A',1,'B',2,0);
   case
  ------
   1
  (1 row)
  ```

- nullif(expr1, expr2)

  Description: Returns **NULL** only when **expr1** is equal to **expr2**. Otherwise, **expr1** is returned.

  **nullif(expr1, expr2)** is equivalent to **CASE WHEN expr1 = expr2 THEN NULL ELSE expr1 END**.

  Example:

  ```
  openGauss=# SELECT nullif('hello','world');
   nullif
  --------
   hello
  (1 row)
  ```

  Note:

  Assume the two parameter data types are different:

  - If implicit conversion exists between the two data types, implicitly convert the parameter of lower priority to this data type using the data type of higher priority. If the conversion succeeds, computation is performed. Otherwise, an error is returned. Example:

    ```
    openGauss=# SELECT nullif('1234'::VARCHAR,123::INT4);
     nullif
    --------
       1234
    (1 row)
    openGauss=# SELECT nullif('1234'::VARCHAR,'2012-12-24'::DATE);
    ERROR:  invalid input syntax for type timestamp: "1234"
    ```

  - If implicit conversion is not applied between two data types, an error is displayed. Example:

    ```
    openGauss=# SELECT nullif(TRUE::BOOLEAN,'2012-12-24'::DATE);
    ERROR:  operator does not exist: boolean = timestamp without time zone
    LINE 1: SELECT nullif(TRUE::BOOLEAN,'2012-12-24'::DATE) FROM sys_dummy;
    ^
    HINT:  No operator matches the given name and argument type(s). You might need to add explicit type casts.
    ```

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- nvl( expr1 , expr2 )

  Description:

  – If the value of **expr1** is **NULL**, the value of **expr2** is returned.
  – If the value of **expr1** is not **NULL**, the value of **expr1** is returned.

  Example:

```
openGauss=# SELECT nvl('hello','world');
  nvl
-------
 hello
(1 row)
```

  Parameters **expr1** and **expr2** can be of any data type. If **expr1** and **expr2** are of different data types, NVL checks whether **expr2** can be implicitly converted to **expr1**. If it can, the **expr1** data type is returned. If **epr2** cannot be implicitly converted to **expr1** but **epr1** can be implicitly converted to **expr2**, the **expr2** data type is returned. If no implicit type conversion exists between the two parameters and the parameters are different data types, an error is reported.

- greatest(expr1 [, ...])

  Description: Selects the largest value from a list of any number of expressions.

  Return type:

  Example:

```
openGauss=# SELECT greatest(1*2,2-3,4-1);
 greatest
----------
        3
(1 row)
openGauss=# SELECT greatest('HARRY', 'HARRIOT', 'HAROLD');
 greatest
----------
 HARRY
(1 row)
```

- least(expr1 [, ...])

  Description: Selects the smallest value from a list of any number of expressions.

  Example:

```
openGauss=# SELECT least(1*2,2-3,4-1);
 least
-------
    -1
(1 row)
openGauss=# SELECT least('HARRY','HARRIOT','HAROLD');
 least
--------
 HAROLD
(1 row)
```

- EMPTY_BLOB()

  Description: Initiates a BLOB variable in an **INSERT** or an **UPDATE** statement to a **NULL** value.

  Return type: BLOB

  Example:

```
-- Create a table.
openGauss=# CREATE TABLE blob_tb(b blob,id int) DISTRIBUTE BY REPLICATION;
-- Insert data.
openGauss=# INSERT INTO blob_tb VALUES (empty_blob(),1);
-- Drop the table.
openGauss=# DROP TABLE blob_tb;
```

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Note: The length is 0 obtained using **DBE_LOB.GET_LENGTH**.

# 12.5.25 System Information Functions

## Session Information Functions

- current_catalog

  Description: Name of the current database (called "catalog" in the SQL standard)

  Return type: name

  Example:

  ```
  openGauss=# SELECT current_catalog;
   current_database
  ------------------
   postgres
  (1 row)
  ```

- current_database()

  Description: Name of the current database

  Return type: name

  Example:

  ```
  openGauss=# SELECT current_database();
   current_database
  ------------------
   postgres
  (1 row)
  ```

- current_query()

  Description: Text of the currently executing query committed by the client (which might contain more than one statement)

  Return type: text

  Example:

  ```
  openGauss=# SELECT current_query();
       current_query
  -------------------------
   SELECT current_query();
  (1 row)
  ```

- current_schema[()]

  Description: Name of the current schema

  Return type: name

  Example:

  ```
  openGauss=# SELECT current_schema();
   current_schema
  ----------------
   public
  (1 row)
  ```

  Note: **current_schema** returns the first valid schema name in the search path. (If the search path is empty or contains no valid schema name, **NULL** is returned.) This is the schema that will be used for any tables or other named objects that are created without specifying a target schema.

- current_schemas(Boolean)

  Description: Name of a schema in the search path

  Return type: name[]

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Example:

```
openGauss=# SELECT current_schemas(true);
  current_schemas
--------------------
 {pg_catalog,public}
(1 row)
```

Note:

**current_schemas(Boolean)** returns an array of the names of all schemas in the search path. The Boolean option specifies whether implicitly included system schemas such as **pg_catalog** are included in the returned search path.

NOTE

The search path can be altered at the run time. The command is as follows:

```
SET search_path TO schema [, schema, ...]
```

- current_user

  Description: Username in the current execution environment

  Return type: name

  Example:

  ```
  openGauss=# SELECT current_user;
   current_user
  --------------
   omm
  (1 row)
  ```

  Note: **current_user** is the user identifier used for permission check. Normally it is equal to the session user, but it can be changed by using **12.14.163 SET ROLE**. It also changes during the execution of functions with the **SECURITY DEFINER** attribute.

- definer_current_user

  Description: Username in the current execution environment

  Return type: name

  Example:

  ```
  openGauss=# SELECT definer_current_user();
   definer_current_user
  ----------------------
   omm
  (1 row)
  ```

  Note: In most cases, the results of **definer_current_user** and **current_user** are the same. However, when this function is executed in a stored procedure, the name of user who defines the current stored procedure is returned.

- pg_current_sessionid()

  Description: Session ID in the current execution environment

  Return type: text

  Example:

  ```
  openGauss=# SELECT pg_current_sessionid();
     pg_current_sessionid
  ---------------------------
   1579228402.140190434944768
  (1 row)
  ```

  Note: **pg_current_sessionid()** is used to obtain the session ID in the current execution environment. The format of the value is *Timestamp.Session ID*. When **enable_thread_pool** is set to **off**, the actual session ID is the thread ID.

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- pg_current_sessid

  Description: Session ID in the current execution environment

  Return type: text

  Example:

  ```
  openGauss=# select pg_current_sessid();
  pg_current_sessid
  -------------------
  140308875015936
  (1 row)
  ```

  Note: In thread pool mode, the ID of the current session is obtained. In non-thread pool mode, the backend thread ID of the current session is obtained.

- pg_current_userid

  Description: Current user ID

  Return type: text

  Example:

  ```
  openGauss=# SELECT pg_current_userid();
  pg_current_userid
  -------------------
  10
  (1 row)
  ```

- tablespace_oid_name()

  Description: Queries the tablespace name based on the tablespace OID.

  Return type: text

  Example:

  ```
  openGauss=# select tablespace_oid_name(1663);
   tablespace_oid_name
  ---------------------
   pg_default
  (1 row)
  ```

- inet_client_addr()

  Description: Remote connection address. **inet_client_addr** returns the IP address of the current client.

  NOTE

  This function is valid only in remote connection mode.

  Return type: inet

  Example:

  ```
  openGauss=# SELECT inet_client_addr();
   inet_client_addr
  ------------------
   10.10.0.50
  (1 row)
  ```

- inet_client_port()

  Description: Remote connection port. **inet_client_port** returns the port number of the current client.

  NOTE

  This function is valid only in remote connection mode.

  Return type: int

  Example:

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```
openGauss=# SELECT inet_client_port();
 inet_client_port
------------------
            33143
(1 row)
```

- inet_server_addr()

  Description: Local connection address. **inet_server_addr** returns the IP address on which the server accepts the current connection.

  NOTE

  This function is valid only in remote connection mode.

  Return type: inet

  Example:

```
openGauss=# SELECT inet_server_addr();
 inet_server_addr
------------------
 10.10.0.13
(1 row)
```

- inet_server_port()

  Description: Local connection port. **inet_server_port** returns the number of the port receiving the current connection. All these functions return **NULL** if the current connection is via a Unix-domain socket.

  NOTE

  This function is valid only in remote connection mode.

  Return type: int

  Example:

```
openGauss=# SELECT inet_server_port();
 inet_server_port
------------------
             8000
(1 row)
```

- pg_backend_pid()

  Description: Process ID of the service process attached to the current session.

  Return type: int

  Example:

```
openGauss=# SELECT pg_backend_pid();
 pg_backend_pid
-----------------
 140229352617744
(1 row)
```

- pg_conf_load_time()

  Description: Configures load time. **pg_conf_load_time** returns the timestamp when the server configuration files were last loaded.

  Return type: timestamp with time zone

  Example:

```
openGauss=# SELECT pg_conf_load_time();
      pg_conf_load_time
-------------------------------
 2017-09-01 16:05:23.89868+08
(1 row)
```

- pg_my_temp_schema()

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Description: OID of the temporary schema of a session. The value is **0** if the OID does not exist.

Return type: oid

Example:

```
openGauss=# SELECT pg_my_temp_schema();
 pg_my_temp_schema
-------------------
                 0
(1 row)
```

Note: **pg_my_temp_schema** returns the OID of the current session's temporary schema, or **0** if it has no temporary schemas (because no temporary tables are created). **pg_is_other_temp_schema** returns **true** if the given OID is the OID of another session's temporary schema.

- pg_is_other_temp_schema(oid)

  Description: Specifies whether the schema is the temporary schema of another session.

  Return type: Boolean

  Example:

  ```
  openGauss=# SELECT pg_is_other_temp_schema(25356);
   pg_is_other_temp_schema
  -------------------------
   f
  (1 row)
  ```

- pg_listening_channels()

  Description: Name of the channel that the session is currently listening on.

  Return type: setof text

  Example:

  ```
  openGauss=# SELECT pg_listening_channels();
   pg_listening_channels
  -----------------------
  (0 rows)
  ```

  Note: **pg_listening_channels** returns a set of names of channels that the current session is currently listening on.

- pg_postmaster_start_time()

  Description: Server start time. **pg_postmaster_start_time** returns the **timestamp with time zone** when the server is started.

  Return type: timestamp with time zone

  Example:

  ```
  openGauss=# SELECT pg_postmaster_start_time();
    pg_postmaster_start_time
  -------------------------------
   2017-08-30 16:02:54.99854+08
  (1 row)
  ```

- sessionid2pid()

  Description: Obtains PID information from a session ID (for example, the **sessid** column in **pv_session_stat**).

  Return type: int8

  Example:

  ```
  openGauss=# select sessionid2pid(sessid::cstring) from pv_session_stat limit 2;
   sessionid2pid
  -----------------
  ```

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```
 139973107902208
 139973107902208
(2 rows)
```

- session_context( 'namespace' , 'parameter')

  Description: Obtains and returns the parameter values of a specified namespace.

  Return type: VARCHAR

  Example:

  ```
  openGauss=# SELECT session_context('USERENV', 'CURRENT_SCHEMA');
   session_context
  -----------------
   public
  (1 row)
  ```

  The result varies according to the current actual schema.

  Note: Currently, only the SESSION_CONTEXT('USERENV', 'CURRENT_SCHEMA') and SESSION_CONTEXT('USERENV', 'CURRENT_USER') formats are supported.

- pg_trigger_depth()

  Description: Nesting level of triggers.

  Return type: int

  Example:

  ```
  openGauss=# SELECT pg_trigger_depth();
   pg_trigger_depth
  ------------------
                 0
  (1 row)
  ```

- opengauss_version()

  Description: Referenced openGauss kernel version.

  Return type: text

  Example:

  ```
  openGauss=# SELECT opengauss_version();
   opengauss_version
  -------------------
   2.0.0
  (1 row)
  ```

- gs_deployment()

  Description: Deployment mode of the current system. For a distributed system, **Distribute** is returned.

  Return type: text

  Example:

  ```
  openGauss=# select gs_deployment();
   gs_deployment
  ---------------
   Distribute
  (1 row)
  ```

- session_user

  Description: Session username.

  Return type: name

  Example:

  ```
  openGauss=# SELECT session_user;
   session_user
  ```

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```
--------------
 omm
(1 row)
```

Note: **session_user** usually specifies the initial user connected to the current database, but the system administrator can change this setting by using **12.14.164 SET SESSION AUTHORIZATION**.

- user

  Description: Equivalent to current_user.

  Return type: name

  Example:

```
openGauss=# SELECT user;
 current_user
--------------
 omm
(1 row)
```

- get_shard_oids_byname

  Description: Returns the OID of the node when the node name is entered.

  Return type: oid

  Example:

```
openGauss=# select get_shard_oids_byname('datanode1');
 get_shard_oids_byname
-----------------------
 {16385}
(1 row)
```

- getpgusername()

  Description: Obtains the database username.

  Return type: name

  Example:

```
openGauss=# select getpgusername();
 getpgusername
---------------
 GaussDB_userna
(1 row)
```

- getdatabaseencoding()

  Description: Obtains the database encoding mode.

  Return type: name

  Example:

```
openGauss=# select getdatabaseencoding();
 getdatabaseencoding
---------------------
 SQL_ASCII
(1 row)
```

- version()

  Description: Version information. **version** returns a string describing a server's version.

  Return type: text

  Example:

```
openGauss=# SELECT version();
                                                
```

```
2935 last mr 6385 release
(1 row)
```

- working_version_num()

  Description: Returns a version number regarding system compatibility.

  Return type: int

  Example:

```
openGauss=# SELECT working_version_num();
 working_version_num
---------------------
               92231
(1 row)
```

- get_hostname()

  Description: Returns the host name of the current node.

  Return type: text

  Example:

```
openGauss=# SELECT get_hostname();
 get_hostname
--------------
 linux-user
(1 row)
```

- get_nodename()

  Description: Returns the name of the current node.

  Return type: text

  Example:

```
openGauss=# SELECT get_nodename();
 get_nodename
--------------
 coordinator1
(1 row)
```

- get_schema_oid(cstring)

  Description: Returns the OID of the queried schema.

  Return type: oid

  Example:

```
openGauss=# SELECT get_schema_oid('public');
 get_schema_oid
----------------
           2200
(1 row)
```

- pgxc_parse_clog(OUT xid int8, OUT nodename text, OUT status text)

  Description: Returns the status of all transactions in the current cluster.

  Return type: set of record

  Example:

```
openGauss=# SELECT pgxc_parse_clog();
 pgxc_parse_clog
----------------
(0,dn_6004_6005_6006,INPROGRESS)
(1,dn_6004_6005_6006,COMMITTED)
(2,dn_6004_6005_6006,INPROGRESS)
(3 row)
```

- pgxc_prepared_xact( )

  Description: Returns the list of transaction GIDs at the prepared stage in the cluster.

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Return type: set of text

Example:

```
openGauss=# SELECT pgxc_prepared_xact();
 pgxc_prepared_xact
--------------------
(0 row)
```

- pgxc_xacts_iscommitted()

  Description: Returns the status of the transaction with the specified XID in the cluster. **t** indicates the committed state, **f** indicates the aborted state, and **null** indicates other states. To execute this function, you must have the **sysadmin** or **monadmin** permission.

  Return type: set of record

  Example:

```
openGauss=# SELECT pgxc_xacts_iscommitted(1);
 pgxc_xacts_iscommitted
--------------------
(dn_6004_6005_6006,t)
(cn_5001,t)
(cn_5002,t)
(dn_6001_6002_6003,t)
(4 row)
```

- pgxc_total_memory_detail()

  Description: Displays the memory usage in the cluster. To execute this function, you must have the **sysadmin** or **monadmin** permission.

  NOTE

  If **enable_memory_limit** is set to **off**, this function cannot be used.

  Return type: set of pv_total_memory_detail

  Example:

```
openGauss=# SELECT pgxc_total_memory_detail();
pgxc_total_memory_detail
--------------------
(dn_6004_6005_6006,max_process_memory,81920)
(dn_6004_6005_6006,process_used_memory,72747)
(dn_6004_6005_6006,max_dynamic_memory,12096)
(dn_6004_6005_6006,dynamic_used_memory,1530)
(4 row)
```

- pv_total_memory_detail

  Description: Collects statistics on memory usage of the current database node in the unit of MB.

  NOTE

  If **enable_memory_limit** is set to **off**, this function cannot be used.

  Return type: record

**Table 12-37** Return value description

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |

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| Name | Type | Description |
| --- | --- | --- |
| memorytype | text | Memory type. The value must be one of the following:<br>• **max_process_memory**: memory occupied by a GaussDB cluster instance<br>• **process_used_memory**: memory occupied by a GaussDB process<br>• **max_dynamic_memory**: maximum dynamic memory<br>• **dynamic_used_memory**: used dynamic memory<br>• **dynamic_peak_memory**: dynamic peak memory<br>• **dynamic_used_shrctx**: maximum dynamic shared memory context<br>• **dynamic_peak_shrctx**: dynamic peak value of the shared memory context<br>• **max_shared_memory**: maximum shared memory<br>• **shared_used_memory**: used shared memory<br>• **max_cstore_memory**: maximum memory allowed for column storage<br>• **cstore_used_memory**: memory used by column storage<br>• **max_sctpcomm_memory**: maximum memory allowed for the communication library<br>• **sctpcomm_used_memory**: memory used by the communication library<br>• **sctpcomm_peak_memory**: memory peak of the communication library<br>• **other_used_memory**: other used memory |
| memorymbytes | integer | Size of allocated memory |

- get_client_info()

  Description: Returns client information.

  Return type: record

## Access Permission Query Functions

The DDL permissions, including ALTER, DROP, COMMENT, INDEX, and VACUUM, are inherent permissions implicitly owned by the owner.

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The following access permission query function only indicates whether a user has a certain permission on an object. That is, the permission on the object recorded in the **acl** column of the system catalog is returned.

- has_any_column_privilege(user, table, privilege)

  Description: Queries whether a specified user has permissions on any column of a table.

  **Table 12-38** Parameter types

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | Username | Username or ID |
| table | text, oid | Table | Table name or ID |
| privilege | text | Permission | • **SELECT**: allows the **SELECT** statement to be executed on any column of a specified table.<br>• **INSERT**: allows the **INSERT** statement to be executed on any column of a specified table.<br>• **UPDATE**: allows the **UPDATE** statement to be executed on any column of a specified table.<br>• **REFERENCES**: allows users to create a foreign key constraint.<br>• **COMMENT**: allows the **COMMENT** statement to be executed on any column of a specified table. |

  Return type: Boolean

- has_any_column_privilege(table, privilege)

  Description: Queries whether the current user has the permission to access any column of a table. For details about the valid parameter types, see **Table 12-38**.

  Return type: Boolean

  Note: **has_any_column_privilege** checks whether a user can access any column of a table in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**, except that the desired access permission type must be some combination of **SELECT**, **INSERT**, **UPDATE**, or **REFERENCES**.

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NOTE

Note that having any of these permissions at the table level indicates that the permission is implicitly granted for each column of the table. Therefore, **has_any_column_privilege** always returns **true** if **has_table_privilege** has the same parameters. But **has_any_column_privilege** also returns **true** if a column-level permission is granted for at least one column.

- has_column_privilege(user, table, column, privilege)

  Description: Specifies whether a specified user has the permission to access columns.

  **Table 12-39** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Username or ID |
| table | text, oid | Table name | Table name or ID |
| column | text, smallint | Column name | Name or attribute number of a column |
| privilege | text | Permission | • **SELECT**: allows the **SELECT** statement to be executed on specified columns of a table.<br>• **INSERT**: allows the **INSERT** statement to be executed on specified columns of a table.<br>• **UPDATE**: allows the **UPDATE** statement to be executed on specified columns of a table.<br>• **REFERENCES**: allows users to create a foreign key constraint.<br>• **COMMENT**: allows the **COMMENT** statement to be executed on specified columns of a table. |

  Return type: Boolean

- has_column_privilege(table, column, privilege)

  Description: Specifies whether the current user has the permission to access columns. For details about the valid parameter types, see **Table 12-39**.

  Return type: Boolean

  **has_column_privilege** checks whether a user can access a column in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**. Columns can be added either by name or by attribute

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number. The desired access permission type must be some combination of **SELECT**, **INSERT**, **UPDATE**, or **REFERENCES**.

NOTE

Note that having any of these permissions at the table level indicates that the permission is implicitly granted for each column of the table.

- has_cek_privilege(user, cek, privilege)

  Description: Specifies whether a specified user has permissions on CEKs.

  **Table 12-40** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Username or ID |
| cek | text, oid | CEK | Name or ID of a CEK |
| privilege | text | Permission | • **USAGE**: allows users to use the specified CEK.<br>• **DROP**: allows users to delete the specified CEK. |

  Return type: Boolean

- has_cmk_privilege(user, cmk, privilege)

  Description: Specifies whether a specified user has permissions on CMKs.

  **Table 12-41** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Username or ID |
| cmk | text, oid | CMK | Name or ID of the CMK |
| privilege | text | Permission | • **USAGE**: allows users to use the specified CMK.<br>• **DROP**: allows users to delete the specified CMK. |

  Return type: Boolean

- has_database_privilege(user, database, privilege)

  Description: Specifies whether a specified user has permissions on databases.

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**Table 12-42** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Username or ID |
| database | text, oid | Database | Database name or ID |
| privilege | text | Permission | • **CREATE**: For databases, allows new schemas to be created within the database.<br>• **TEMPORARY**: allows users to create temporary tables when the database is used.<br>• **TEMP**: allows users to create temporary tables when the database is used.<br>• **CONNECT**: allows users to access specified databases.<br>• **ALTER**: allows users to modify the attributes of a specified object.<br>• **DROP**: allows users to delete specified objects.<br>• **COMMENT**: allows users to define or modify comments of a specified object. |

Return type: Boolean

- has_database_privilege(database, privilege)

  Description: Queries whether the current user has the permission to access a database. For details about the valid parameter types, see **Table 12-42**.

  Return type: Boolean

  Note: **has_database_privilege** checks whether a user can access a database in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**. The desired access permission type must be some combination of **CREATE**, **CONNECT**, **TEMPORARY**, or **TEMP** (which is equivalent to **TEMPORARY**).

- has_directory_privilege(user, directory, privilege)

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**Table 12-43** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Username or ID |
| directory | text, oid | Directory | Directory name or OID |
| privilege | text | Permission | • **READ**: allows read operations on the directory.<br>• **WRITE**: allows write operations on the directory. |

Description: Specifies whether a specified user has permissions on directories.

Return type: Boolean

- has_directory_privilege(directory, privilege)

  Description: Queries whether the current user has the permission to access a directory. For details about the valid parameter types, see **Table 12-43**.

  Return type: Boolean

- has_foreign_data_wrapper_privilege(user, fdw, privilege)

**Table 12-44** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Username or ID |
| fdw | text, oid | Foreign data wrapper | Name or ID of the foreign data wrapper |
| privilege | text | Permission | **USAGE**: allows access to the foreign data wrapper. |

Description: Specifies whether a specified user has permissions on foreign data wrappers.

Return type: Boolean

- has_foreign_data_wrapper_privilege(fdw, privilege)

  Description: Queries whether the current user has permissions on foreign data wrappers. For details about the valid parameter types, see **Table 12-44**.

  Return type: Boolean

  Note: **has_foreign_data_wrapper_privilege** checks whether a user can access a foreign data wrapper in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**. The desired access permission type must be **USAGE**.

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- has_function_privilege(user, function, privilege)

  **Table 12-45** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Username or ID |
| function | text, oid | Function | Function name or ID |
| privilege | text | Permission | **EXECUTE**: allows users to use specified functions and the operators that are realized by the functions.<br>• **ALTER**: allows users to modify the attributes of a specified object.<br>• **DROP**: allows users to delete a specified object.<br>• **COMMENT**: allows users to define or modify comments of a specified object. |

  Description: Specifies whether a specified user has permissions on functions.

  Return type: Boolean

- has_function_privilege(function, privilege)

  Description: Specifies whether the current user has permissions on functions. For details about valid parameter types, see **Table 12-45**.

  Return type: Boolean

  Note: **has_function_privilege** checks whether a user can access a function in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**. When a function is specified by a text string rather than by an OID, the allowed input is the same as that for the **regprocedure** data type (see **12.3.15 Object Identifier Types**). The desired access permission type must be **EXECUTE**.

- has_language_privilege(user, language, privilege)

  **Table 12-46** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Username or ID |

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| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| language | text, oid | Language | Language name or ID |
| privilege | text | Permission | **USAG**: allows users to specify a procedural language when creating a function. |

Description: Specifies whether a specified user has permissions on languages.

Return type: Boolean

- has_language_privilege(language, privilege)

  Description: Specifies whether the current user has permissions on languages. For details about valid parameter types, see **Table 12-46**.

  Return type: Boolean

  Note: **has_language_privilege** checks whether a user can access a procedural language in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**. The desired access permission type must be **USAGE**.

- has_nodegroup_privilege(user, nodegroup, privilege)

  Description: Checks whether a user has the permission to access a cluster node.

  Return type: Boolean

**Table 12-47** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Existing username or ID |
| nodegroup | text, oid | Cluster node | Existing cluster node |

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| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| privilege | text | Permission | • **USAGE**: For sub-clusters, allows users who can access objects contained in the schema to access tables in the sub-cluster.<br>• **CREATE**: For sub-clusters, allows users to create tables within the sub-cluster.<br>• **COMPUTE**: allows users to perform elastic computing in the sub-cluster.<br>• **ALTER**: allows users to modify the attributes of a specified object.<br>• **DROP**: allows users to delete a specified object. |

- has_nodegroup_privilege(nodegroup, privilege)

  Description: Checks whether a user has the permission to access a cluster node.

  Return type: Boolean
- has_schema_privilege(user, schema, privilege)

  Description: Specifies whether a specified user has permissions on schemas.

  Return type: Boolean
- has_schema_privilege(schema, privilege)

  Description: Specifies whether the current user has permissions on schemas.

  Return type: Boolean

  Note: **has_schema_privilege** checks whether a user can access a schema in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**. The desired access permission type must be **CREATE**, **USAGE**, **ALTER**, **DROP**, or **COMMENT**.
- has_sequence_privilege(user, sequence, privilege)

  Description: Queries whether a specified user has permissions on sequences.

  Return type: Boolean

**Table 12-48** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name, oid | User | Existing username or ID |
| sequence | text, oid | Sequence | Existing sequence name or ID |

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| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| privilege | text | Permission | • **USAGE**: For sequences, allows users to use the **nextval** function.<br>• **SELECT**: allows users to create a sequence.<br>• **UPDATE**: allows users to execute the **UPDATE** statement.<br>• **ALTER**: allows users to modify the attributes of a specified object.<br>• **DROP**: allows users to delete a specified object.<br>• **COMMENT**: allows users to define or modify comments of a specified object. |

- has_sequence_privilege(sequence, privilege)

  Description: Queries whether the current user has permissions on sequences.

  Return type: Boolean

- has_server_privilege(user, server, privilege)

  Description: Specifies whether a specified user has permissions on foreign servers.

  Return type: Boolean

- has_server_privilege(server, privilege)

  Description: Specifies whether the current user has permissions on foreign servers.

  Return type: Boolean

  Note: **has_server_privilege** checks whether a user can access a foreign server in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**. The access permission type must be **USAGE**, **ALTER**, **DROP**, or **COMMENT**.

- has_table_privilege(user, table, privilege)

  Description: Specifies whether a specified user has permissions on tables.

  Return type: Boolean

- has_table_privilege(table, privilege)

  Description: Specifies whether the current user has permissions on tables.

  Return type: Boolean

  Note: **has_table_privilege** checks whether a user can access a table in a particular way. The user can be specified by name or by OID (**pg_authid.oid**), or be set to **public** which indicates public pseudo roles. If this parameter is omitted, **current_user** is used. The table can be specified by name or by OID.

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When it is specified by name, the name can be schema-qualified if necessary. If the desired access permission type is specified by a text string, the text string must be one of the values **SELECT**, **INSERT**, **UPDATE**, **DELETE**, **TRUNCATE**, **REFERENCESTRIGGER**, **ALTER**, **DROP**, **COMMENT**, **INDEX**, or **VACUUM**. Optionally, **WITH GRANT OPTION** can be added to a permission type to test whether the permission is held with the grant option. Also, multiple permission types can be listed separated by commas, in which case the result will be **true** if any of the listed permissions is held.

Example:

```
openGauss=# SELECT has_table_privilege('tpcds.web_site', 'select');
 has_table_privilege
---------------------
 t
(1 row)

openGauss=# SELECT has_table_privilege('omm', 'tpcds.web_site', 'select,INSERT WITH GRANT
OPTION ');
 has_table_privilege
---------------------
 t
(1 row)
```

- has_tablespace_privilege(user, tablespace, privilege)

  Description: Specifies whether a specified user has permissions on tablespaces.

  Return type: Boolean

- has_tablespace_privilege(tablespace, privilege)

  Description: Specifies whether the current user has permissions on tablespaces.

  Return type: Boolean

  Note: **has_tablespace_privilege** checks whether a user can access a tablespace in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**. The access permission type must be **CREATE**, **ALTER**, **DROP**, or **COMMENT**.

- pg_has_role(user, role, privilege)

  Description: Specifies whether a specified user has permissions on roles.

  Return type: Boolean

- pg_has_role(role, privilege)

  Description: Specifies whether the current user has permissions on roles.

  Return type: Boolean

  Note: **pg_has_role** checks whether a user can access a role in a particular way. Its parameter possibilities are analogous to those of **has_table_privilege**, except that **public** cannot be used as a username. The desired access permission type must be some combination of **MEMBER** or **USAGE**. **MEMBER** denotes direct or indirect membership in the role (that is, permission **SET ROLE**), while **USAGE** denotes the usage permission on the role that is available without the **SET ROLE** permission.

- has_any_privilege(user, privilege)

  Description: Queries whether a specified user has certain ANY permission. If multiple permissions are queried at the same time, **true** is returned as long as one permission is obtained.

  Return type: Boolean

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**Table 12-49** Parameter type description

| Parameter | Valid Input Parameter Type | Description | Value Range |
| --- | --- | --- | --- |
| user | name | User | Existing username |
| privilege | text | ANY permission | Available values:<br>CREATE ANY TABLE [WITH ADMIN OPTION]<br>ALTER ANY TABLE [WITH ADMIN OPTION]<br>DROP ANY TABLE [WITH ADMIN OPTION]<br>SELECT ANY TABLE [WITH ADMIN OPTION]<br>INSERT ANY TABLE [WITH ADMIN OPTION]<br>UPDATE ANY TABLE [WITH ADMIN OPTION]<br>DELETE ANY TABLE [WITH ADMIN OPTION]<br>CREATE ANY SEQUENCE [WITH ADMIN OPTION]<br>CREATE ANY INDEX [WITH ADMIN OPTION]<br>CREATE ANY FUNCTION [WITH ADMIN OPTION]<br>EXECUTE ANY FUNCTION [WITH ADMIN OPTION]<br>CREATE ANY PACKAGE [WITH ADMIN OPTION]<br>EXECUTE ANY PACKAGE [WITH ADMIN OPTION]<br>CREATE ANY TYPE [WITH ADMIN OPTION] |

## Schema Visibility Query Functions

Each function performs the visibility check on one type of database objects. For functions and operators, an object in the search path is visible if there is no object of the same name and parameter data type earlier in the path. For operator classes, both name and associated index access methods are considered.

All these functions require object OIDs to identify the object to be checked. If you want to test an object by name, it is convenient to use the OID alias type (**regclass**, **regtype**, **regprocedure**, **regoperator**, **regconfig**, or **regdictionary**).

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For example, a table is said to be visible if the schema where the table is located is in the search path and no table of the same name appears earlier in the search path. This is equivalent to the statement that the table can be referenced by name without explicit schema qualification. For example, to list the names of all visible tables, run the following command:

```
openGauss=# SELECT relname FROM pg_class WHERE pg_table_is_visible(oid);
```

- pg_collation_is_visible(collation_oid)

  Description: Specifies whether the collation is visible in the search path.

  Return type: Boolean
- pg_conversion_is_visible(conversion_oid)

  Description: Specifies whether the conversion is visible in the search path.

  Return type: Boolean
- pg_function_is_visible(function_oid)

  Description: Specifies whether the function is visible in the search path.

  Return type: Boolean
- pg_opclass_is_visible(opclass_oid)

  Description: Specifies whether the operator class is visible in the search path.

  Return type: Boolean
- pg_operator_is_visible(operator_oid)

  Description: Specifies whether the operator is visible in the search path.

  Return type: Boolean
- pg_opfamily_is_visible(opclass_oid)

  Description: Specifies whether the operator family is visible in the search path.

  Return type: Boolean
- pg_table_is_visible(table_oid)

  Description: Specifies whether the table is visible in the search path.

  Return type: Boolean
- pg_ts_config_is_visible(config_oid)

  Description: Specifies whether the text search configuration is visible in the search path.

  Return type: Boolean
- pg_ts_dict_is_visible(dict_oid)

  Description: Specifies whether the text search dictionary is visible in the search path.

  Return type: Boolean
- pg_ts_parser_is_visible(parser_oid)

  Description: Specifies whether the text search parser is visible in the search path.

  Return type: Boolean
- pg_ts_template_is_visible(template_oid)

  Description: Specifies whether the text search template is visible in the search path.

  Return type: Boolean

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- pg_type_is_visible(type_oid)

  Description: Specifies whether the type (or domain) is visible in the search path.

  Return type: Boolean

## System Catalog Information Functions

- format_type(type_oid, typemod)

  Description: Obtains the SQL name of a data type.

  Return type: text

  Note: **format_type** returns the SQL name of a data type that is identified by its type OID and possible type modifier. **NULL** is passed for the type modifier if no specific modifier is known. Certain type modifiers are passed for data types with length limitations. The SQL name returned by **format_type** contains the length of the data type, which can be calculated by taking sizeof(int32) from actual storage length [actual storage len - sizeof(int32)] in the unit of bytes. 32-bit space is required to store the customized length set by users. Therefore, the actual storage length contains 4 bytes more than the customized length. In the following example, the SQL name returned by **format_type** is character varying(6), indicating the length of the varchar type is 6 bytes. Therefore, the actual storage length of the varchar type is 10 bytes.

  ```
  openGauss=# SELECT format_type((SELECT oid FROM pg_type WHERE typname='varchar'), 10);
      format_type
  ----------------------
   character varying(6)
  (1 row)
  ```

- pg_check_authid(role_oid)

  Description: Checks whether a role name with a given OID exists.

  Return type: Boolean

  ```
  openGauss=# select pg_check_authid(1);
  pg_check_authid
  -----------------
  f
  (1 row)
  ```

- pg_describe_object(catalog_id, object_id, object_sub_id)

  Description: Obtains the description of a database object.

  Return type: text

  Note: **pg_describe_object** returns the description of a database object specified by a catalog OID, an object OID, and a (possibly zero) sub-object ID. This is useful to determine the identity of an object stored in the **pg_depend** catalog.

- pg_get_constraintdef(constraint_oid)

  Description: Obtains the definition of a constraint.

  Return type: text

- pg_get_constraintdef(constraint_oid, pretty_bool)

  Description: Obtains the definition of a constraint.

  Return type: text

  Note: **pg_get_constraintdef** and **pg_get_indexdef** respectively reconstruct the creation command for a constraint and an index.

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- pg_get_expr(pg_node_tree, relation_oid)

  Description: Decompiles the internal form of an expression, assuming that any Vars in it refer to the relationship indicated by the second parameter.

  Return type: text

- pg_get_expr(pg_node_tree, relation_oid, pretty_bool)

  Description: Decompiles the internal form of an expression, assuming that any Vars in it refer to the relationship indicated by the second parameter.

  Return type: text

  Note: **pg_get_expr** decompiles the internal form of an individual expression, such as the default value of a column. It can be useful when the content of system catalogs is checked. If the expression might contain Vars, specify the OID of the relationship they refer to as the second parameter; if no Vars are expected, zero is sufficient.

- pg_get_functiondef(func_oid)

  Description: Obtains the definition of a function.

  Return type: text

  Example:

```
openGauss=# select * from pg_get_functiondef(598);
 headerlines |                    definition
-------------+-----------------------------------------------------
           4 | CREATE OR REPLACE FUNCTION pg_catalog.abbrev(inet)+
             |  RETURNS text                                     +
             |  LANGUAGE internal                                +
             |  IMMUTABLE STRICT NOT FENCED NOT SHIPPABLE        +
             | AS $function$inet_abbrev$function$                +
             |
(1 row)
```

- pg_get_function_arguments(func_oid)

  Description: Obtains the parameter list of the function's definition (with default values).

  Return type: text

  Note: **pg_get_function_arguments** returns the parameter list of a function, in the form it would need to appear in **CREATE FUNCTION**.

- pg_get_function_identity_arguments(func_oid)

  Description: Obtains the parameter list to identify a function (without default values).

  Return type: text

  Note: **pg_get_function_identity_arguments** returns the parameter list required to identify a function, in the form it would need to appear in **ALTER FUNCTION**. This form omits default values.

- pg_get_function_result(func_oid)

  Description: Obtains the **RETURNS** clause for a function.

  Return type: text

  Note: **pg_get_function_result** returns the appropriate **RETURNS** clause for the function.

- pg_get_indexdef(index_oid)

  Description: Obtains the **CREATE INDEX** command for an index.

  Return type: text

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Example:

```
openGauss=# select * from pg_get_indexdef(16416);
                          pg_get_indexdef
------------------------------------------------------------------------
 CREATE INDEX test3_b_idx ON test3 USING btree (b) TABLESPACE pg_default
(1 row)
```

- pg_get_indexdef(index_oid, dump_schema_only)

  Description: Obtains the **CREATE INDEX** command for indexes in dump scenarios. In the current version, the value of **dump_schema_only** does not affect the function output.

  Return type: text

  Example:

```
openGauss=# select * from pg_get_indexdef(16416, true);
                          pg_get_indexdef
------------------------------------------------------------------------
 CREATE INDEX test3_b_idx ON test3 USING btree (b) TABLESPACE pg_default
(1 row)
```

- pg_get_indexdef(index_oid, column_no, pretty_bool)

  Description: Obtains the **CREATE INDEX** command for an index, or definition of just one index column when the value of **column_no** is not zero.

  Return type: text

  Example:

```
openGauss=# select * from pg_get_indexdef(16416, 0, false);
                          pg_get_indexdef
------------------------------------------------------------------------
 CREATE INDEX test3_b_idx ON test3 USING btree (b) TABLESPACE pg_default
(1 row)
openGauss=# select * from pg_get_indexdef(16416, 1, false);
 pg_get_indexdef
-----------------
 b
(1 row)
```

  Note: **pg_get_functiondef** returns a complete **CREATE OR REPLACE FUNCTION** statement for a function.

- pg_get_keywords()

  Description: Obtains the list of SQL keywords and their categories.

  Return type: setof record

  Note: **pg_get_keywords** returns a set of records describing the SQL keywords recognized by the server. The **word** column contains the keywords. The **catcode** column contains a category code: **U** for unreserved, **C** for column name, **T** for type or function name, or **R** for reserved. The **catdesc** column contains a possibly-localized string describing the category.

- pg_get_ruledef(rule_oid)

  Description: Obtains the **CREATE RULE** command for a rule.

  Return type: text

- pg_get_ruledef(rule_oid, pretty_bool)

  Description: Obtains the **CREATE RULE** command for a rule.

  Return type: text

- pg_get_userbyid(role_oid)

  Description: Obtains the role name with a given OID.

  Return type: name

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Note: **pg_get_userbyid** extracts a role's name given its OID.

- pg_check_authid(role_id)

  Description: Checks whether a user exists based on **role_id**.

  Return type: text

```
openGauss=# select pg_check_authid(20);
pg_check_authid
-----------------
f
(1 row)
```

- pg_get_viewdef(view_name)

  Description: Obtains the underlying **SELECT** command for a view.

  Return type: text

- pg_get_viewdef(view_name, pretty_bool)

  Description: Obtains the underlying **SELECT** command for a view. Lines with columns are wrapped to 80 columns if **pretty_bool** is set to **true**.

  Return type: text

  Note: **pg_get_viewdef** reconstructs the **SELECT** query that defines a view. Most of these functions come in two forms. When the function has the **pretty_bool** parameter and the value is **true**, it can optionally "pretty-print" the result. The pretty-printed format is more readable. The other one is the default format which is more likely to be interpreted in the same way by future versions. Avoid using pretty-printed output for dump purposes. Passing **false** for the pretty-print parameter yields the same result as the variant that does not have the parameter.

- pg_get_viewdef(view_oid)

  Description: Obtains the underlying **SELECT** command for a view.

  Return type: text

- pg_get_viewdef(view_oid, pretty_bool)

  Description: Obtains the underlying **SELECT** command for a view. Lines with columns are wrapped to 80 columns if **pretty_bool** is set to **true**.

  Return type: text

- pg_get_viewdef(view_oid, wrap_column_int)

  Description: Obtains the underlying **SELECT** command for a view. Lines with columns are wrapped to the specified number of columns and printing is implicit.

  Return type: text

- pg_get_tabledef(table_oid)

  Description: Obtains the definition of a table based on **table_oid**.

  Return type: text

  Example:

```
openGauss=# select * from pg_get_tabledef(16384);
                  pg_get_tabledef
-----------------------------------------------------
 SET search_path = public;                          +
 CREATE  TABLE t1 (                                 +
        c1 bigint DEFAULT nextval('serial'::regclass)+
 )                                                  +
 WITH (orientation=row, compression=no)             +
 DISTRIBUTE BY HASH(c1)                             +
```

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```
 TO GROUP group1;
(1 row)
```

- pg_get_tabledef(table_name)

  Description: Obtains the definition of a table based on **table_name**.

  Return type: text

  Example:

```
openGauss=# select * from pg_get_tabledef('t1');
                  pg_get_tabledef
------------------------------------------------------------
 SET search_path = public;                          +
 CREATE  TABLE t1 (                                +
        c1 bigint DEFAULT nextval('serial'::regclass)+
 )                                                  +
 WITH (orientation=row, compression=no)             +
 DISTRIBUTE BY HASH(c1)                             +
 TO GROUP group1;
(1 row)
```

  Note: **pg_get_tabledef** reconstructs the **CREATE** statement of the definition of the table, including the table definition, index information, and comments. Users need to create the dependent objects of the table, such as groups, schemas, tablespaces, and servers. The table definition does not include the statements for creating these dependent objects.

- pg_options_to_table(reloptions)

  Description: Obtains the set of storage option name/value pairs.

  Return type: setof record

  Note: **pg_options_to_table** returns the set of storage option name/value pairs (**option_name**/**option_value**) when **pg_class.reloptions** or **pg_attribute.attoptions** is passed.

- pg_tablespace_databases(tablespace_oid)

  Description: Obtains the set of database OIDs that have objects in the specified tablespace.

  Return type: setof oid

  Note: **pg_tablespace_databases** allows a tablespace to be checked. It returns the set of OIDs of databases that have objects stored in the tablespace. If this function returns any rows of data, the tablespace is not empty and cannot be dropped. To display the specific objects in the tablespace, you need to connect to the databases identified by **pg_tablespace_databases** and query their **pg_class** catalogs.

- pg_tablespace_location(tablespace_oid)

  Description: Obtains the path in the file system that this tablespace is located in.

  Return type: text

- pg_typeof(any)

  Description: Obtains the data type of any value.

  Return type: regtype

  Note: **pg_typeof** returns the OID of the data type of the value that is passed to it. This can be helpful for troubleshooting or dynamically constructing SQL queries. It is declared that the function returns **regtype**, which is an OID alias type (see **12.3.15 Object Identifier Types**). This means that it is the same as an OID for comparison purposes but displays as a type name.

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Example:

```
openGauss=# SELECT pg_typeof(33);
 pg_typeof
-----------
 integer
(1 row)

openGauss=# SELECT typlen FROM pg_type WHERE oid = pg_typeof(33);
 typlen
--------
      4
(1 row)
```

- collation for (any)

  Description: Obtains the collation of the parameter.

  Return type: text

  Note: The expression **collation for** returns the collation of the value that is passed to it. Example:

  ```
  openGauss=# SELECT collation for (description) FROM pg_description LIMIT 1;
   pg_collation_for
  ------------------
   "default"
  (1 row)
  ```

  The value might be quoted and schema-qualified. If no collation is derived for the parameter expression, then a null value is returned. If the parameter is not of a collectable data type, then an error is thrown.

- getdistributekey(table_name)

  Description: Obtains a distribution column for a hash table.

  Return type: text

  Example:

  ```
  openGauss=# SELECT getdistributekey('item');
   getdistributekey
  ------------------
   i_item_sk
  (1 row)
  ```

- pg_extension_update_paths(name)

  Description: Returns the version update path of the specified extension. This function can be called only by the system administrator. The current feature is a lab feature. Contact Huawei technical support before using it.

  Return type: text (source text), text (target text), text (path text)

- pg_get_serial_sequence(tablename, colname)

  Description: Obtains the sequence of the corresponding table name and column name.

  Return type: text

  Example:

  ```
  openGauss=# select * from pg_get_serial_sequence('t1', 'c1');
   pg_get_serial_sequence
  ------------------------
   public.serial
  (1 row)
  ```

- pg_sequence_parameters(sequence_oid)

  Description: Obtains the parameters of a specified sequence, including the start value, minimum value, maximum value, and incremental value.

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Return type: int16, int16, int16, int16, Boolean

Example:

```
openGauss=# select * from pg_sequence_parameters(16420);
 start_value | minimum_value |     maximum_value     | increment | cycle_option
-------------+---------------+-----------------------+-----------+--------------
         101 |             1 | 9223372036854775807 |         1 | f
(1 row)
```

- pgxc_get_variable_info( )

  Description: Obtains variable values on the node, including **nodeName**, **nextOid**, **nextXid**, **oldestXid**, **xidVacLimit**, **oldestXidDB**, **lastExtendCSNLogpage**, **startExtendCSNLogpage**, **nextCommitSeqNo**, **latestCompleteXid**, and **startupMaxXid**.

  Return type: set of pg_variable_info

  Example:

  ```
  openGauss=# select pgxc_get_variable_info( );
                      pgxc_get_variable_info
  ---------------------------------------------------------------------------
  (dn_6004_6005_6006,25617,141396349,2073,20000002073,15808,138111,0,127154152,141396348,104
  433004)
  (1 row)
  ```

- gs_get_index_status(schema_name, index_name)

  Description: Obtains the index status information on all nodes, including whether an index can be inserted and whether an index is available. This function is mainly used to check the index status during online index creation or when the index creation fails. The return values include **node_name**, **indisready**, and **indisvalid**. Only when **indisready** and **indisvalid** of indexes on all nodes are set to **true** and the index state is not changed to unusable, the current index is available.

  Return type: text, Boolean, Boolean

  Example:

  ```
  openGauss=# select * from gs_get_index_status('public', 'index1');
    node_name    | indisready | indisvalid
  ----------------+------------+------------
   datanode1      | t          | t
   datanode2      | t          | t
   coordinator1   | t          | t
  (3 row)
  ```

## Comment Information Functions

- col_description(table_oid, column_number)

  Description: Obtains the comment for a table column.

  Return type: text

  Note: **col_description** returns the comment for a table column, which is specified by the OID of its table and its column number.

- obj_description(object_oid, catalog_name)

  Description: Obtains the comment for a database object.

  Return type: text

  Note: The two-parameter form of **obj_description** returns the comment for a database object specified by its OID and the name of the system catalog to which it belongs. For example, **obj_description(123456,'pg_class')** would retrieve the comment for the table with OID 123456. The one-parameter form of **obj_description** requires only the OID.

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**obj_description** cannot be used for table columns since columns do not have OIDs of their own.

- obj_description(object_oid)

  Description: Obtains the comment for a database object.

  Return type: text

- shobj_description(object_oid, catalog_name)

  Description: Obtains the comment for a shared database object.

  Return type: text

  Note: **shobj_description** is used just like **obj_description**, except that the former is used for shared objects. Some system catalogs are global to all databases in the cluster, and the comments for objects in them are stored globally as well.

## XIDs and Snapshots

Internal XIDs are 64 bits. **txid_snapshot**, data type used by these functions, stores information about XID visibility at a particular moment in time. **Table 12-50** describes its components.

**Table 12-50** Snapshot components

| Name | Description |
| --- | --- |
| xmin | Earliest XID (**txid**) that is still active. All earlier transactions will either be committed and visible, or rolled back. |
| xmax | First as-yet-unassigned **txid**. All **txids** greater than or equal to this are not yet started as of the time of the snapshot, so they are invisible. |
| xip_list | Active **txids** at the time of the snapshot. The list includes only those active **txids** between **xmin** and **xmax**; there might be active **txids** higher than **xmax**. A **txid** that is greater than or equal to **xmin** and less than **xmax** and that is not in this list was already completed at the time of the snapshot, and is either visible or rolled back according to its commit status. The list does not include **txids** of subtransactions. |

The textual representation of **txid_snapshot** is **xmin:xmax:xip_list**.

For example, **10:20:10,14,15** means **xmin=10, xmax=20, xip_list=10, 14, 15**.

The following functions provide server transaction information in an exportable form. These functions are mainly used to determine which transactions were committed between two snapshots.

- pgxc_is_committed(transaction_id)

  Description: Specifies whether the given XID is committed or ignored. **NULL** indicates an unknown state (such as running, preparing, or freezing).

  Return type: Boolean

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- txid_current()

  Description: Obtains the current XID.

  Return type: bigint

- gs_txid_oldestxmin()

  Description: Obtains the minimum XID (specified by **oldesxmin**).

  Return type: bigint

- txid_current_snapshot()

  Description: Obtains the current snapshot.

  Return type: txid_snapshot

- txid_snapshot_xip(txid_snapshot)

  Description: Obtains in-progress XIDs in a snapshot.

  Return type: setof bigint

- txid_snapshot_xmax(txid_snapshot)

  Description: Obtains **xmax** of snapshots.

  Return type: bigint

- txid_snapshot_xmin(txid_snapshot)

  Description: Obtains **xmin** of snapshots.

  Return type: bigint

- txid_visible_in_snapshot(bigint, txid_snapshot)

  Description: Specifies whether the XID is visible in a snapshot (do not use subtransaction IDs).

  Return type: Boolean

- get_local_prepared_xact()

  Description: Obtains the two-phase residual transaction information of the current node, including the XID, GID of the two-phase transaction, prepared time, owner OID, database OID, and node name of the current node.

  Return type: xid, text, timestamptz, oid, oid, text

- get_remote_prepared_xacts()

  Description: Obtains the two-phase residual transaction information of all remote nodes, including the XID, GID of the two-phase transaction, prepared time, owner name, database name, and node name.

  Return type: xid, text, timestamptz, name, name, text

- global_clean_prepared_xacts(text, text)

  Description: Concurrently cleans two-phase residual transactions. Only the gs_clean tool can call this function for cleaning. In other situations, **false** is returned.

  Return type: Boolean

- pgxc_stat_get_wal_senders()

  Description: Returns the sent logs of all primary DNs and the received logs of their corresponding standby DNs in the cluster. Only users with the **system admin** or **monitor admin** permission can use this function.

  The return values are as follows:

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**Table 12-51** pgxc_stat_get_wal_senders parameter description

| Parameter | Description |
| --- | --- |
| nodename | Instance name |
| sender_pid | PID of the thread for sending logs |
| local_role | Instance role |
| peer_role | Role of the instance on the receiver |
| peer_state | Status of the instance on the receiver |
| state | Synchronization status between instances |
| sender_sent_location | Location where the sender sends logs |
| sender_write_location | Location where the sender writes logs |
| sender_flush_location | Location where the sender flushes logs to disks |
| sender_replay_location | Location of the instance logs. For a primary DN, the value is the same as that of **sender_flush_location**. Otherwise, the value is the location where the sender replays the instance logs. |
| receiver_received_location | Location where the receiver receives logs |
| receiver_write_location | Location where the receiver writes logs |
| receiver_flush_location | Location where the receiver flushes logs to disks |
| receiver_replay_location | Location where the receiver replays logs |

- pgxc_stat_get_wal_senders_status()

  Description: Returns the receiving status of transaction logs on all nodes. Only users with the **system admin** or **monitor admin** permission can use this function.

  The return values are as follows:

  **Table 12-52** pgxc_stat_get_wal_senders_status parameter description

| Parameter | Description |
| --- | --- |
| nodename | Name of the primary node |
| source_ip | IP address of the primary node |

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| Parameter | Description |
| --- | --- |
| source_port | Port number of the primary node |
| dest_ip | IP address of the standby node |
| dest_port | Port number of the standby node |
| sender_pid | PID of the sender thread |
| local_role | Type of the primary node |
| peer_role | Type of the standby node |
| peer_state | Status of the standby node |
| state | WAL sender status |
| sender_sent_location | Sending position of the primary node |
| sender_write_location | Writing position of the primary node |
| sender_replay_location | Redo position of the primary node |
| receiver_received_location | Receiving position of the standby node |
| receiver_write_location | Writing position of the standby node |
| receiver_flush_location | Flushing location of the standby node |
| receiver_replay_location | Redo location of the standby node |

- gs_get_next_xid_csn()

  Description: Returns the values of **next_xid** and **next_csn** on all nodes globally.

  The return values are as follows:

  **Table 12-53** gs_get_next_xid_csn parameter description

| Parameter | Description |
| --- | --- |
| nodename | Node name |
| next_xid | ID of the next transaction on the current node. |
| next_csn | Next CSN of the current node. |

- slice(hstore, text[])

  Description: Extracts the subset of the hstore type.

  Return type: hstore

  Example:

```
openGauss=# select slice('a=>1,b=>2,c=>3'::hstore, ARRAY['b','c','x']);
      slice
--------------------
```

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```
 "b"=>"2", "c"=>"3"
(1 row)
```

- slice_array(hstore, text[])

  Description: Extracts the set of values of the hstore type.

  Return type: value array

  Example:

```
openGauss=# select slice_array('a=>1,b=>2,c=>3'::hstore, ARRAY['b','c','x']);
 slice_array
-------------
 {2,3,NULL}
(1 row)
```

- skeys(hstore)

  Description: Returns the set of all keys of the hstore type.

  Return type: a set of keys

  Example:

```
openGauss=# select skeys('a=>1,b=>2');
 skeys
-------
 a
 b
(2 rows)
```

- simsearch_lib_load_status()

  Description: Queries the dynamic library loading status (success or failure).

  Return type: SETOF record

- simsearch_gpu_vector_status()

  Description: Queries whether there is a vector in the status of searchlet.

  Return type: SETOF record

  > NOTE
  >
  > This function is no longer supported in the current version due to specification changes. Do not use this function.

- pg_control_system()

  Description: Returns the status of the system control file.

  Return type: SETOF record

- pg_control_checkpoint()

  Description: Returns the system checkpoint status.

  Return type: SETOF record

- get_delta_info

  Description: Obtains the data storage status in the delta table of a column-store table.

  Parameter: rel text

  Return type: part_name text, total_live_tuple bigint, total_data_size bigint, max_blocknum bigint

- get_prepared_pending_xid

  Description: Returns **nextxid** when restoration is complete.

  Parameter: nan

  Return type: text

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- pg_clean_region_info

  Description: Clears the region map.

  Parameter: nan

  Return type: character varying

- pg_get_delta_info

  Description: Obtains delta information from a single DN.

  Parameter: rel text, schema_name text

  Return type: part_name text, live_tuple bigint, data_size bigint, blocknum bigint

- pgxc_get_delta_info

  Description: Obtains delta information from all DNs. Only users with the **sysadmin** or **monitor admin** permission can access the information.

  Parameter: rel text, schema_name text

  Return type: part_name text, live_tuple bigint, data_size bigint, blocknum bigint

- pg_get_replication_slot_name

  Description: Obtains the slot name.

  Parameter: nan

  Return type: text

- pg_get_running_xacts

  Description: Obtains running **xact**.

  Parameter: nan

  Return type: handle integer, gxid xid, state tinyint, node text, xmin xid, vacuum boolean, timeline bigint, prepare_xid xid, pid bigint, next_xid xid

- pg_get_variable_info

  Description: Obtains the shared memory variable cache.

  Parameter: nan

  Return type: node_name text, nextOid oid, nextXid xid, oldestXid xid, xidVacLimit xid, oldestXidDB oid, lastExtendCSNLogpage xid, startExtendCSNLogpage xid, nextCommitSeqNo xid, latestCompletedXid xid, startupMaxXid xid

- pg_get_xidlimit

  Description: Obtains XID information from the shared memory.

  Parameter: nan

  Return type: nextXid xid, oldestXid xid, xidVacLimit xid, xidWarnLimit xid, xidStopLimit xid, xidWrapLimit xid, oldestXidDB oid

- pg_relation_compression_ratio

  Description: Queries the compression rate of a table. By default, **1.0** is returned.

  Parameter: text

  Return type: real

- pg_relation_with_compression

  Description: Specifies whether a table is compressed.

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Parameter: text

Return type: Boolean

- pg_stat_file_recursive

  Description: Lists all files in a path.

  Parameter: location text

  Return type: path text, filename text, size bigint, isdir boolean

- pg_stat_get_activity_for_temptable

  Description: Returns records of background processes related to the temporary table.

  Parameter: nan

  Return type: datid oid, timelineid integer, tempid integer, sessionid bigint

- pg_stat_get_activity_ng

  Description: Returns records of background processes related to the node group.

  Parameter: pid bigint

  Return type: datid oid, pid bigint, sessionid bigint, node_group text

- pg_stat_get_cgroup_info

  Description: Returns Cgroup information.

  Parameter: nan

  Return type: cgroup_name text, percent integer, usage_percent integer, shares bigint, usage bigint, cpuset text, relpath text, valid text, node_group text

- pg_stat_get_realtime_info_internal

  Description: Returns real-time information. Currently, this API is unavailable. **FailedToGetSessionInfo** is returned.

  Parameter: oid, oid, bigint, cstring, oid

  Return type: text

- pg_stat_get_session_wlmstat

  Description: Returns the load information of the current session.

  Parameter: pid integer

  Return type: datid oid, threadid bigint, sessionid bigint, threadpid integer, usesysid oid, appname text, query text, priority bigint, block_time bigint, elapsed_time bigint, total_cpu_time bigint, skew_percent integer, statement_mem integer, active_points integer, dop_value integer, current_cgroup text, current_status text, enqueue_state text, attribute text, is_plana boolean, node_group text, srespool name

- pg_stat_get_wlm_ec_operator_info

  Description: Obtains the operator information of the EC execution plan from the internal hash table.

  Parameter: nan

  Return type: queryid bigint, plan_node_id integer, plan_node_name text, start_time timestamp with time zone, duration bigint, tuple_processed bigint, min_peak_memory integer, max_peak_memory integer, average_peak_memory integer, ec_operator integer, ec_status text, ec_execute_datanode text, ec_dsn text, ec_username text, ec_query text, ec_libodbc_type text, ec_fetch_count bigint

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- pg_stat_get_wlm_instance_info

  Description: Returns the load information of the current instance.

  Parameter: nan

  Return type: instancename text, timestamp, timestamp with time zone, used_cpu integer, free_memory integer, used_memory integer, io_await double precision, io_util double precision, disk_read double precision, disk_write double precision, process_read bigint, process_write bigint, logical_read bigint, logical_write bigint, read_counts bigint, write_counts bigint

- pg_stat_get_wlm_instance_info_with_cleanup

  Description: Returns the load information of the current instance and saves the information to the system catalog.

  Parameter: nan

  Return type: instancename text, timestamp, timestamp with time zone, used_cpu integer, free_memory integer, used_memory integer, io_await double precision, io_util double precision, disk_read double precision, disk_write double precision, process_read bigint, process_write bigint, logical_read bigint, logical_write bigint, read_counts bigint, write_counts bigint

- pg_stat_get_wlm_node_resource_info

  Description: Obtains the resource information of the current node.

  Parameter: nan

  Return type: min_mem_util integer, max_mem_util integer, min_cpu_util integer, max_cpu_util integer, min_io_util integer, max_io_util integer, used_mem_rate integer

- pg_stat_get_wlm_operator_info

  Description: Obtains the operator information of the execution plan from the internal hash table.

  Parameter: nan

  Return type: queryid bigint, pid bigint, plan_node_id integer, plan_node_name text, start_time timestamp with time zone, duration bigint, query_dop integer, estimated_rows bigint, tuple_processed bigint, min_peak_memory integer, max_peak_memory integer, average_peak_memory integer, memory_skew_percent integer, min_spill_size integer, max_spill_size integer, average_spill_size integer, spill_skew_percent integer, min_cpu_time bigint, max_cpu_time bigint, total_cpu_time bigint, cpu_skew_percent integer, warning text

- pg_stat_get_wlm_realtime_ec_operator_info

  Description: Obtains the operator information of the EC execution plan from the internal hash table.

  Parameter: nan

  Return type: queryid bigint, plan_node_id integer, plan_node_name text, start_time timestamp with time zone, ec_operator integer, ec_status text, ec_execute_datanode text, ec_dsn text, ec_username text, ec_query text, ec_libodbc_type text, ec_fetch_count bigint

- pg_stat_get_wlm_realtime_operator_info

  Description: Obtains the operator information of the real-time execution plan from the internal hash table.

  Parameter: nan

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Return type: queryid bigint, pid bigint, plan_node_id integer, plan_node_name text, start_time timestamp with time zone, duration bigint, status text, query_dop integer, estimated_rows bigint, tuple_processed bigint, min_peak_memory integer, max_peak_memory integer, average_peak_memory integer, memory_skew_percent integer, min_spill_size integer, max_spill_size integer, average_spill_size integer, spill_skew_percent integer, min_cpu_time bigint, max_cpu_time bigint, total_cpu_time bigint, cpu_skew_percent integer, warning text

- pg_stat_get_wlm_realtime_session_info

  Description: Returns the load information of the real-time session.

  Parameter: nan

  Return type: nodename text, threadid bigint, block_time bigint, duration bigint, estimate_total_time bigint, estimate_left_time bigint, schemaname text, query_band text, spill_info text, control_group text, estimate_memory integer, min_peak_memory integer, max_peak_memory integer, average_peak_memory integer, memory_skew_percent integer, min_spill_size integer, max_spill_size integer, average_spill_size integer, spill_skew_percent integer, min_dn_time bigint, max_dn_time bigint, average_dn_time bigint, dntime_skew_percent integer, min_cpu_time bigint, max_cpu_time bigint, total_cpu_time bigint, cpu_skew_percent integer, min_peak_iops integer, max_peak_iops integer, average_peak_iops integer, iops_skew_percent integer, warning text, query text, query_plan text, cpu_top1_node_name text, cpu_top2_node_name text, cpu_top3_node_name text, cpu_top4_node_name text, cpu_top5_node_name text, mem_top1_node_name text, mem_top2_node_name text, mem_top3_node_name text, mem_top4_node_name text, mem_top5_node_name text, cpu_top1_value bigint, cpu_top2_value bigint, cpu_top3_value bigint, cpu_top4_value bigint, cpu_top5_value bigint, mem_top1_value bigint, mem_top2_value bigint, mem_top3_value bigint, mem_top4_value bigint, mem_top5_value bigint, top_mem_dn text, top_cpu_dn text

- pg_stat_get_wlm_session_info_internal

  Description: Returns the session load information.

  Parameter: oid, bigint, bigint, oid

  Return type: SETOF text

- pg_stat_get_wlm_session_iostat_info

  Description: Returns the session load I/O information.

  Parameter: nan

  Return type: threadid bigint, maxcurr_iops integer, mincurr_iops integer, maxpeak_iops integer, minpeak_iops integer, iops_limits integer, io_priority integer, curr_io_limits integer

- pg_stat_get_wlm_statistics

  Description: Returns session load statistics.

  Parameter: nan

  Return type: statement text, block_time bigint, elapsed_time bigint, total_cpu_time bigint, qualification_time bigint, skew_percent integer, control_group text, status text, action text

- pg_stat_get_workload_struct_info

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Description: Returns the load management data structure. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

Parameter: nan

Return type: text

- pg_test_err_contain_err

  Description: Tests the error type and return information.

  Parameter: integer

  Return type: void

- pv_session_memory_detail_tp

  Description: Returns the memory usage of the session. For details, see **pv_session_memory_detail**.

  Parameter: nan

  Return type: sessid text, sesstype text, contextname text, level smallint, parent text, totalsize bigint, freesize bigint, usedsize bigint

- gs_get_table_distribution

  Description: Returns the distribution of table data on each DN.

  Parameter: table_name text, schema_name text

  Return type: text

- pv_builtin_functions

  Description: Displays information about all built-in system functions.

  Parameter: nan

  Return type: proname name, pronamespace oid, proowner oid, prolang oid, procost real, prorows real, provariadic oid, protransform regproc, proisagg boolean, proiswindow boolean, prosecdef boolean, proleakproof boolean, proisstrict boolean, proretset boolean, provolatile "char", pronargs smallint, pronargdefaults smallint, prorettype oid, proargtypes oidvector, proallargtypes integer[], proargmodes "char"[], proargnames text[], proargdefaults pg_node_tree, prosrc text, probin text, proconfig text[], proacl aclitem[], prodefaultargpos int2vector, fencedmode boolean, proshippable boolean, propackage boolean, oid oid

- pv_thread_memory_detail

  Description: Returns the memory information of each thread.

  Parameter: nan

  Return type: threadid text, tid bigint, thrdtype text, contextname text, level smallint, parent text, totalsize bigint, freesize bigint, usedsize bigint

- pg_shared_memory_detail

  Description: Returns usage information about all generated shared memory contexts. For details about each column, see **16.2.3.4 SHARED_MEMORY_DETAIL**.

  Parameter: nan

  Return type: contextname text, level smallint, parent text, totalsize bigint, freesize bigint, usedsize bigint

- pgxc_get_running_xacts

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Description: Returns information about running transactions on each node in the cluster. The field content is the same as that in **15.3.196 PGXC_RUNNING_XACTS**. Only users with the **system admin** or **monitor admin** permission can view the information.

Parameter: nan

Return type: setof record

- pgxc_snapshot_status()

  Description: Returns the status of key memory information in the GTM in GTM mode for fault locating. GTM-Free and GTM-Lite do not support this function.

  Parameter: nan

  Return type: xmin xid, xmax xid, xcnt int, oldestxmin xid, next_xid xid, timeline int, active_thread_num int, max_active_thread_num int, snapshot_num int, snapshot_totalsize bigint

  The return values are described as follows:

  **Table 12-54** get_gtm_lite_status parameter description

| Parameter | Description |
| --- | --- |
| xmin | Minimum active XID in the GTM. |
| xmax | Largest XID committed in the GTM plus 1. Transactions whose IDs are greater than or equal to this value are active. |
| xcnt | Number of active transactions in the GTM. |
| oldestxmin | ID of the earliest accessed transaction in the GTM. |
| next_xid | ID of the next transaction allocated by the GTM. |
| timeline | Current time line in the GTM. |
| active_thread_num | Number of active worker threads in the GTM. |
| max_active_thread_num | Peak number of worker threads in the GTM within one minute. |
| snapshot_num | Number of snapshots delivered by the GTM within one minute. |
| snapshot_totalsize | Total size of snapshots delivered by the GTM within one minute. |

- get_gtm_lite_status()

  Description: Returns the backup XID and CSN in the GTM for fault locating. This system function is not supported in GTM-Free mode.

  The return values are as follows:

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**Table 12-55** get_gtm_lite_status parameter description

| Parameter | Description |
| --- | --- |
| backup_xid | Backup XID in the GTM. |
| csn | Latest CSN issued by the GTM. |

# 12.5.26 System Administration Functions

## 12.5.26.1 Configuration Settings Functions

Configuration setting functions are used for querying and modifying configuration parameters during running.

- current_setting(setting_name)

  Description: Specifies the current setting.

  Return type: text

  Note: **current_setting** obtains the current setting of **setting_name** by query. It is equivalent to the **SHOW** statement. For example:

  ```
  openGauss=# SELECT current_setting('datestyle');

   current_setting
  -----------------
   ISO, MDY
  (1 row)
  ```

- set_working_grand_version_num_manually(tmp_version)

  Description: Upgrades new features of GaussDB by switching the authorization version.

  Return type: void

- shell_in(type)

  Description: Inputs a route for the shell type that has not yet been filled.

  Return type: void

- shell_out(type)

  Description: Outputs a route for the shell type that has not yet been filled.

  Return type: void

- set_config(setting_name, new_value, is_local)

  Description: Sets the parameter and returns a new value.

  Return type: text

  Note: **set_config** sets the parameter **setting_name** to **new_value**. If **is_local** is **true**, the new value will only apply to the current transaction. If you want the new value to apply for the current session, use **false** instead. The function corresponds to the **SET** statement.

  Example:

  ```
  openGauss=# SELECT set_config('log_statement_stats', 'off', false);

   set_config
  ------------
  ```

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```
 off
(1 row)
```

## 12.5.26.2 Universal File Access Functions

Universal file access functions provide local access interfaces for files on a database server. Only files in the database cluster directory and the **log_directory** directory can be accessed. Use a relative path for files in the database cluster directory, and a path matching the **log_directory** configuration setting for log files. Only database initialization users can use these functions.

- pg_ls_dir(dirname text)

  Description: Lists files in a directory.

  Return type: setof text

  Note: **pg_ls_dir** returns all the names in the specified directory, except the special entries "." and "..".

  Example:

```
openGauss=# SELECT pg_ls_dir('./');
      pg_ls_dir
----------------------
 .postgresql.conf.swp
 postgresql.conf
 pg_tblspc
 PG_VERSION
 pg_ident.conf
 core
 server.crt
 pg_serial
 pg_twophase
 postgresql.conf.lock
 pg_stat_tmp
 pg_notify
 pg_subtrans
 pg_ctl.lock
 pg_xlog
 pg_clog
 base
 pg_snapshots
 postmaster.opts
 postmaster.pid
 server.key.rand
 server.key.cipher
 pg_multixact
 pg_errorinfo
 server.key
 pg_hba.conf
 pg_replslot
 .pg_hba.conf.swp
 cacert.pem
 pg_hba.conf.lock
 global
 gaussdb.state
(32 rows)
```

- pg_read_file(filename text, offset bigint, length bigint)

  Description: Returns the content of a text file.

  Return type: text

  Note: **pg_read_file** returns part of a text file. It can return a maximum of *length* bytes from *offset*. The actual size of fetched data is less than *length* if the end of the file is reached first. If *offset* is negative, it is the length rolled

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back from the file end. If *offset* and *length* are omitted, the entire file is returned. Only the database initialization user can use this function.

Example:

```
openGauss=# SELECT pg_read_file('postmaster.pid',0,100);
            pg_read_file
---------------------------------------
 53078                                 +
 /srv/BigData/testdir/data1/coordinator+
 1500022474                            +
 8000                                  +
 /var/run/FusionInsight                +
 localhost                             +
  2
(1 row)
```

- pg_read_binary_file(filename text [, offset bigint, length bigint,missing_ok boolean])

  Description: Returns the contents of a binary file that can be called only by the initial user.

  Return type: bytea

  Note: **pg_read_binary_file** is similar to **pg_read_file**, except that the result is a **bytea** value; accordingly, no encoding checks are performed. In combination with the **convert_from** function, this function can be used to read a file in a specified encoding.

  ```
  openGauss=# SELECT convert_from(pg_read_binary_file('filename'), 'UTF8');
  ```

- pg_stat_file(filename text)

  Description: Returns status information about a file.

  Return type: record

  Note: **pg_stat_file** returns a record containing the file size, last access timestamp, last modification timestamp, last file status change timestamp, and a **Boolean** value indicating if it is a directory. Typical use cases are as follows:

  ```
  openGauss=# SELECT * FROM pg_stat_file('filename');
  openGauss=# SELECT (pg_stat_file('filename')).modification;
  ```

  Example:

  ```
  openGauss=# SELECT convert_from(pg_read_binary_file('postmaster.pid'), 'UTF8');
              convert_from
  ---------------------------------------
   4881                                 +
   /srv/BigData/gaussdb/data1/coordinator+
   1496308688                           +
   25108                                +
   /opt/huawei/Bigdata/gaussdb/gaussdb_tmp +
   *                                    +
    25108001  43352069                  +

  (1 row)
  openGauss=# SELECT * FROM pg_stat_file('postmaster.pid');

   size |         access         |      modification      |         change
  | creation | isdir
  ------+------------------------+------------------------+------------------------
  +----------+-------
    117 | 2017-06-05 11:06:34+08 | 2017-06-01 17:18:08+08 | 2017-06-01 17:18:08+08
  |          | f
  (1 row)
  openGauss=# SELECT (pg_stat_file('postmaster.pid')).modification;
       modification
  ------------------------
  ```

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```
 2017-06-01 17:18:08+08
(1 row)
```

## 12.5.26.3 Server Signal Functions

Server signal functions send control signals to other server processes. Only the system administrator has the permission to execute the following functions:

- pg_cancel_backend(pid int)

  Description: Cancels the current query of a backend.

  Return type: Boolean

  Note: **pg_cancel_backend** sends a query cancellation (SIGINT) signal to the backend process identified by **pid**. The PID of an active backend process can be found in the **pid** column of the **pg_stat_activity** view, or can be found by listing the database process using **ps** on the server. A user with the **SYSADMIN** permission, the owner of the database connected to the backend process, the owner of the backend process, or a user who inherits the **gs_role_signal_backend** permission of the built-in role has the permission to use this function.

- pg_cancel_session(pid bigint, sessionid bigint)

  Description: Cancels a backend session.

  Return type: Boolean

  Note: The input parameters of **pg_cancel_session** can be queried using the **pid** and **sessionid** fields in **pg_stat_activity**. It can be used to clear inactive sessions in thread pool mode.

- pg_cancel_invalid_query()

  Description: Cancels the invalid query of a backend.

  Return type: Boolean

  Note: Only the system administrator has the permission to cancel queries that are running in the backend of a degraded GTM.

- pg_reload_conf()

  Description: Causes all server processes to reload their configuration files.

  Return type: Boolean

  Note: **pg_reload_conf** sends a SIGHUP signal to the server. As a result, all server processes reload their configuration files.

- pg_rotate_logfile()

  Description: Rotates the log files of the server.

  Return type: Boolean

  Note: **pg_rotate_logfile** sends a signal to the log file manager, instructing the manager to immediately switch to a new output file. This function works only when **redirect_stderr** is used for log output. Otherwise, no log file manager subprocess exists.

- pg_terminate_session(pid bigint, sessionid bigint)

  Description: Terminates a backend session.

  Return type: Boolean

  Note: The input parameters of this function can be queried using the **pid** and **sessionid** fields in **pg_stat_activity**. It can be used to clear inactive sessions in

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thread pool mode. A user with the **SYSADMIN** permission, the owner of the database connected to the session, the owner of the session, or a user who inherits the **gs_role_signal_backend** permission of the built-in role has the permission to use this function.

- pg_terminate_backend(pid int)

  Description: Terminates a backend thread. Only the system administrator and thread owner can use this function.

  Return type: Boolean

  Note: Each of these functions returns **true** if they are successful and **false** otherwise. A user with the **SYSADMIN** permission, the owner of the database connected to the backend thread, the owner of the backend thread, or a user who inherits the **gs_role_signal_backend** permission of the built-in role can use this function.

  Example:

```
openGauss=# SELECT pid from pg_stat_activity;
       pid
-----------------
 140657876268816
(1 rows)

openGauss=# SELECT pg_terminate_backend(140657876268816);
 pg_terminate_backend
----------------------
 t
(1 row)
```

## 12.5.26.4 Backup and Restoration Control Functions

## Backup Control Functions

Backup control functions help with online backup.

- pg_create_restore_point(name text)

  Description: Creates a named point for performing the restoration operation (restricted to the system administrator).

  Return type: text

  Note: **pg_create_restore_point** creates a named transaction log record that can be used as a restoration target, and returns the corresponding transaction log location. The given name can then be used with **recovery_target_name** to specify the point up to which restoration will proceed. Avoid creating multiple restoration points with the same name, since restoration will stop at the first one whose name matches the restoration target.

- pg_current_xlog_location()

  Description: Obtains the write position of the current transaction log.

  Return type: text

  Note: **pg_current_xlog_location** displays the write position of the current transaction log in the same format as those of the previous functions. Read-only operations do not require permissions of the system administrator.

- pg_current_xlog_insert_location()

  Description: Obtains the insert position of the current transaction log.

  Return type: text

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Note: **pg_current_xlog_insert_location** displays the insert position of the current transaction log. The insertion point is the logical end of the transaction log at any instant, while the write location is the end of what has been written out from the server's internal buffers. The write position is the end that can be detected externally from the server. This operation can be performed to archive only some of completed transaction log files. The insert position is mainly used for commissioning the server. Read-only operations do not require permissions of the system administrator.

- gs_current_xlog_insert_end_location()

  Description: Obtains the insert position of the current transaction log.

  Return type: text

  Note: **gs_current_xlog_insert_end_location** displays the insert position of the current transaction log.

- pg_start_backup(label text, is_full_backup boolean)

  Description: Starts to perform online backup. (You need to enable **operate_mode** as an administrator, replication role, or O&M administrator.) Label strings starting with **gs_roach** are reserved and can be used only by the internal backup tool GaussRoach.

  Return type: text

  Note: **pg_start_backup** receives a user-defined backup label (usually the name of the position where the backup dump file is stored). This function writes a backup label file to the data directory of the database cluster and then returns the starting position of backed up transaction logs in text mode.

  ```
  openGauss=# SELECT pg_start_backup('label_goes_here',true);
   pg_start_backup
  -----------------
   0/3000020
  (1 row)
  ```

- pg_stop_backup()

  Description: Completes online backup You need to execute this function as the system administrator or a replication role.

  Return type: text

  Note: **pg_stop_backup** deletes the label file created by **pg_start_backup** and creates a backup history file in the transaction log archive area. The history file includes the label given to **pg_start_backup**, the start and end transaction log locations for the backup, and the start and end time of the backup. The return value is the backup's ending transaction log location. After the end position is calculated, the insert position of the current transaction log automatically goes ahead to the next transaction log file. In this way, the ended transaction log file can be immediately archived so that backup is complete.

- pg_switch_xlog()

  Description: Switches to a new transaction log file You need to enable **operation_mode** as the administrator or O&M administrator.

  Return type: text

  Note: **pg_switch_xlog** moves to the next transaction log file so that the current log file can be archived (if continuous archive is used). The return value is the ending transaction log location + 1 within the just-completed transaction log file. If there has been no transaction log activity since the last

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transaction log switchover, **pg_switch_xlog** will do nothing but return the start location of the transaction log file currently in use.

- pg_xlogfile_name(location text)

  Description: Converts the position string in a transaction log to a file name.

  Return type: text

  Note: **pg_xlogfile_name** extracts only the transaction log file name. If the given transaction log position is the transaction log file border, a transaction log file name will be returned for both the two functions. This is usually the desired behavior for managing transaction log archiving, since the preceding file is the last one that currently needs to be archived.

- pg_xlogfile_name_offset(location text)

  Description: Converts the position string in a transaction log to a file name and returns the byte offset in the file.

  Return type: text, integer

  Note: **pg_xlogfile_name_offset** can extract transaction log file names and byte offsets from the returned results of the preceding functions. Example:

  ```
  openGauss=# SELECT * FROM pg_xlogfile_name_offset(pg_stop_backup());
  NOTICE:  pg_stop_backup cleanup done, waiting for required WAL segments to be archived
  NOTICE:  pg_stop_backup complete, all required WAL segments have been archived
         file_name         | file_offset
  --------------------------+-------------
  000000010000000000000003 |         272
  (1 row)
  ```

- pg_xlog_location_diff(location text, location text)

  Description: Calculates the difference in bytes between two transaction log locations.

  Return type: numeric

- pg_cbm_tracked_location()

  Description: Queries the LSN location parsed by CBM.

  Return type: text

- pg_cbm_get_merged_file(startLSNArg text, endLSNArg text)

  Description: Combines CBM files within the specified LSN range into one and returns the name of the combined file.

  Return type: text

  Note: Only the system administrator or O&M administrator can obtain the CBM combination file.

- pg_cbm_get_changed_block(startLSNArg text, endLSNArg text)

  Description: Combines CBM files within the specified LSN range into a table and return records of this table.

  Return type: record

  Note: The table columns include the start LSN, end LSN, tablespace OID, database OID, table relfilenode, table fork number, whether the table is deleted, whether the table is created, whether the table is truncated, number of pages in the truncated table, number of modified pages, and list of modified page numbers.

- pg_cbm_recycle_file(targetLSNArg text)

  Description: Deletes the CBM files that are no longer used and returns the first LSN after the deletion.

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Return type: text

- pg_cbm_force_track(targetLSNArg text,timeOut int)

  Description: Forcibly executes the CBM trace to the specified Xlog position and returns the Xlog position of the actual trace end point.

  Return type: text

- pg_enable_delay_ddl_recycle()

  Description: Enables DDL delay and returns the Xlog position of the enabling point. You need to enable **operation_mode** as the administrator or O&M administrator.

  Return type: text

- pg_disable_delay_ddl_recycle(barrierLSNArg text, isForce bool)

  Description: Disables DDL delay and returns the Xlog range where DDL delay takes effect. You need to enable **operation_mode** as the administrator or O&M administrator.

  Return type: record

- pg_enable_delay_xlog_recycle()

  Description: Enables the Xlog recycling delay function for CN recovery. You need to enable **operation_mode** as the administrator or O&M administrator.

  Return type: void

- pg_disable_delay_xlog_recycle()

  Description: Disables the Xlog recycling delay function for CN recovery. You need to enable **operation_mode** as the administrator or O&M administrator.

  Return type: void

- pg_cbm_rotate_file(rotate_lsn text)

  Description: Forcibly switches the file after the CBM parses **rotate_lsn**. This function is called during the build process.

  Return type: void

- gs_roach_stop_backup(backupid text)

  Description: Stops a backup started by the internal backup tool GaussRoach. It is similar to the **pg_stop_backup system** function but is more lightweight.

  Return type: text. The content is the insertion position of the current log.

- gs_roach_enable_delay_ddl_recycle(backupid name)

  Description: Enables DDL delay and returns the log location of the enabling point. It is similar to the **pg_enable_delay_ddl_recycle** system function but is more lightweight. In addition, different **backupid** values can be used to concurrently open DDL statements with delay.

  Return type: text. The content is the log location of the start point.

- gs_roach_disable_delay_ddl_recycle(backupid text)

  Description: Disables DDL delay, returns the range of logs on which DDL delay takes effect, and deletes the physical files of column-store tables that are deleted by users within this range. It is similar to the **pg_enable_delay_ddl_recycle** system function but is more lightweight. In addition, the DDL delay function can be disabled concurrently by specifying different backupid values.

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Return type: record. The content is the range of logs for which DDL is delayed to take effect.

- gs_roach_switch_xlog(request_ckpt bool)

  Description: Switches the currently used log segment file and triggers a full checkpoint if **request_ckpt** is **true**.

  Return type: text. The content is the location of the segment log.

- gs_block_dw_io(timeout int, identifier text)

  Description: Blocks dual-write page flushing.

  Parameter description:

  – timeout

    Block duration.

    Value range: [0,3600] (s). The value **0** indicates that the block duration is 0s.

  – identifier

    ID of the operation.

    Value range: a string, supporting only uppercase letters, lowercase letters, digits, and underscores (_).

  Return type: Boolean

  Note: To call this function, the user must have the SYSADMIN or OPRADMIN permission, and **operate_mode** must be enabled for the O&M administrator role.

- gs_is_dw_io_blocked()

  Description: Checks whether disk flushing on the current dual-write page is blocked. If disk flushing is blocked, **true** is returned.

  Return type: Boolean

  Note: To call this function, the user must have the SYSADMIN or OPRADMIN permission, and **operate_mode** must be enabled for the O&M administrator role.

## Restoration Control Functions

Restoration control functions provide information about the status of standby nodes. These functions may be executed both during restoration and in normal running.

- pg_is_in_recovery()

  Description: Returns **true** if restoration is still in progress.

  Return type: Boolean

- pg_last_xlog_receive_location()

  Description: Obtains the last transaction log location received and synchronized to disk by streaming replication. While streaming replication is in progress, this will increase monotonically. If restoration has been completed, then this value will remain static at the value of the last WAL record received and synchronized to disk during restoration. If streaming replication is disabled or if it has not yet started, the function returns a null value.

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Return type: text

- pg_last_xlog_replay_location()

  Description: Obtains last transaction log location replayed during restoration. If restoration is still in progress, this will increase monotonically. If restoration has been completed, then this value will remain static at the value of the last WAL record received during that restoration. When the server has been started normally without restoration, the function returns a null value.

  Return type: text

- pg_last_xact_replay_timestamp()

  Description: Obtains the timestamp of last transaction replayed during restoration. This is the time to commit a transaction or abort a WAL record on the primary node. If no transactions have been replayed during restoration, this function will return a null value. If restoration is still in progress, this will increase monotonically. If restoration has been completed, then this value will remain static at the value of the last WAL record received during that restoration. If the server normally starts without manual intervention, this function will return a null value.

  Return type: timestamp with time zone

Restoration control functions control restoration processes. These functions may be executed only during restoration.

- pg_is_xlog_replay_paused()

  Description: Returns **true** if restoration is paused.

  Return type: Boolean

- pg_xlog_replay_pause()

  Description: Pauses restoration immediately.

  Return type: void

- pg_xlog_replay_resume()

  Description: Restarts restoration if it was paused.

  Return type: void

- gs_get_active_archiving_standby()

  Description: Queries information about archive standby nodes in the same shard. The standby node name, archive location, and number of archived logs are returned.

  Return type: text, text, int

- gs_pitr_get_warning_for_xlog_force_recycle()

  Description: Checks whether logs are recycled because a large number of logs are stacked in the archive slot after archiving is enabled.

  Return type: Boolean

- gs_pitr_clean_history_global_barriers(stop_barrier_timestamp cstring)

  Description: Clears all barrier records generated before the specified time. The earliest barrier record is returned. The input parameter is of the cstring type and is a Linux timestamp. You need to perform this operation as the administrator or O&M administrator.

  Return type: text

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- gs_pitr_archive_slot_force_advance(stop_barrier_timestamp cstring)

  Description: Forcibly pushes the archive slot and clears unnecessary barrier records. The new archive slot location is returned. The input parameter is of the cstring type and is a Linux timestamp. You need to perform this operation as the administrator or O&M administrator.

  Return type: text

While restoration is paused, no further database changes are applied. In hot standby mode, all new queries will see the same consistent snapshot of the database, and no further query conflicts will be generated until restoration is resumed.

If streaming replication is disabled, the paused state may continue indefinitely without problem. While streaming replication is in progress, WAL records will continue to be received, which will eventually fill available disk space. This progress depends on the duration of the pause, the rate of WAL generation, and available disk space.

## 12.5.26.5 Dual-Cluster DR Control Functions

Dual-cluster DR control functions can be used to create an archive slot, which specifies the OBS information for storing physical logs.

- pg_create_physical_replication_slot_extern(slotname text, dummy_standby bool, extra_content text, need_recycle_xlog bool)

  Description: Creates an OBS or a NAS archive slot. **slotname** indicates the slot name of the DR standby. The primary and standby nodes must use the same slot name. **dummy_standby** specifies whether the database is deployed in primary/standby/secondary mode or one-primary and multi-standby mode. The value **false** indicates that the database is deployed in one-primary and multi-standby mode, and the value **true** indicates that the database is deployed in primary/standby/secondary mode. **extra_content** contains some information about the archive slot. For an OBS archive slot, the format is **OBS;obs_server_ip;obs_bucket_name;obs_ak;obs_sk;archive_path;is_recovery;is_vote_replicate**, where **OBS** indicates the archive media of the archive slot, **obs_server_ip** indicates the IP address of OBS, **obs_bucket_name** indicates the bucket name, **obs_ak** indicates the AK of OBS, **obs_sk** indicates the SK of OBS, **archive_path** indicates the archive path **i**, and **is_recovery** indicates whether the slot is an archive slot or a recovery slot. The value **0** indicates that the slot is an archive slot and is used by the primary database instance. The value **1** indicates that the slot is a recovery slot and is used by the DR database instance. **is_vote_replicate** indicates whether the voting copy is archived first. The value **0** indicates that the synchronous standby server is archived first, and the value **1** indicates that the voting copy is archived first. This field is reserved in the current version and is not adapted yet. For a NAS archive slot, the format is **NAS;archive_path;is_recovery;is_vote_replicate**. Compared with the OBS archive slot, the NAS archive slot does not have the OBS configuration information, while the meanings of other fields are the same.

  If the media is not specified, the OBS archive slot is used by default. The **extra_content** format is **obs_server_ip;obs_bucket_name;obs_ak;obs_sk;archive_path;is_recovery;is_vote_replicate**.

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**need_recycle_xlog** specifies whether to recycle old archived logs when creating an archive slot. The value **true** indicates that old archived logs are recycled, and the value **false** indicates that old archive logs are not recycled.

Return type: records, including **slotname** and **xlog_position** of the current DR standby.

Note: Users who invoke this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

Example:

Create an OBS archive slot.

```
openGauss=# select * from pg_create_physical_replication_slot_extern('uuid', false, 'OBS;obs.cn-north-7.ulanqab.huawei.com;dyk;19D772JBCACXX3KWS51D;********;openGauss_uuid/dn1;0;0', false);
 slotname | xlog_position
----------+---------------
 uuid     |
(1 row)
```

Create a NAS archive slot.

```
openGauss=# select * from pg_create_physical_replication_slot_extern('uuid', false, 'NAS;/data/nas/media/openGauss_uuid/dn1;0;0', false);
 slotname | xlog_position
----------+---------------
 uuid     |
```

- gs_set_obs_delete_location(delete_location text)

  Description: Sets the location where OBS archive logs can be deleted. The value of **delete_location** is a LSN. The logs before this location have been replayed and flushed to disks in the DR cluster and can be deleted on OBS.

  Return type: xlog_file_name text, indicating the file name of the logs that can be deleted. The value of this parameter is returned regardless of whether OBS is deleted successfully.

  ```
  openGauss=# select gs_set_obs_delete_location('0/54000000');
   gs_set_obs_delete_location
  ----------------------------
   000000010000000000000054_00
  (1 row)
  ```

- gs_hadr_do_switchover()

  Description: Triggers a planned switchover in the primary cluster in the geo-redundancy scenario.

  Return type: Boolean, indicating whether the switchover process is performed normally and whether services are taken over successfully.

- gs_set_obs_delete_location_with_slotname(cstring, cstring )

  Description: Sets the location where OBS archive logs can be deleted in a DR relationship. The first parameter indicates the LSN. The logs before this location have been replayed and flushed to disks in the DR database instance and can be deleted on OBS. The second parameter indicates the name of the archive slot.

  Return type: xlog_file_name text, indicating the file name of the logs that can be deleted. The value of this parameter is returned regardless of whether OBS is deleted successfully.

- gs_streaming_dr_in_switchover()

  Description: Triggers a planned switchover in the primary cluster in remote DR solutions based on streaming replication.

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Return type: Boolean, indicating whether the switchover process is performed normally and whether services are taken over successfully.

## 12.5.26.6 Dual-Cluster DR Query Functions

- gs_get_global_barrier_status()

  Description: If two-city 3DC DR is enabled, the primary cluster and DR cluster synchronize logs through OBS. The barrier log is flushed to disks in the primary cluster, and replayed in the DR cluster to determine the archive log progress of the primary cluster and the log replay progress of the DR cluster. **gs_get_global_barrier_status** is used to query the latest global barrier archived in OBS by the primary cluster.

  Return type: text

  global_barrier_id: indicates the globally latest barrier ID.

  global_achive_barrier_id: indicates the globally latest archived barrier ID.

- gs_get_local_barrier_status()

  Description: If two-city 3DC DR is enabled, the primary cluster and DR cluster synchronize logs through OBS. The barrier log is flushed to disks in the primary cluster, and replayed in the DR cluster to determine the archive log progress of the primary cluster and the log replay progress of the DR cluster. **gs_get_local_barrier_status** is used to query the current log replay status of each node in the DR cluster.

  Return type: text

  **barrier_id**: latest barrier ID of a node in the DR cluster.

  **barrier_lsn**: LSN of the latest barrier ID returned by a node in the DR cluster.

  **archive_lsn**: location of archived logs obtained by a node in the DR cluster. This parameter does not take effect currently.

  **flush_lsn**: location of logs that have been flushed to disks on a node in the DR cluster.

- gs_get_global_barriers_status()

  Description: If two-city 3DC DR solutions based on OBS are enabled, logs of the primary database instance and multiple DR database instances are synchronized through OBS. The barrier logs are flushed to the disk of the primary database instance. The progress of archiving logs of the primary database instance and the progress of replaying logs of the DR database instances are determined by replaying the DR database instances. **gs_get_global_barriers_status** is used to query the latest global barrier that has been archived in OBS for the primary database instance.

  Return type: text

  **slot_name**: name of the slot used for DR.

  **global_barrier_id**: globally latest barrier ID.

  **global_achive_barrier_id**: globally latest archived barrier ID.

- gs_upload_obs_file('slot_name', 'src_file', 'dest_file')

  Description: Function used by the primary cluster to upload data to OBS if two-city 3DC DR is enabled.

  Return type: void

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**slot_name**: name of the replication slot created by the CN in the primary cluster.

**src_file**: location of files to be uploaded in the CN data directory of the primary cluster.

**dest_file**: location of files uploaded to OBS.

- gs_download_obs_file('slot_name', 'src_file', 'dest_file')

  Description: Function used by the DR cluster to download data from OBS to the local host if two-city 3DC DR is enabled.

  Return type: void

  **slot_name**: name of the replication slot created by the CN in the DR cluster.

  **src_file**: location of files to be downloaded from OBS.

  **dest_file**: location of downloaded files in the CN data directory of the DR cluster.

- gs_get_obs_file_context('file_name', 'slot_name')

  Description: Queries file content on OBS if two-city 3DC DR is enabled.

  Return type: text

  **file_name**: name of the file on OBS.

  **slot_name**: name of the replication slot created by the CN in the primary or DR cluster.

- gs_set_obs_file_context('file_name', 'file_context','slot_name')

  Description: Creates a file on OBS and writes content into the file if two-city 3DC DR is enabled.

  Return type: text

  **file_name**: name of the file on OBS.

  **file_context**: content to be written into the file.

  **slot_name**: name of the replication slot created by the CN in the primary or DR cluster.

- gs_get_hadr_key_cn()

  Description: Creates a file on OBS and writes content into the file if two-city 3DC DR is enabled.

  Return type: text

  **file_name**: name of the file on OBS.

  **file_context**: content to be written into the file.

  **slot_name**: name of the replication slot created by the CN in the primary or DR cluster.

- gs_hadr_has_barrier_creator()

  Description: Checks whether the **barrier_creator** thread exists on the current CN if two-city 3DC DR is enabled. If yes, **true** is returned (restricted to the system administrator).

  Return type: Boolean

  Note: This function is used only when a planned switchover is performed in the DR cluster.

- gs_hadr_in_recovery()

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Description: Checks whether the current node is in barrier-based log restoration if two-city 3DC DR is enabled. If yes, **true** is returned. Only after the log restoration is complete, can the DR cluster be promoted to the production cluster during the switchover process. This operation must be performed by the system administrator.

Return type: Boolean

NOTE

This function is used only when a planned switchover is performed in the DR cluster.

- gs_streaming_dr_get_switchover_barrier()

  Description: Checks whether the CN and first standby DN in the DR cluster have received the switchover barrier logs and replayed the logs in the streaming replication-based two-city 3DC DR solution. If it has, **true** is returned. In the DR cluster, the procedure for promoting the DR database instance to the production database instance in the switchover process can be started only after the switchover barrier logs of all DNs are replayed (restricted to the system administrator).

  Return type: Boolean

  Note: This function is used only when a planned switchover is performed in the DR database instance in streaming DR solutions.

- gs_streaming_dr_service_truncation_check()

  Description: Checks whether the CN and primary DN in the primary cluster has sent the switchover barrier logs in the streaming replication-based two-city 3DC DR solution. If it has, **true** is returned. The procedure for demoting the production database instance to the DR database instance in the switchover process can be started only after the logs are sent (restricted to the system administrator).

  Return type: Boolean

  Note: This function is used only when a planned switchover is performed in the DR database instance.

- gs_hadr_local_rto_and_rpo_stat()

  Description: Displays the log flow control information of the local database instance and DR database instance for streaming DR. (If this command is executed on a node that does not participate in streaming DR, for example, a standby DN or a CN, no information may be returned.)

  The return value type is record. The types and meanings of the fields are as follows:

| Parameter | Type | Description |
| --- | --- | --- |
| hadr_sender_node_name | text | Node name, including the primary database instance and the first standby node of the standby database instance. |
| hadr_receiver_node_name | text | Name of the first standby node of the standby database instance. |

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| Parameter | Type | Description |
| --- | --- | --- |
| source_ip | text | IP address of the primary DN of the primary database instance. |
| source_port | int | Communication port of the primary DN of the primary database instance. |
| dest_ip | text | IP address of the first standby DN of the standby database instance. |
| dest_port | int | Communication port of the first standby DN of the standby database instance. |
| current_rto | int | Flow control information, that is, log RTO time of the current primary and standby database instances (unit: second). |
| target_rto | int | Flow control information, that is, RTO time between the target primary and standby database instances (unit: second). |
| current_rpo | int | Flow control information, that is, log RPO time of the current primary and standby database instances (unit: second). |
| target_rpo | int | Flow control information, that is, RPO time between the target primary and standby database instances (unit: second). |
| rto_sleep_time | int | RTO flow control information, that is, expected sleep time (unit: μs) required by walsender on the host to reach the specified RTO. |
| rpo_sleep_time | int | RPO flow control information, that is, the expected sleep time (unit: μs) required by xlogInsert on the host to reach the specified RPO. |

- gs_hadr_remote_rto_and_rpo_stat()

  Description: Displays the log flow control information of all other shards or CN database instances and DR database instances for streaming DR. (Generally, this command is executed on CNs. If this command is executed on DNs, no information may be returned.)

  The return value type is record. The types and meanings of the fields are as follows:

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| Parameter | Type | Description |
| --- | --- | --- |
| hadr_sender_node_name | text | Node name, including the primary database instance and the first standby node of the standby database instance. |
| hadr_receiver_node_name | text | Name of the first standby node of the standby database instance. |
| source_ip | text | IP address of the primary DN of the primary database instance. |
| source_port | int | Communication port of the primary DN of the primary database instance. |
| dest_ip | text | IP address of the first standby DN of the standby database instance. |
| dest_port | int | Communication port of the first standby DN of the standby database instance. |
| current_rto | int | Flow control information, that is, log RTO time of the current primary and standby database instances (unit: second). |
| target_rto | int | Flow control information, that is, RTO time between the target primary and standby database instances (unit: second). |
| current_rpo | int | Flow control information, that is, log RPO time of the current primary and standby database instances (unit: second). |
| target_rpo | int | Flow control information, that is, RPO time between the target primary and standby database instances (unit: second). |
| rto_sleep_time | int | RTO flow control information, that is, expected sleep time (unit: μs) required by walsender on the host to reach the specified RTO. |
| rpo_sleep_time | int | RPO flow control information, that is, the expected sleep time (unit: μs) required by xlogInsert on the host to reach the specified RPO. |

## 12.5.26.7 Snapshot Synchronization Functions

Snapshot synchronization functions save the current snapshot and return its identifier.

- pg_export_snapshot()
  Description: Saves the current snapshot and returns its identifier.
  Return type: text

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Note: **pg_export_snapshot** saves the current snapshot and returns a text string identifying the snapshot. This string must be passed to clients that want to import the snapshot. A snapshot can be imported when the **set transaction snapshot snapshot_id;** command is executed. Doing so is possible only when the transaction is set to the **SERIALIZABLE** or **REPEATABLE READ** isolation level. GaussDB does not support these two isolation levels currently. The output of the function cannot be used as the input of **set transaction snapshot**.

- pg_export_snapshot_and_csn()

  Description: Saves the current snapshot and returns its identifier. Compared with **pg_export_snapshot()**, **pg_export_snapshot()** returns a CSN, indicating the CSN of the current snapshot.

  Return type: text

## 12.5.26.8 Database Object Functions

## Database Object Size Functions

Database object size functions calculate the actual disk space used by database objects.

- pg_column_size(any)

  Description: Specifies the number of bytes used to store a particular value (possibly compressed)

  Return type: int

  Note: **pg_column_size** displays the space for storing an independent data value.

  ```
  openGauss=# SELECT pg_column_size(1);
   pg_column_size
  ----------------
               4
  (1 row)
  ```

- pg_database_size(oid)

  Description: Specifies the disk space used by the database with the specified OID.

  Return type: bigint

- pg_database_size(name)

  Description: Specifies the disk space used by the database with the specified name.

  Return type: bigint

  Note: **pg_database_size** receives the OID or name of a database and returns the disk space used by the corresponding object.

  Example:

  ```
  openGauss=# SELECT pg_database_size('postgres');
   pg_database_size
  ------------------
          51590112
  (1 row)
  ```

- pg_relation_size(oid)

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Description: Specifies the disk space used by the table with a specified OID or index.

Return type: bigint

- get_db_source_datasize()

  Description: Estimates the total size of non-compressed data in the current database.

  Return type: bigint

  Remarks: (1) Perform an analysis before this function is called. (2) Calculate the total data capacity in the non-compressed state by estimating the compression rate of the column-store tables.

  Example:

```
openGauss=# analyze;
ANALYZE
openGauss=# select get_db_source_datasize();
 get_db_source_datasize
------------------------
            35384925667
(1 row)
```

- pg_relation_size(text)

  Description: Specifies the disk space used by the table with a specified name or index. The table name can be schema-qualified.

  Return type: bigint

- pg_relation_size(relation regclass, fork text)

  Description: Specifies the disk space used by the specified bifurcating tree ('main', 'fsm', or 'vm') of a certain table or index.

  Return type: bigint

- pg_relation_size(relation regclass)

  Description: Is an abbreviation of **pg_relation_size(..., 'main')**.

  Return type: bigint

  Note: **pg_relation_size** receives the OID or name of a table, an index, or a compressed table, and returns the size.

- pg_partition_size(oid,oid)

  Description: Specifies the disk space used by the partition with a specified OID. The first **oid** is the OID of the table and the second **oid** is the OID of the partition.

  Return type: bigint

- pg_partition_size(text, text)

  Description: Specifies the disk space used by the partition with a specified name. The first **text** is the table name and the second **text** is the partition name.

  Return type: bigint

- pg_partition_indexes_size(oid,oid)

  Description: Specifies the disk space used by the index of the partition with a specified OID. The first **oid** is the OID of the table and the second **oid** is the OID of the partition.

  Return type: bigint

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- pg_partition_indexes_size(text,text)

  Description: Specifies the disk space used by the index of the partition with a specified name. The first **text** is the table name and the second **text** is the partition name.

  Return type: bigint

- pg_indexes_size(regclass)

  Description: Specifies the total disk space used by the index appended to the specified table.

  Return type: bigint

- pg_size_pretty(bigint)

  Description: Converts a size in bytes expressed as a 64-bit integer into a human-readable format with size units.

  Return type: text

- pg_size_pretty(numeric)

  Description: Converts a size in bytes expressed as a numeric value into a human-readable format with size units.

  Return type: text

  Note: **pg_size_pretty** formats the results of other functions into a human-readable format. KB, MB, GB, and TB can be used.

- pg_table_size(regclass)

  Description: Specifies the disk space used by the specified table, excluding indexes (but including TOAST, free space mapping, and visibility mapping).

  Return type: bigint

- pg_tablespace_size(oid)

  Description: Specifies the disk space used by the tablespace with a specified OID.

  Return type: bigint

- pg_tablespace_size(name)

  Description: Specifies the disk space used by the tablespace with a specified name.

  Return type: bigint

  Note:

  **pg_tablespace_size** receives the OID or name of a database and returns the disk space used by the corresponding object.

- pg_total_relation_size(oid)

  Description: Specifies the disk space used by the table with a specified OID, including the index and the compressed data.

  Return type: bigint

- pg_total_relation_size(regclass)

  Description: Specifies the total disk space used by the specified table, including all indexes and TOAST data.

  Return type: bigint

- pg_total_relation_size(text)

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Description: Specifies the disk space used by the table with a specified name, including the index and the compressed data. The table name can be schema-qualified.

Return type: bigint

Note: **pg_total_relation_size** receives the OID or name of a table or a compressed table, and returns the sizes of the data, related indexes, and the compressed table in bytes.

- datalength(any)

  Description: Specifies the number of bytes used by an expression of a specified data type (data management space, data compression, or data type conversion is not considered).

  Return type: int

  Note: **datalength** is used to calculate the space of an independent data value.

  Example:

```
openGauss=# SELECT datalength(1);
datalength
------------
4
(1 row)
```

The following table lists the supported data types and calculation methods.

| Data Type | | | Storage Space |
| --- | --- | --- | --- |
| Numeric data types | Integer types | TINYINT | 1 |
| | | SMALLINT | 2 |
| | | INTEGER | 4 |
| | | BINARY_INTEGER | 4 |
| | | BIGINT | 8 |
| | Arbitrary precision types | DECIMAL | Every four decimal digits occupy two bytes. The digits before and after the decimal point are calculated separately. |
| | | NUMERIC | Every four decimal digits occupy two bytes. The digits before and after the decimal point are calculated separately. |
| | | NUMBER | Every four decimal digits occupy two bytes. The digits before and after the decimal point are calculated separately. |

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| | | | |
|---|---|---|---|
| | Sequence integer | SMALLSERIAL | 2 |
| | | SERIAL | 4 |
| | | BIGSERIAL | 8 |
| | Floating point types | FLOAT4 | 4 |
| | | DOUBLE PRECISION | 8 |
| | | FLOAT8 | 8 |
| | | BINARY_DOUBLE | 8 |
| | | FLOAT[(p)] | Every four decimal digits occupy two bytes. The digits before and after the decimal point are calculated separately. |
| | | DEC[(p[,s])] | Every four decimal digits occupy two bytes. The digits before and after the decimal point are calculated separately. |
| | | INTEGER[(p[,s])] | Every four decimal digits occupy two bytes. The digits before and after the decimal point are calculated separately. |
| Boolean data types | Boolean type | BOOLEAN | 1 |
| Character data types | Character types | CHAR | n |
| | | CHAR(n) | n |
| | | CHARACTER(n) | n |
| | | NCHAR(n) | n |
| | | VARCHAR(n) | n |
| | | CHARACTER | Actual number of bytes of a character |
| | | VARYING(n) | Actual number of bytes of a character |
| | | VARCHAR2(n) | Actual number of bytes of a character |
| | | NVARCHAR2(n) | Actual number of bytes of a character |

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| | | | |
|---|---|---|---|
| | | TEXT | Actual number of bytes of a character |
| | | CLOB | Actual number of bytes of a character |
| Time data types | Time types | DATE | 8 |
| | | TIME | 8 |
| | | TIMEZ | 12 |
| | | TIMESTAMP | 8 |
| | | TIMESTAMPZ | 8 |
| | | SMALLDATETIME | 8 |
| | | INTERVAL DAY TO SECOND | 16 |
| | | INTERVAL | 16 |
| | | RELTIME | 4 |
| | | ABSTIME | 4 |
| | | TINTERVAL | 12 |

## Database Object Position Functions

- pg_relation_filenode(relation regclass)

  Description: Specifies the ID of a filenode with the specified relationship.

  Return type: oid

  Description: **pg_relation_filenode** receives the OID or name of a table, index, sequence, or compressed table, and returns the **filenode** number allocated to it. **filenode** is the basic component of the file name used by the relationship. For most tables, the result is the same as that of **pg_class.relfilenode**. For the specified system directory, **relfilenode** is **0** and this function must be used to obtain the correct value. If a relationship that is not stored is transmitted, such as a view, this function returns a null value.

- pg_relation_filepath(relation regclass)

  Description: Specifies the name of a file path with the specified relationship.

  Return type: text

  Description: **pg_relation_filepath** is similar to **pg_relation_filenode**, except that **pg_relation_filepath** returns the whole file path name for the relationship (relative to the data directory **PGDATA** of the database cluster).

- get_large_table_name(relfile_node text, threshold_size_gb int8)

  Description: Queries whether the table size (in GB) exceeds the threshold (**threshold_size_gb**) based on the table file code (**relfile_node**). If yes, the schema name and table name (in schemaname.tablename format) are returned, otherwise, null is returned.

  Return type: text

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- pg_filenode_relation(tablespacename, relname)

  Description: Obtains the table names corresponding to the tablespace and relfilenode.

  Return type: regclass

- pg_partition_filenode(partition_oid)

  Description: Obtains **filenode** corresponding to the OID lock of a specified partitioned table.

  Return type: oid

- pg_partition_filepath(partition_oid)

  Description: Specifies the file path name of a partition.

  Return type: text

## Recycle Bin Object Functions

- gs_is_recycle_object(classid, objid, objname)

  Description: Determines whether an object is in the recycle bin. This function is not supported in distributed mode.

  Return type: Boolean

## 12.5.26.9 Advisory Lock Functions

Advisory lock functions manage advisory locks.

- pg_advisory_lock(key bigint)

  Description: Obtains an exclusive session-level advisory lock.

  Return type: void

  Note: **pg_advisory_lock** locks resources defined by an application. The resources can be identified using a 64-bit or two nonoverlapped 32-bit key values. If another session locks the resources, the function blocks the resources until they can be used. The lock is exclusive. Multiple locking requests are pushed into the stack. Therefore, if the same resource is locked three times, it must be unlocked three times so that it is released to another session.

- pg_advisory_lock(key1 int, key2 int)

  Description: Obtains an exclusive session-level advisory lock.

  Return type: void

  Note: Only users with the **sysadmin** permission can add session-level exclusive advisory locks to the key-value pair (65535, 65535).

- pg_advisory_lock(int4, int4, Name)

  Description: Obtains the exclusive advisory lock of a specified database.

  Return type: void

- pg_advisory_lock_shared(key bigint)

  Description: Obtains a shared session-level advisory lock.

  Return type: void

- pg_advisory_lock_shared(key1 int, key2 int)

  Description: Obtains a shared session-level advisory lock.

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Return type: void

Note: **pg_advisory_lock_shared** works in the same way as **pg_advisory_lock**, except the lock can be shared with other sessions requesting shared locks. Only would-be exclusive lockers are locked out.

- pg_advisory_unlock(key bigint)

  Description: Releases an exclusive session-level advisory lock.

  Return type: Boolean

- pg_advisory_unlock(key1 int, key2 int)

  Description: Releases an exclusive session-level advisory lock.

  Return type: Boolean

  Note: **pg_advisory_unlock** releases the obtained exclusive advisory lock. If the release is successful, the function returns **true**. If the lock was not held, it will return **false**. In addition, a SQL warning will be reported by the server.

- pg_advisory_unlock(int4, int4, Name)

  Description: Releases the exclusive advisory lock of a specified database.

  Return type: Boolean

  Note: If the release is successful, **true** is returned. If no lock is held, **false** is returned.

- pg_advisory_unlock_shared(key bigint)

  Description: Releases a shared session-level advisory lock.

  Return type: Boolean

- pg_advisory_unlock_shared(key1 int, key2 int)

  Description: Releases a shared session-level advisory lock.

  Return type: Boolean

  Note: **pg_advisory_unlock_shared** works in the same way as **pg_advisory_unlock**, except it releases a shared session-level advisory lock.

- pg_advisory_unlock_all()

  Description: Releases all advisory locks owned by the current session.

  Return type: void

  Note: **pg_advisory_unlock_all** releases all advisory locks owned by the current session. The function is implicitly invoked when the session ends even if the client is abnormally disconnected.

- pg_advisory_xact_lock(key bigint)

  Description: Obtains an exclusive transaction-level advisory lock.

  Return type: void

- pg_advisory_xact_lock(key1 int, key2 int)

  Description: Obtains an exclusive transaction-level advisory lock.

  Return type: void

  Note: **pg_advisory_xact_lock** works in the same way as **pg_advisory_lock**, except the lock is automatically released at the end of the current transaction and cannot be released explicitly. Only users with the **sysadmin** permission can add transaction-level exclusive advisory locks to the key-value pair (65535, 65535).

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- pg_advisory_xact_lock_shared(key bigint)

  Description: Obtains a shared transaction-level advisory lock.

  Return type: void

- pg_advisory_xact_lock_shared(key1 int, key2 int)

  Description: Obtains a shared transaction-level advisory lock.

  Return type: void

  Note: **pg_advisory_xact_lock_shared** works in the same way as **pg_advisory_lock_shared**, except the lock is automatically released at the end of the current transaction and cannot be released explicitly.

- pg_try_advisory_lock(key bigint)

  Description: Obtains an exclusive session-level advisory lock if available.

  Return type: Boolean

  Note: **pg_try_advisory_lock** is similar to **pg_advisory_lock**, except **pg_try_advisory_lock** does not block the resource until the resource is released. **pg_try_advisory_lock** either immediately obtains the lock and returns **true** or returns **false**, which indicates the lock cannot be performed currently.

- pg_try_advisory_lock(key1 int, key2 int)

  Description: Obtains an exclusive session-level advisory lock if available.

  Return type: Boolean

  Note: Only users with the **sysadmin** permission can add session-level exclusive advisory locks to the key-value pair (65535, 65535).

- pg_try_advisory_lock_shared(key bigint)

  Description: Obtains a shared session-level advisory lock if available.

  Return type: Boolean

- pg_try_advisory_lock_shared(key1 int, key2 int)

  Description: Obtains a shared session-level advisory lock if available.

  Return type: Boolean

  Note: **pg_try_advisory_lock_shared** is similar to **pg_try_advisory_lock**, except **pg_try_advisory_lock_shared** attempts to obtain a shared lock instead of an exclusive lock.

- pg_try_advisory_xact_lock(key bigint)

  Description: Obtains an exclusive transaction-level advisory lock if available.

  Return type: Boolean

- pg_try_advisory_xact_lock(key1 int, key2 int)

  Description: Obtains an exclusive transaction-level advisory lock if available.

  Return type: Boolean

  Note: **pg_try_advisory_xact_lock** works in the same way as **pg_try_advisory_lock**, except the lock, if acquired, is automatically released at the end of the current transaction and cannot be released explicitly. Note: Only users with the **sysadmin** permission can add transaction-level exclusive advisory locks to the key-value pair (65535, 65535).

- pg_try_advisory_xact_lock_shared(key bigint)

  Description: Obtains a shared transaction-level advisory lock if available.

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Return type: Boolean

- pg_try_advisory_xact_lock_shared(key1 int, key2 int)

  Description: Obtains a shared transaction-level advisory lock if available.

  Return type: Boolean

  Note: **pg_try_advisory_xact_lock_shared** works in the same way as **pg_try_advisory_lock_shared**, except the lock, if acquired, is automatically released at the end of the current transaction and cannot be released explicitly.

- lock_cluster_ddl()

  Description: Attempts to obtain a session-level exclusive advisory lock for all active CNs in the cluster.

  Return type: Boolean

  Note: Only users with the **sysadmin** permission can call this function.

- unlock_cluster_ddl()

  Description: Attempts to add a session-level exclusive advisory lock on a CN.

  Return type: Boolean

## 12.5.26.10 Logical Replication Functions

- pg_create_logical_replication_slot('slot_name', 'plugin_name')

  Description: Creates a logical replication slot.

  Parameter description:

  – slot_name

    Indicates the name of the streaming replication slot.

    Value range: a string, supporting only lowercase letters, digits, underscores (_), question marks (?), hyphens (-), and periods (.). One period or two periods cannot be used as the replication slot name.

  – plugin_name

    Indicates the name of the plugin.

    Value range: a string, supporting only **mppdb_decoding**

  Return type: name, text

  Note: The first return value is the slot name, and the second one is the start LSN for decoding in the logical replication slot. Users who call this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

- pg_create_physical_replication_slot('slot_name', 'isDummyStandby')

  Description: Creates a physical replication slot.

  Parameter description:

  – slot_name

    Indicates the name of the streaming replication slot.

    Value range: a string, supporting only lowercase letters, digits, underscores (_), question marks (?), hyphens (-), and periods (.). One period or two periods cannot be used as the replication slot name.

  – isDummyStandby

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Specifies whether the replication slot is created by connecting the standby node to the primary node.

Type: Boolean

Return type: name, text

Note: Users who call this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

- pg_drop_replication_slot('slot_name')

  Description: Deletes a streaming replication slot.

  Parameter description:

  – slot_name

    Indicates the name of the streaming replication slot.

    Value range: a string, supporting only lowercase letters, digits, underscores (_), question marks (?), hyphens (-), and periods (.). One period or two periods cannot be used as the replication slot name.

  Return type: void

  Note: Users who call this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

- pg_logical_slot_peek_changes('slot_name', 'LSN', upto_nchanges, 'options_name', 'options_value')

  Description: Performs decoding but does not go to the next streaming replication slot. (The decoding result will be returned again during the next decoding.)

  Parameter description:

  – slot_name

    Indicates the name of the streaming replication slot.

    Value range: a string, supporting only lowercase letters, digits, underscores (_), question marks (?), hyphens (-), and periods (.). One period or two periods cannot be used as the replication slot name.

  – LSN

    Indicates a target LSN. Decoding is performed only when an LSN is less than or equal to this value.

    Value range: a string, in the format of *xlogid*/*xrecoff*, for example, 1/2AAFC60 (If this parameter is set to a null value, the target LSN indicating the end position of decoding is not specified.)

  – upto_nchanges

    Indicates the number of decoded records (including the **begin** and **commit** timestamps). Assume that there are three transactions, which involve 3, 5, and 7 records, respectively. If **upto_nchanges** is set to **4**, 8 records of the first two transactions will be decoded. Specifically, decoding is stopped when the number of decoded records exceeds the value of **upto_nchanges** after decoding in the first two transactions is complete.

    Value range: a non-negative integer

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NOTE

If any of the **LSN** and **upto_nchanges** values are reached, decoding ends.

- **options**: Specifies optional parameters, consisting of **options_name** and **options_value**.
  - include-xids

    Specifies whether the decoded **data** column contains XID information.

    Valid value: **0** and **1**. The default value is **1**.
    - **0**: The decoded **data** column does not contain XID information.
    - **1**: The decoded **data** column contains XID information.
  - skip-empty-xacts

    Specifies whether to ignore empty transaction information during decoding.

    Valid value: **0** and **1**. The default value is **0**.
    - **0**: The empty transaction information is not ignored during decoding.
    - **1**: The empty transaction information is ignored during decoding.
  - include-timestamp

    Specifies whether decoded information contains the **commit** timestamp.

    Valid value: **0** and **1**. The default value is **0**.
    - **0**: The decoded information does not contain the **commit** timestamp.
    - **1**: The decoded information contains the **commit** timestamp.
  - only-local

    Specifies whether to decode only local logs.

    Valid value: **0** and **1**. The default value is **1**.
    - **0**: Non-local logs and local logs are decoded.
    - **1**: Only local logs are decoded.
  - force-binary

    Specifies whether to output the decoding result in binary format.

    Value range: **0**
    - **0**: The decoding result is output in text format.
  - white-table-list

    Whitelist parameter, including the schema and table name to be decoded.

    Value range: a string that contains table names in the whitelist. Different tables are separated by commas (,). An asterisk (*) is used to fuzzily match all tables. Schema names and table names are separated by periods (.). No space character is allowed. Example:

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**select * from pg_logical_slot_peek_changes('slot1', NULL, 4096, 'white-table-list', 'public.t1,public.t2');**

- max-txn-in-memory

  Memory control parameter. The unit is MB. If the memory occupied by a single transaction is greater than the value of this parameter, data is flushed to disks.

  Value range: an integer ranging from 0 to 100. The default value is **0**, indicating that memory control is disabled.

- max-reorderbuffer-in-memory

  Memory control parameter. The unit is GB. If the total memory (including the cache) of transactions being concatenated in the sender thread is greater than the value of this parameter, the current decoding transaction is flushed to disks.

  Value range: an integer ranging from 0 to 100. The default value is **0**, indicating that memory control is disabled.

Return type: text, xid, text

Note: The function returns the decoding results. Each decoding result contains three columns, corresponding to the above return types and indicating the LSN, XID, and decoded content, respectively. Users who call this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

- pg_logical_slot_get_changes('slot_name', 'LSN', upto_nchanges, 'options_name', 'options_value')

  Description: Performs decoding and goes to the next streaming replication slot.

  Parameter: This function has the same parameters as **pg_logical_slot_peek_changes**. For details, see **•pg_logical_slot_peek_ch...**.

  Note: Users who call this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

- pg_logical_slot_peek_binary_changes('slot_name', 'LSN', upto_nchanges, 'options_name', 'options_value')

  Description: Performs decoding in binary mode and does not go to the next streaming replication slot. (The decoded data can be obtained again during the next decoding.)

  Parameter description:

  – slot_name

    Indicates the name of the streaming replication slot.

    Value range: a string, supporting only lowercase letters, digits, underscores (_), question marks (?), hyphens (-), and periods (.). One period or two periods cannot be used as the replication slot name.

  – LSN

    Indicates a target LSN. Decoding is performed only when an LSN is less than or equal to this value.

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Value range: a string, in the format of *xlogid*/*xrecoff*, for example, 1/2AAFC60 (If this parameter is set to a null value, the target LSN indicating the end position of decoding is not specified.)

– upto_nchanges

Indicates the number of decoded records (including the **begin** and **commit** timestamps). Assume that there are three transactions, which involve 3, 5, and 7 records, respectively. If **upto_nchanges** is set to **4**, 8 records of the first two transactions will be decoded. Specifically, decoding is stopped when the number of decoded records exceeds the value of **upto_nchanges** after decoding in the first two transactions is complete.

Value range: a non-negative integer

NOTE

If any of the **LSN** and **upto_nchanges** values are reached, decoding ends.

– **options**: Specifies optional parameters, consisting of **options_name** and **options_value**.

- include-xids

  Specifies whether the decoded **data** column contains XID information.

  Valid value: **0** and **1**. The default value is **1**.

  - **0**: The decoded **data** column does not contain XID information.
  - **1**: The decoded **data** column contains XID information.

- skip-empty-xacts

  Specifies whether to ignore empty transaction information during decoding.

  Valid value: **0** and **1**. The default value is **0**.

  - **0**: The empty transaction information is not ignored during decoding.
  - **1**: The empty transaction information is ignored during decoding.

- include-timestamp

  Specifies whether decoded information contains the **commit** timestamp.

  Valid value: **0** and **1**. The default value is **0**.

  - **0**: The decoded information does not contain the **commit** timestamp.
  - **1**: The decoded information contains the **commit** timestamp.

- only-local

  Specifies whether to decode only local logs.

  Valid value: **0** and **1**. The default value is **1**.

  - **0**: Non-local logs and local logs are decoded.
  - **1**: Only local logs are decoded.

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  - force-binary

    Specifies whether to output the decoding result in binary format.

    Value range: **0** and **1**. The default value is **0**. The result is output in binary format.

  - white-table-list

    Whitelist parameter, including the schema and table name to be decoded.

    Value range: a string that contains table names in the whitelist. Different tables are separated by commas (,). An asterisk (*) is used to fuzzily match all tables. Schema names and table names are separated by periods (.). No space character is allowed. Example: **select * from pg_logical_slot_peek_binary_changes('slot1', NULL, 4096, 'white-table-list', 'public.t1,public.t2');**

  Return type: text, xid, bytea

  Note: The function returns the decoding results. Each decoding result contains three columns, corresponding to the above return types and indicating the LSN, XID, and decoded content in binary format, respectively. Users who call this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

- pg_logical_slot_get_binary_changes('slot_name', 'LSN', upto_nchanges, 'options_name', 'options_value')

  Description: Performs decoding in binary mode and does not go to the next streaming replication slot.

  Parameter: This function has the same parameters as **pg_logical_slot_peek_binary_changes**. For details, see **•pg_logical_slot_peek_bi...**

  Note: Users who call this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

- pg_replication_slot_advance ('slot_name', 'LSN')

  Description: Directly goes to the streaming replication slot for a specified LSN, without outputting any decoding result.

  Parameter description:

  – slot_name

    Indicates the name of the streaming replication slot.

    Value range: a string, supporting only lowercase letters, digits, underscores (_), question marks (?), hyphens (-), and periods (.). One period or two periods cannot be used as the replication slot name.

  – LSN

    Indicates a target LSN. Next decoding will be performed only in transactions whose commit position is greater than this value. If an input LSN is smaller than the position recorded in the current streaming replication slot, the function is directly returned. If the input LSN is greater than the LSN of the current physical log, the latter LSN will be directly used for decoding.

    Value range: a string, in the format of *xlogid*/*xrecoff*

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Return type: name, text

Note: A return result contains the slot name and LSN that is actually used for decoding. Users who call this function must have the **SYSADMIN** permission or the **REPLICATION** permission, or inherit the **gs_role_replication** permission of the built-in role.

- pg_get_replication_slots()

  Description: Obtains the replication slot list.

  Example:

```
openGauss=# select * from pg_get_replication_slots();
 slot_name |     plugin     | slot_type | datoid | active | xmin | catalog_xmin | restart_lsn |
dummy_standby | confirmed_flush
-----------+----------------+-----------+--------+--------+------+--------------+-------------+---------------
+-----------------
 dn_s1     |                | physical  |      0 | t      |      |              | 0/23DB14E0  | f             |
 slot1     | mppdb_decoding | logical   |  16304 | f      |      |        60966 | 0/1AFA1BB0  | f             |
0/23DA5700
(2 rows)
```

  Return value: text, text, text, oid, boolean, xid, xid, text, boolean, text

- pg_logical_get_area_changes('LSN_start', 'LSN_end', upto_nchanges, 'decoding_plugin', 'xlog_path', 'options_name', 'options_value')

  Description: Specifies an LSN range or an Xlog file for decoding when no DDL operation is performed.

  The constraints are as follows:

  1. When the API is called, only when **wal_level** is set to **logical**, the generated log files can be parsed. If the used Xlog file is not of the logical level, the decoded content does not have the corresponding value and type, and there is no other impact.

  2. The Xlog file can be parsed only by a copy of a fully homogeneous DN to ensure that the metadata corresponding to the data can be found and no DDL or VACUUM FULL operation is performed.

  3. You can find the Xlog to be parsed.

  4. Do not read too many Xlog files at a time. You are advised to read one Xlog file at a time. It is estimated that the memory occupied by one Xlog file is two to three times the size of the Xlog file.

  5. The Xlog file before scale-out cannot be decoded.

  Note: Users who call this function must have the **SYSADMIN** permission or the O&M administrator permission in O&M mode.

  Parameter description:

  – LSN_start

    Specifies the LSN at the start of decoding.

    Value range: a string, in the format of *xlogid*/*xrecoff*, for example, 1/2AAFC60 (If this parameter is set to a null value, the target LSN indicating the end position of decoding is not specified.)

  – LSN_end

    Specifies the LSN at the end of decoding.

    Value range: a string, in the format of *xlogid*/*xrecoff*, for example, 1/2AAFC60 (If this parameter is set to a null value, the target LSN indicating the end position of decoding is not specified.)

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  - upto_nchanges

    Indicates the number of decoded records (including the **begin** and **commit** timestamps). Assume that there are three transactions, which involve 3, 5, and 7 records, respectively. If **upto_nchanges** is set to **4**, 8 records of the first two transactions will be decoded. Specifically, decoding is stopped when the number of decoded records exceeds the value of **upto_nchanges** after decoding in the first two transactions is complete.

    Value range: a non-negative integer

    NOTE

    If any of the **LSN** and **upto_nchanges** values are reached, decoding ends.

  - decoding_plugin

  Decoding plug-in, which is a .so plug-in that specifies the output format of the decoded content.

  Value range: **mppdb_decoding** and **sql_decoding**.

  - xlog_path

  Decoding plug-in, which specifies the Xlog absolute path and file level of the decoding file.

  Value range: **NULL** or a character string of the absolute path of the Xlog file.

  - **options**: This parameter is optional and consists of a series of **options_name** and **options_value**. You can retain the default value. For details, see **pg_logical_slot_peek_changes**.

  Example:

```
openGauss=# SELECT pg_current_xlog_location();
 pg_current_xlog_location
--------------------------
 0/E62E238
(1 row)

openGauss=# create table t1 (a int primary key,b int,c int);
NOTICE:  CREATE TABLE / PRIMARY KEY will create implicit index "t1_pkey" for table "t1"
CREATE TABLE
openGauss=# insert into t1 values(1,1,1);
INSERT 0 1
openGauss=# insert into t1 values(2,2,2);
INSERT 0 1

openGauss=# select data from pg_logical_get_area_changes('0/
E62E238',NULL,NULL,'sql_decoding',NULL);
 location  |  xid  |                      data
-----------+-------+-------------------------------------------------
 0/E62E8D0 | 27213 | COMMIT (at 2022-01-26 15:08:03.349057+08) 3020226
 0/E6325F0 | 27214 | COMMIT (at 2022-01-26 15:08:07.309869+08) 3020234
...
```

- gs_get_parallel_decode_status()

  Description: Monitors the length of the read log queue and decoding result queue of each decoding thread to locate the concurrent decoding performance bottleneck.

  Return type: text, int, text, text, text, int64, int64

  Example:

```
openGauss=# select * from gs_get_parallel_decode_status();
 slot_name | parallel_decode_num | read_change_queue_length  | decode_change_queue_length |
reader_lsn | working_txn_cnt | working_txn_memory
```

```
-----------+---------------------+--------------------------+--------------------------+-----------
+-----------------+--------------------
 slot1     |                   2 | queue0: 1005, queue1: 320 | queue0: 63, queue1: 748    | 0/1DCE2578
|              42 |          192927504
(1 row)
```

Note: In the return values, **slot_name** indicates the replication slot name, **parallel_decode_num** indicates the number of parallel decoder threads in the replication slot, **read_change_queue_length** indicates the current length of the log queue read by each decoder thread, **decode_change_queue_length** indicates the current length of the decoding result queue of each decoder thread, **reader_lsn** indicates the log location read by the reader thread, **working_txn_cnt** indicates the number of transactions being concatenated in the current sender thread, and **working_txn_memory** indicates the total memory (in bytes) occupied by the concatenation transactions in the sender thread.

- pg_replication_origin_create (node_name)

  Description: Creates a replication source with a given external name and returns the internal ID assigned to it.

  Note: Users who call this function must have the **SYSADMIN** permission.

  Parameter description:

  – node_name

    Specifies the name of the replication source to be created.

    Value range: a string, supporting only letters, digits, and the following special characters: _?-.

  Return type: oid

- pg_replication_origin_drop (node_name)

  Description: Deletes a previously created replication source, including any associated replay progress.

  Note: Users who call this function must have the **SYSADMIN** permission.

  Parameter description:

  – node_name

    Specifies the name of the replication source to be deleted.

    Value range: a string, supporting only letters, digits, and the following special characters: _?-.

- pg_replication_origin_oid (node_name)

  Description: Searches for a replication source by name and returns the internal ID. If no such replication source is found, an error is thrown.

  Note: Users who call this function must have the **SYSADMIN** permission.

  Parameter description:

  – node_name

    Specifies the name of the replication source to be queried.

    Value range: a string, supporting only letters, digits, and the following special characters: _?-.

  Return type: oid

- pg_replication_origin_session_setup (node_name)

  Description: Marks the current session for replaying from a given origin, allowing you to trace replay progress. This function can be used only when no

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origin is selected. Run the **pg_replication_origin_session_reset** command to cancel the configuration.

Note: Users who call this function must have the **SYSADMIN** permission.

Parameter description:

– node_name

Specifies the name of the replication source.

Value range: a string, supporting only letters, digits, and the following special characters: _?-.

- pg_replication_origin_session_reset ()

  Description: Cancels the **pg_replication_origin_session_setup()** effect.

  Note: Users who call this function must have the **SYSADMIN** permission.

- pg_replication_origin_session_is_setup ()

  Description: Returns a true value if a replication source is selected in the current session.

  Note: Users who call this function must have the **SYSADMIN** permission.

  Return type: Boolean

- pg_replication_origin_session_progress (flush)

  Description: Returns the replay position of the replication source selected in the current session.

  Note: Users who call this function must have the **SYSADMIN** permission.

  Parameter description:

  – flush

  Specifies whether the corresponding local transaction has been flushed to disks.

  Value range: Boolean

  Return type: LSN

- pg_replication_origin_xact_setup (origin_lsn, origin_timestamp)

  Description: Marks the current transaction as recommitted at a given LSN and timestamp. This function can be called only when **pg_replication_origin_session_setup** is used to select a replication source.

  Note: Users who call this function must have the **SYSADMIN** permission.

  Parameter description:

  – origin_lsn

  Specifies the position for replaying the replication source.

  Value range: LSN

  – origin_timestamp

  Specifies the time when a transaction is committed.

  Value range: timestamp with time zone

- pg_replication_origin_xact_reset ()

  Description: Cancels the **pg_replication_origin_xact_setup()** effect.

  Note: Users who call this function must have the **SYSADMIN** permission.

- pg_replication_origin_advance (node_name, lsn)

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Description:

Sets the replication progress of a given node to a given position. This is primarily used to set the initial position, or to set a new position after a configuration change or similar change.

Note: Improper use of this function may cause inconsistent replication data.

Note: Users who call this function must have the **SYSADMIN** permission.

Parameter description:

- node_name

  Specifies the name of an existing replication source.

  Value range: a string, supporting only letters, digits, and the following special characters: _?-.

- lsn

  Specifies the position for replaying the replication source.

  Value range: LSN

- pg_replication_origin_progress (node_name, flush)

  Description: Returns the position for replaying the given replication source.

  Note: Users who call this function must have the **SYSADMIN** permission.

  Parameter description:

  - node_name

    Specifies the name of the replication source.

    Value range: a string, supporting only letters, digits, and the following special characters: _?-.

  - flush

    Specifies whether the corresponding local transaction has been flushed to disks.

    Value range: Boolean

- pg_show_replication_origin_status()

  Description: Displays the replication status of the replication source.

  Note: Users who call this function must have the **SYSADMIN** permission.

  Return type:

  - **local_id**: OID, which specifies the ID of the replication source.
  - **external_id**: text, which specifies the name of the replication source.
  - **remote_lsn**: LSN of the replication source.
  - **local_lsn**: local LSN.

- pg_get_publication_tables(pub_name)

  Description: Returns the relid list of tables to be published based on the publication name.

  Parameter description:

  - pub_name

    Specifies the name of an existing publication.

    Value range: a string, supporting only letters, digits, and the following special characters: _?-.

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Return type: relid list

- pg_stat_get_subscription(sub_oid oid) → record

  Description:

  Returns the subscription status information after a subscription OID is entered.

  Parameter description:

- subid

  Specifies the OID of a subscription.

  Value range: oid

  Return type:

  - **relid**: OID of the table.
  - **pid**: thread_id, which indicates the thread ID of the background apply/sync thread.
  - **received_lsn**: pg_lsn, which indicates the latest LSN received from the publisher.
  - **last_msg_send_time**: timestamp, which indicates the time when the last message is sent from the publisher.
  - **last_msg_receipt_time**: timestamp, which indicates the time when the last message is received by the subscriber.
  - **latest_end_lsn**: pg_lsn, which indicates the LSN of the publisher when the last keepalive message is received.
  - **latest_end_time**: timstamp, which indicates the time when the last keepalive message is received.

## 12.5.26.11 Segment-Page Storage Functions

- local_segment_space_info(tablespacename TEXT, databasename TEXT)

  Description: Generates usage information about all extent groups in the tablespace of the current node.

  Return type:

| | |
|---|---|
| node_name | Node name |
| extent_size | Extent specifications of an extent group. The unit is the number of blocks. |
| forknum | Fork number |
| total_blocks | Total number of extents in a physical file |
| meta_data_blocks | Number of blocks occupied by the metadata managed in a tablespace, including the space header and map page but excluding the segment head |
| used_data_blocks | Number of extents used for storing data, including the segment head |

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| | |
|---|---|
| utilization | Percentage of the number of used blocks to the total number of blocks, that is, (the value of **used_data_blocks** + the value of **meta_data_block**)/the value of **total_blocks** |
| high_water_mark | High-water mark, indicating the number of allocated extents and maximum physical page number. Blocks that exceed the high-water mark are not used and can be directly recycled. |

Example:

```
select * from local_segment_space_info('pg_default', 'postgres');
     node_name      | extent_size | forknum | total_blocks | meta_data_blocks | used_data_blocks |
utilization | high_water_mark
--------------------+-------------+---------+--------------+------------------+------------------+-------------
+-----------------
 dn_6001_6002_6003 |           1 |       0 |        16384 |             4157 |                1 |     .253784 |
4158
 dn_6001_6002_6003 |           8 |       0 |        16384 |             4157 |                8 |     .254211 |
4165
(2 rows)
```

- global_segment_space_info(tablespacename TEXT, databasename TEXT)

  Description: Returns the usage information of all nodes in the cluster. The effect is similar to that of **local_segment_space_info**.

- pg_stat_segment_extent_usage(int4 tablespace oid, int4 database oid, int4 extent_type, int4 forknum)

  Description: Specifies the usage information of each allocated extent in an extent group returned each time. **extent_type** indicates the type of the extent group. The value is an integer ranging from 1 to 5. If the value is not within the range, an error is reported. **forknum** indicates the fork number. The value is an integer ranging from 0 to 4. Currently, only the following values are valid: **0** for data files, **1** for FSM files, and **2** for visibility map files.

  Return type:

| Name | Description |
|---|---|
| start_block | Start physical page number of an extent |
| extent_size | Size of an extent |
| usage_type | Usage type of an extent, for example, **segment head** and **data extent** |
| ower_location | Object location of an extent to which a pointer points. For example, the owner of a data extent is the head of the segment to which the data extent belongs. |
| special_data | Position of an extent in its owner. The value of this field is related to the usage type. For example, special data of a data extent is the extent ID in the segment to which the data extent belongs. |

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The value of **usage_type** is enumerated. The meaning of each value is as follows:

- **Non-bucket table segment head**: data segment head of a non-hash bucket table
- **Non-bucket table fork head**: Fork segment header of a non-segment-page table
- **Bucket table main head**: primary table segment header of a hash bucket table
- **Bucket table map block**: Map block of a hash bucket table
- **Bucket segment head**: segment head of each bucket in a hash bucket table
- **Data extent**: data block

Example:

```
select * from pg_stat_segment_extent_usage((select oid::int4 from pg_tablespace where
spcname='pg_default'), (select oid::int4 from pg_database where datname='postgres'), 1, 0);
start_block | extent_size |       usage_type       | ower_location | special_data
-------------+-------------+------------------------+---------------+--------------
4157 |           1 | Bucket table main head |    4294967295 |            0
4158 |           1 | Bucket table map block |          4157 |            0
4159 |           1 | Bucket table map block |          4157 |            1
4160 |           1 | Bucket table map block |          4157 |            2
4161 |           1 | Bucket table map block |          4157 |            3
4162 |           1 | Bucket table map block |          4157 |            4
4163 |           1 | Bucket table map block |          4157 |            5
4164 |           1 | Bucket table map block |          4157 |            6
4165 |           1 | Bucket table map block |          4157 |            7
4166 |           1 | Bucket table map block |          4157 |            8
```

- local_space_shrink(tablespacename TEXT, databasename TEXT)

  Description: Shrinks specified physical segment-page space on the current node. Only the currently connected database can be shrank.

  Return value: empty

- gs_space_shrink(int4 tablespace, int4 database, int4 extent_type, int4 forknum)

  Description: Works similar to **local_space_shrink**. That is, shrinks specified physical segment-page space. However, the parameters are different. The input parameters are the OIDs of the tablespace and database, and the value of **extent_type** is an integer ranging from 2 to 5. Note: The value **1** of **extent_type** indicates segment-page metadata. Currently, the physical file that contains the metadata cannot be shrunk. This function is used only by tools. You are not advised to use it directly.

  Return value: empty

- global_space_shrink(tablespacename TEXT, databasename TEXT)

  Description: Compresses segment-page storage space on all DNs in a cluster. This is performed on a CN.

  Note: If **global_space_shrink** locks the cluster. DDL operations cannot be performed. **local_space_shrink** does not lock the cluster.

- pg_stat_remain_segment_info()

  Description: Displays residual extents on the current node due to faults. Residual extents are classified into two types: segments that are allocated but not used and extents that are allocated but not used. The main difference is

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that a segment contains multiple extents. During reclamation, all extents in the segment need to be recycled.

Return type:

| Name | Description |
| --- | --- |
| space_id | Tablespace ID |
| db_id | Database ID |
| block_id | Extent ID |
| type | Extent type. The options are as follows: **ALLOC_SEGMENT**, **DROP_SEGMENT**, and **SHRINK_EXTENT**. |

The values of **type** are described as follows:

- **ALLOC_SEGMENT**: When a user creates a segment-page table and the segment is just allocated but the transaction of creating a table is not committed, the node is faulty. As a result, the segment is not used after being allocated.
- **DROP_SEGMENT**: When a user deletes a segment-page table and the transaction is successfully committed, the bit corresponding to the segment page of the table is not reset and a fault, such as power failure, occurs. As a result, the segment is not used or released.
- **SHRINK_EXTENT**: When a user shrinks a segment-page table and does not release the idle extent, a fault, such as power failure, occurs. As a result, the extent remains and cannot be reused.

Example:

```
select * from pg_stat_remain_segment_info();
space_id | db_id | block_id | type
----------+-------+----------+------
1663     |   16385|       4156| ALLOC_SEGMENT
```

- pg_free_remain_segment(int4 spaceId, int4 dbId, int4 segmentId)

  Description: Releases a specified residual extent. The value must be obtained from the **pg_stat_remain_segment_info** function. The function verifies input values. If the specified extent is not among the recorded residual extents, an error message is returned. If the specified extent is a single extent, the extent is released independently. If it is a segment, the segment and all extents in the segment are released.

  Return value: empty

## 12.5.26.12 Other Functions

- pgxc_pool_check()

  Description: Checks whether the connection data buffered in the pool is consistent with **pgxc_node**.

  Return type: Boolean

- pgxc_pool_reload()

  Description: Updates the connection information buffered in the pool.

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Return type: Boolean

- reload_active_coordinator()

  Description: Updates the connection information buffered in the pool for all active CNs.

  Return type: void

- pgxc_lock_for_backup()

  Description: Locks a cluster for taking backup that would be restored on the new node to be added.

  Return type: Boolean

  NOTE

  **pgxc_lock_for_backup** locks a cluster before **gs_dump** or **gs_dumpall** is used to back up the cluster. After a cluster is locked, operations changing the system structure are not allowed. This function does not affect DML statements.

- pg_pool_validate(clear bool, node_name text)

  Description: Displays invalid connections in the pooler between the CN and node_name. When the value of **clear** is **true**, invalid connections are cleared.

  Return type: record

- pgxc_pool_connection_status()

  Description: Checks whether the pooler connection status is **normal**.

  Return type: Boolean

- pg_nodes_memory()

  Description: Queries the memory usage of all nodes.

  Return type: record

- table_skewness(text)

  Description: Queries the percentage of table data among all nodes.

  Parameter: Indicates that the type of the name of the to-be-queried table is text.

  Return type: record

- table_skewness(text, text, text)

  Description: Queries the percentage of a specified column in the table data among all nodes.

  Parameters: name of the table to be queried, specified column name, and number of records in the specified table. The default value is **0**, indicating that all records are queried. All parameters are of the text type.

  Return type: record

  Return value description: Node ID, number of data rows in a specified column, and percentage of the data volume of the current node to the total data volume

  Example:

  ```
  Return the distribution of the first five rows of data in the a column of the t table on a node.
  openGauss=# select table_skewness('t', 'a',5);
   table_skewness
  ----------------
   (1,3,60.000%)
   (2,2,40.000%)
  (2 rows)
  ```

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```
Return the distribution of all data in the a column of the t table on a node.
openGauss=# select table_skewness('t', 'a');
 table_skewness
----------------
 (1,7,70.000%)
 (2,2,20.000%)
 (0,1,10.000%)
(3 rows)
```

- table_skewness_with_schema(text, text)

  Description: Checks the proportion of table data on all nodes. The function is the same as that of **table_skewness(text)**.

  **text** indicates that the types of the schema name and table name for the table to be queried are both text.

  Return type: record

- table_data_skewness(colrecord, type)

  Description: Queries the node where the table data is located.

  Parameter description:

  **colrecord**: column name record of the table to be queried. The value is of the record type.

  **type**: hash distribution type

  Return type: smallint

  Example:

  ```
  openGauss=# select table_data_skewness(row(index), 'R') from test1;
   table_data_skewness
  ---------------------
                     4
                     3
                     1
                     2
  (4 rows)
  ```

- table_distribution(schemaname text, tablename text)

  Description: Queries the storage space occupied by a specified table on each node.

  **text** indicates that the types of the schema name and table name for the table to be queried are both text.

  Return type: record

  NOTE

  - To query the storage distribution of a specified table by using this function, you must have the SELECT permission for the table.
  - The performance of **table_distribution** is better than that of **table_skewness**. Especially, in a large cluster with a large amount of data, **table_distribution** is recommended. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)
  - When you use **table_distribution** and want to view the space usage, you can use **dnsize** or **(sum(dnsize) over ())** to view the percentage.

- table_distribution()

  Description: Queries the storage distribution of all tables in the current database.

  Return type: record

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NOTE

- This function involves the query for information about all tables in the database. To execute this function, you must have the administrator rights.
- Based on the **table_distribution()** function, GaussDB provides the **15.3.192 PGXC_GET_TABLE_SKEWNESS** view as an alternative way to query data skew. You are advised to use this view when the number of tables in the database is less than 10000.

- plan_seed

  Description: Obtains the seed value of the previous query statement (internal use).

  Return type: int

- pg_stat_get_env

  Description: Obtains the environment variable information of the current node. Only users with the sysadmin or monitor admin permission can access the environment variable information.

  Return type: record

  Example:

```
openGauss=# select pg_stat_get_env();
                                                
```

- pgxc_get_node_env

  Description: Provides the environment variable information about all nodes in a cluster.

  Return type: record

- pgxc_disaster_read_set(text)

  Description: Configures node information about the DR cluster on ETCD. Only the DR cluster is available and can be called only by initial users.

  Return type: Boolean

- pgxc_disaster_read_init

  Description: Initializes readable DR resources and status information. Only the DR cluster is available and can be called only by initial users.

  Return type: Boolean

- pgxc_disaster_read_clear

  Description: Clears readable DR resources and status information. Only the DR cluster is available and can be called only by initial users.

  Return type: Boolean

- pgxc_disaster_read_status

  Description: Provides node information about the DR cluster. This function is available only for the DR cluster.

  Return type: record

- gs_switch_relfilenode

  Description: Exchanges metadata of two tables or partitions. (This is only used for the redistribution tool. An error message is displayed when the function is directly used by users).

  Return type: int

- pg_catalog.plancache_clean()

  Description: Clears the global plan cache that is not used on the current node.

  Return type: Boolean

- DBE_PERF.global_plancache_clean()

  Description: Clears the global plan cache that is not used on all nodes.

  Return type: Boolean

- copy_error_log_create()

  Description: Creates the error table (**public.pgxc_copy_error_log**) required by the COPY FROM error tolerance mechanism.

  Return type: Boolean

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NOTE

- This function attempts to create the **public.pgxc_copy_error_log** table. For details about the table, see **Table 12-56**.
- In addition, it creates a B-tree index on the **relname** column and executes **REVOKE ALL on public.pgxc_copy_error_log FROM public** to manage permissions on the error table (the permissions are the same as those of the COPY statement).
- **public.pgxc_copy_error_log** is a row-store table. Therefore, this function can be executed and COPY error tolerance is available only when row-store tables can be created in the cluster. Row-store tables cannot be created in the cluster if **enable_hadoop_env** is set to **on** (by default, this parameter set to **off** for GaussDB).
- Same as the error table and the COPY statement, the function requires sysadmin or higher permissions.
- If the **public.pgxc_copy_error_log** table or the **copy_error_log_relname_idx** index exists before the function creates it, the function will report an error and roll back.

**Table 12-56** Error table public.pgxc_copy_error_log

| Column | Type | Description |
| --- | --- | --- |
| relname | character varying | Table name in the form of *Schema name*.*Table name* |
| begintime | timestamp with time zone | Time when a data format error was reported |
| filename | character varying | Name of the source data file where a data format error occurs |
| lineno | bigint | Number of the row where a data format error occurs in a source data file |
| rawrecord | text | Raw record of a data format error in the source data file |
| detail | text | Error details |

- pg_stat_get_data_senders()

  Description: Provides detailed information about the data-copy sending thread active at the moment.

  Return type: record
- textlen()

  Description: Provides the method of querying the logical length of text.

  Return type: int
- threadpool_status()

  Description: Displays the status of worker threads and sessions in the thread pool.

  Return type: record
- get_local_active_session()

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Description: Provides sampling records of historical active sessions stored in the memory by current node. Users with the sysadmin or monitor admin permission can view all historical active session records of the current node. Common users can view the historical active session records of the current session.

Return type: record

- dbe_perf.get_global_active_session()

  Description: Provides sampling records of the historical active sessions stored in the memory of all nodes.

  Return type: record

- dbe_perf.get_global_gs_asp(timestamp,timestamp)

  Description: Provides sampling records of the historical active sessions stored in the **gs_asp** system catalog of all nodes.

  Return type: record

- get_wait_event_info()

  Description: Provides detailed information about the wait event.

  Return type: record

- dbe_perf.get_datanode_active_session(text)

  Description: Provides sampling records of historical active sessions stored in the memory of DN, which is queried from CN.

  Return type: record

  Note: This function queries the records in the **local_active_session** view on the target DN and matches the records with those in the **local_active_session** view on all CNs to obtain the query string. Therefore, a large amount of memory is occupied.

- dbe_perf.get_datanode_active_session_hist(text,timestamp,timestamp)

  Description: Provides sampling records of historical active sessions stored in the **gs_asp** system catalog of DN, which is queried from CN.

  Return type: record

  Note: This function queries the **gs_asp** records of a specified period on the target DN. If the period is specified too long, too many records will be queried, which takes a long time.

- generate_wdr_report(bigint, bigint, cstring, cstring,cstring)

  Description: Generates a system diagnosis report based on two snapshots. By default, the initial user or monitor administrator can access the report. The result can be queried only in the system database but cannot be queried in the user database.

  Return type: text

  **Table 12-57** generate_wdr_report parameter description

| Parameter | Description | Range |
| --- | --- | --- |
| begin_snap_id | Snapshot ID that starts the diagnosis report period. | N/A |

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| | | |
|---|---|---|
| end_snap_id | Snapshot ID that ends the diagnosis report period. By default, the value of **end_snap_id** is greater than that of **begin_snap_id**. | N/A |
| report_type | Specifies the type of the generated report. | • **summary**<br>• **detail**<br>• **all**: Both **summary** and **detail** types are included. |
| report_scope | Specifies the scope for a report to be generated. | • **cluster**: database-level information<br>• **node**: node-level information. |
| node_name | • When **report_scope** is set to **node**, set this parameter to the name of the corresponding node.<br>• If **report_scope** is set to **cluster**, this parameter can be omitted or set to **NULL**. | • **node**: node name in GaussDB.<br>• **cluster**: This value is omitted, left blank or set to **NULL**. |

- create_wdr_snapshot()

  Description: Manually generates system diagnosis snapshots. This function requires the sysadmin permission and can be executed only on the CCN.

  Return type: text

- kill_snapshot()

  Description: Kills the WDR snapshot background thread. Users who invoke this function must have the SYSADMIN permission, the REPLICATION permission, or inherit the **gs_role_replication** permission of the built-in role.

  Return type: void

- capture_view_to_json(text,integer)

  Description: Saves the view result to the directory specified by GUC: **perf_directory**. If **is_crossdb** is set to **1**, the view is accessed once for all databases. If the value of **is_crossdb** is **0**, the current database is accessed only once. Only users with the sysadmin or monitor admin permission can execute this function.

  Return type: int

- reset_unique_sql(text,text,bigint)

  Description: Clears the unique SQL statements in the memory of CN/DN. (The sysadmin or monitor admin permission is required.)

  Return type: Boolean

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**Table 12-58** reset_unique_sql parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| scope | text | Clearance scope type. The options are as follows:<br>**'GLOBAL'**: Clears all CNs/DNs. If the value is **'GLOBAL'**, this function can be executed only on the CN.<br>**'LOCAL'**: Clears the current node. |
| clean_type | text | **'BY_USERID'**: Unique SQL statements are cleared based on user IDs.<br>**'BY_CNID'**: Unique SQL statements are cleared based on CN IDs.<br>**'ALL'**: All data is cleared. |
| clean_value | int8 | Clearance value corresponding to the clearance type. If the second parameter is set to **ALL**, the third parameter does not take effect and can be set to any value. |

- wdr_xdb_query(db_name_str text, query text)

  Description: Provides the capability of executing local cross-database queries. For example, when connecting to the Postgres database, access tables in the **test** database. Only the system administrator has the permission to execute this function.

  ```
  select col1 from wdr_xdb_query('dbname=test','select col1 from t1') as dd(col1 int);
  ```

  Return type: record

- pg_wlm_jump_queue(pid int)

  Description: Moves a task to the top of the queue of CN.

  Return type: Boolean

  - **true**: success
  - **false**: failure

- gs_wlm_switch_cgroup(pid int, cgroup text)

  Description: Moves a job to another Cgroup to change the job priority.

  Return type: Boolean

  - **true**: success
  - **false**: failure

- pv_session_memctx_detail(threadid tid, MemoryContextName text)

  Description: Records information about the memory context **MemoryContextName** of the thread **tid** into the *threadid*_**timestamp.log** file in the *$GAUSSLOG*/**pg_log/***${node_name}*/**dumpmem** directory. *threadid* can be obtained from *sessid* in the **PV_SESSION_MEMORY_DETAIL** table. In the officially released version, only the **MemoryContextName** that is an empty string (two single quotation marks indicate that the input is an empty string) is accepted. In this case, all memory context information is recorded.

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Otherwise, no operation is performed. This function can be executed only by the administrator.

Return type: Boolean

- **true**: success
- **false**: failure

- pg_shared_memctx_detail(MemoryContextName text)

  Description: Records information about the memory context **MemoryContextName** into the *threadid*_**timestamp.log** file in the *$GAUSSLOG*/**pg_log**/*${node_name}*/**dumpmem** directory. Calling this function in the officially released version does not involve any operation. Only the administrator can execute this function.

  Return type: Boolean

  - **true**: success
  - **false**: failure

- pv_compute_pool_workload()

  Description: Provides the current load information about computing cluster on cloud. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.)

  Return type: record

- local_bgwriter_stat()

  Description: Displays the information about pages flushed by the bgwriter thread of this instance, number of pages in the candidate buffer chain, and buffer eviction information.

  Return type: record

- local_candidate_stat()

  Description: Displays the number of pages in the candidate buffer chain of this instance and buffer eviction information, including the normal buffer pool and segment buffer pool.

  Return type: record

- local_ckpt_stat()

  Description: Displays the information about checkpoints and flushing pages of the current instance.

  Return type: record

- local_double_write_stat()

  Description: Displays the doublewrite file status of the current instance.

  Return type: record

**Table 12-59** local_double_write_stat parameters

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| curr_dwn | int8 | Sequence number of the doublewrite file |
| curr_start_page | int8 | Start page for restoring the doublewrite file |

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| Parameter | Type | Description |
| --- | --- | --- |
| file_trunc_num | int8 | Number of times that the doublewrite file is reused |
| file_reset_num | int8 | Number of reset times after the doublewrite file is full |
| total_writes | int8 | Total number of I/Os of the doublewrite file |
| low_threshold_writes | int8 | Number of I/Os for writing the doublewrite files with low efficiency (the number of I/O flushing pages at a time is less than 16.) |
| high_threshold_writes | int8 | Number of I/Os for writing the doublewrite file with high efficiency (the number of I/O flushing pages at a time is more than 421.) |
| total_pages | int8 | Total number of pages that are flushed to the doublewrite file area |
| low_threshold_pages | int8 | Number of pages that are flushed with low efficiency |
| high_threshold_pages | int8 | Number of pages that are flushed with high efficiency |
| file_id | int8 | ID of the current doublewrite file |

- local_single_flush_dw_stat()

  Description: Displays the eviction of dual-write files on a single page in the instance.

  Return type: record
- local_pagewriter_stat()

  Description: Displays the page flushing information and checkpoint information of the current instance.

  Return type: record
- local_redo_stat()

  Description: Displays the replay status of the current standby instance.

  Return type: record

  Note: The returned replay status includes the current replay position and the replay position of the minimum restoration point.
- local_recovery_status()

  Description: Displays log flow control information about the primary and standby nodes.

  Return type: record
- local_rto_status()

  Description: Displays log flow control information about the primary and standby nodes.

  Return type: record

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- gs_wlm_node_recover(boolean isForce)

  Description: Recovers nodes after the dynamic load management node is faulty. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only administrators can execute this function. This function is called by the cluster management module. You are not advised to directly call this function.

  Return type: Boolean

- gs_wlm_node_clean(cstring nodename)

  Description: Clears data after the dynamic load management node is faulty. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only administrators can execute this function. This function is called by the cluster management module. You are not advised to directly call this function.

  Return type: Boolean

- gs_cgroup_map_ng_conf(group name)

  Description: Reads the Cgroup configuration file of a specified logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only users with the sysadmin permission can execute this function.

  Return type: record

- pgxc_cgroup_map_ng_conf(group name)

  Description: Reads the Cgroup configuration file of a specified logical cluster on all nodes. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only users with the sysadmin permission can execute this function.

  Return type: Boolean

- gs_wlm_switch_cgroup(sess_id int8, cgroup name)

  Description: Switches the Cgroup of a specified session.

  Return type: record

- comm_client_info()

  Description: Queries active client connections of a single node. For details about the returned result, see **15.3.29 COMM_CLIENT_INFO**.

  Return type: setof record

- pg_sync_cstore_delta(text)

  Description: Synchronizes the delta table structure of a specified column-store table with that of the column-store primary table.

  Return type: bigint

- pg_sync_cstore_delta()

  Description: Synchronizes the delta table structure of all column-store tables with that of the column-store primary table.

  Return type: bigint

- pg_get_flush_lsn()

  Description: Returns the location of the Xlog flushed from the current node.

  Return type: text

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- pg_get_sync_flush_lsn()

  Description: Returns the location of the Xlog flushed by the majority on the current node.

  Return type: text

- gs_create_log_tables()

  Description: Creates foreign tables and views for run logs and performance logs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

  Example:

  ```
  openGauss=# select gs_create_log_tables();
   gs_create_log_tables
  ----------------------

  (1 row)
  ```

  Return type: void

- pgxc_wlm_rebuild_user_resource_pool()

  Description: Rebuilds user and resource pool cache information. Only the system administrator can execute this function.

  Return type: Boolean

- locktag_decode(locktag text)

  Description: Parses lock details from **locktag**.

  Example:

  ```
  openGauss=# select locktag_decode('271b:0:0:0:0:6');
                locktag_decode
  ---------------------------------------------
   locktype:transactionid, transactionid:10011
  (1 row)
  ```

  Return type: text

- disable_conn(disconn_mode text, host text, port integer)

  Description: Specifies that the CM Agent processes commands delivered by the CM Server. When a DN is selected as the primary DN, it is configured to reject connections to all DNs, forcibly connect to a DN, or connect to all DNs in polling mode. Only the initial user and system administrator can call this function.

  Return type: void

  **Table 12-60** disable_conn parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| disconn_mode | text | DN connection mode:<br>• **'prohibit_connection'**: rejects to connect to all DNs.<br>• **'specify_connection'**: forcibly connects to a DN.<br>• **'polling_connection'**: connects to all DNs in polling mode. |
| host | text | IP address of the DN |

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| Parameter | Type | Description |
| --- | --- | --- |
| port | integer | Port number of the DN |

- dbe_perf.get_global_full_sql_by_timestamp(start_timestamp timestamp with time zone, end_timestamp timestamp with time zone)

  Description: Obtains full SQL information about a cluster. The result can be queried only in the system database but cannot be queried in the user database.

  Return type: record

  **Table 12-61** dbe_perf.get_global_full_sql_by_timestamp parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| start_timestamp | timestamp with time zone | Start point of the SQL start time range. |
| end_timestamp | timestamp with time zone | End point of the SQL start time range. |

- dbe_perf.get_global_slow_sql_by_timestamp(start_timestamp timestamp with time zone, end_timestamp timestamp with time zone)

  Description: Obtains cluster-level slow SQL information. The result can be queried only in the system database but cannot be queried in the user database.

  Return type: record

  **Table 12-62** dbe_perf.get_global_slow_sql_by_timestamp parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| start_timestamp | timestamp with time zone | Start point of the SQL start time range. |
| end_timestamp | timestamp with time zone | End point of the SQL start time range. |

- statement_detail_decode(detail text, format text, pretty boolean)

  Description: Parses the **details** column in a full or slow SQL statement. The result can be queried only in the system database but cannot be queried in the user database.

  Return type: text

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**Table 12-63** statement_detail_decode parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| **detail** | text | Set of events generated by the SQL statement (unreadable). |
| format | text | Parsing output format. The value is **plaintext**. |
| pretty | boolean | Whether to display the text in pretty format when **format** is set to **plaintext**. The options are as follows:<br>• The value **true** indicates that **\n** is used to separate events.<br>• The value **false** indicates that events are separated by commas (,). |

- pgxc_get_csn(tid)

  Description: Returns the transaction submission sequence number (CSN) corresponding to a given transaction ID.

  Return type: int8

- pgxc_get_searchlet_info()

  Description: Returns information about Searchlets on all nodes.

  Return type: setof record

  NOTE

  This function is no longer supported in the current version due to specification changes. Do not use this function.

- pgxc_get_searchlet_table_attr_info()

  Description: Returns the attribute information of tables in searchlet on all nodes.

  Return type: setof record

  NOTE

  This function is no longer supported in the current version due to specification changes. Do not use this function.

- get_global_user_transaction()

  Description: Returns transaction information about each user on all nodes.

  Return type: node_name name, usename name, commit_counter bigint, rollback_counter bigint, resp_min bigint, resp_max bigint, resp_avg bigint, resp_total bigint, bg_commit_counter bigint, bg_rollback_counter bigint, bg_resp_min bigint, bg_resp_max bigint, bg_resp_avg bigint, and bg_resp_total bigint

- pg_collation_for

  Description: Returns the sorting rule corresponding to the input parameter string.

  Parameter: any (Explicit type conversion is required for constants.)

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Return type: text

- pgxc_unlock_for_sp_database(name Name)

  Description: Releases a specified database lock.

  Parameter: database name

  Return type: Boolean

- pgxc_lock_for_sp_database(name Name)

  Description: Locks a specified database.

  Parameter: database name

  Return type: Boolean

- pgxc_unlock_for_transfer(name Name)

  Description: Releases the lock used for data transmission (data redistribution).

  Parameter: database name

  Return type: Boolean

- pgxc_lock_for_transfer(name Name)

  Description: Locks the database for data transmission (data redistribution).

  Parameter: database name

  Return type: Boolean

- gs_catalog_attribute_records()

  Description: Returns the definition of each field in a specified system catalog. Only common system catalogs whose OIDs are less than 10000 are supported. Indexes and TOAST tables are not supported.

  Parameter: OID of the system catalog

  Return type: record

- gs_comm_proxy_thread_status()

  Description: Collects statistics on data packets sent and received by the proxy communication library **comm_proxy** when a user-mode network is configured for the cluster. This function is not supported in the current version.

  Parameter: nan

  Return type: record

- dynamic_func_control(scope text, function_name text, action text, "{params}" text[])

  Description: Dynamically enables built-in functions. Currently, only full SQL statements can be dynamically enabled.

  Return type: record

**Table 12-64** Parameter description of dynamic_func_control

| Parameter | Type | Description |
| --- | --- | --- |
| scope | text | Scope where the function is to be dynamically enabled. Currently, only **'GLOBAL'** and **'LOCAL'** are supported. |
| function_name | text | Function name. Currently, only **'STMT'** is supported. |

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| Parameter | Type | Description |
| --- | --- | --- |
| action | text | When **function_name** is set to **'STMT'**, the value of **action** can only be **TRACK**, **UNTRACK**, **LIST**, or **CLEAN**.<br>● **TRACK**: records the full SQL information of normalized SQL statements.<br>● **UNTRACK**: cancels the recording of full SQL information of normalized SQL statements.<br>● **LIST**: lists normalized SQL information that is recorded in the current track.<br>● **CLEAN**: cleans normalized SQL information that is recorded in the current track. |
| params | text[] | When **function_name** is set to **'STMT'**, the parameters corresponding to different actions are set as follows:<br>● TRACK: '{"Normalized SQLID", "L0/L1/L2"}'<br>● UNTRACK: '{"Normalized SQLID"}'<br>● LIST - '{}'<br>● CLEAN - '{}' |

- gs_parse_page_bypath(path text, blocknum bigint, relation_type text, read_memory boolean)

  Description: Parses a specified table page and returns the path for storing the parsed content.

  Return type: text

  Note: Only the system administrator or O&M administrator can execute this function.

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**Table 12-65** gs_parse_page_bypath parameters

| Parameter | Type | Description |
| --- | --- | --- |
| path | text | • For an ordinary table or a segment-page ordinary table, the relative path is *Tablespace name*/*Database OID*/*Relfilenode of the table (physical file name)*. For example, **base/16603/16394**.<br>• For a segment-page hash bucket table, the relative path is *Tablespace name*/*Database OID*/*Logical page number of the segment head*_**b(bucketid)**. For example, **base/16603/16394_b1437**.<br>• You can run the **pg_relation_filepath(table_name text)** command to query the relative path of the table file. To obtain the path of the partitioned table, view the **pg_partition** system catalog and call **pg_partition_filepath(partition_oid)**.<br>• Valid path formats are as follows:<br>– global/relNode<br>– base/dbNode/relNode<br>– pg_tblspc/spcNode/version_dir/dbNode/relNode<br>For hash bucket tables, add **_b(bucketid)** to the end of the path. |
| blocknum | bigint | • **–1**: Information about all blocks (forcibly parsed from disks)<br>• **0-***MaxBlockNumber*: Information about the corresponding block |
| relation_type | text | • **heap**: Astore table<br>• **btree**: B-tree index<br>• **segment**: Segment-page table |
| read_memory | boolean | • **false**: The system parses the page from the disk file.<br>• **true**: The system attempts to parse the page from the shared buffer. If the page does not exist in the shared buffer, the system parses the page from the disk file. |

- gs_xlogdump_lsn(start_lsn text, end_lsn text)

  Description: Parses Xlogs within the specified LSN range and returns the path for storing the parsed content. You can use **pg_current_xlog_location()** to obtain the current Xlog position.

  Parameters: LSN start position and LSN end position

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Return type: text

Note: Only the system administrator or O&M administrator can execute this function.

- gs_xlogdump_xid(c_xid xid)

  Description: Parses Xlogs of a specified XID and returns the path for storing the parsed content. You can use **txid_current()** to obtain the current XID.

  Parameter: XID

  Return type: text

  Note: Only the system administrator or O&M administrator can execute this function.

- gs_xlogdump_tablepath(path text, blocknum bigint, relation_type text)

  Description: Parses logs corresponding to a specified table page and returns the path for storing the parsed content.

  Return type: text

  Note: Only the system administrator or O&M administrator can execute this function.

**Table 12-66** gs_xlogdump_tablepath parameters

| Parameter | Type | Description |
| --- | --- | --- |
| path | text | • For an ordinary table or a segment-page ordinary table, the relative path is *Tablespace name*/*Database OID*/*Relfilenode of the table (physical file name)*. For example, **base/16603/16394**.<br>• For a segment-page hash bucket table, the relative path is *Tablespace name*/*Database OID*/*Logical page number of the segment head*_**b(bucketid)**. For example, **base/16603/16394_b1437**.<br>• You can run the **pg_relation_filepath(table_name text)** command to query the relative path of the table file. To obtain the path of the partitioned table, view the **pg_partition** system catalog and call **pg_partition_filepath(partition_oid)**.<br>• Valid path formats are as follows:<br>– global/relNode<br>– base/dbNode/relNode<br>– pg_tblspc/spcNode/version_dir/dbNode/relNode<br>For hash bucket tables, add **_b(bucketid)** to the end of the path. |

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| Parameter | Type | Description |
| --- | --- | --- |
| blocknum | bigint | • **–1**: Information about all blocks (forcibly parsed from disks)<br>• **0-***MaxBlockNumber*: Information about the corresponding block |
| relation_type | text | • **heap**: Astore table<br>• **btree**: B-tree index<br>• **segment**: Segment-page table |

- gs_xlogdump_parsepage_tablepath(path text, blocknum bigint, relation_type text, read_memory boolean)

  Description: Parses the specified table page and logs corresponding to the table page and returns the path for storing the parsed content. It can be regarded as one execution of **gs_parse_page_bypath** and **gs_xlogdump_tablepath**. The prerequisite for executing this function is that the table file exists. To view logs of deleted tables, call **gs_xlogdump_tablepath**.

  Return type: text

  Note: Only the system administrator or O&M administrator can execute this function.

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**Table 12-67** gs_xlogdump_parsepage_tablepath parameters

| Parameter | Type | Description |
| --- | --- | --- |
| path | text | • For an ordinary table or a segment-page ordinary table, the relative path is *Tablespace name*/*Database OID*/*Relfilenode of the table (physical file name)*. For example, **base/16603/16394**.<br>• For a segment-page hash bucket table, the relative path is *Tablespace name*/*Database OID*/*Logical page number of the segment head*_**b(bucketid)**. For example, **base/16603/16394_b1437**.<br>• You can run the **pg_relation_filepath(table_name text)** command to query the relative path of the table file. To obtain the path of the partitioned table, view the **pg_partition** system catalog and call **pg_partition_filepath(partition_oid)**.<br>• Valid path formats are as follows:<br>– global/relNode<br>– base/dbNode/relNode<br>– pg_tblspc/spcNode/version_dir/dbNode/relNode<br>For hash bucket tables, add **_b(bucketid)** to the end of the path. |
| blocknum | bigint | • **–1**: Information about all blocks (forcibly parsed from disks)<br>• **0-***MaxBlockNumber*: Information about the corresponding block |
| relation_type | text | • **heap**: Astore table<br>• **btree**: B-tree index<br>• **segment**: Segment-page table |
| read_memory | boolean | • **false**: The system parses the page from the disk file.<br>• **true**: The system attempts to parse the page from the shared buffer. If the page does not exist in the shared buffer, the system parses the page from the disk file. |

- gs_index_recycle_queue(Oid oid, int type, uint32 blkno)
  Description: Parses the UB-tree index recycling queue information.
  Return type: record

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**Table 12-68** gs_index_recycle_queue parameters

| Parameter | Type | Description |
| --- | --- | --- |
| oid | Oid | • Index file **relfilenode**, which can be queried using **select relfilenode from pg_class where relname='***name***'**, where *name* indicates the name of the index file. |
| type | int | • **0** indicates that the entire queue to be recycled is parsed.<br>• **1** indicates that the entire empty page queue is parsed.<br>• **2** indicates that a single page is parsed. |
| blkno | uint32 | ID of the recycling queue page. This parameter is valid only when **type** is set to **2**. The value of **blkno** ranges from 1 to 4294967294. |

NOTE

This function is not supported in the distributed version. An error message will be displayed if it is used in the distributed version.

- gs_stat_wal_entrytable(int64 idx)

  Description: Exports the content of the WAL insertion status table in the Xlog.

  Return type: record

**Table 12-69** gs_stat_wal_entrytable parameters

| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Input parameter | idx | int64 | • **–1**: queries all elements in an array.<br>• **0-***Maximum value*: content of a specific array element. |
| Output parameter | idx | uint64 | Records the subscripts in the corresponding array. |
| Output parameter | endlsn | uint64 | Records the LSN label. |

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| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Output parameter | lrc | int32 | Records the corresponding LRC. |
| Output parameter | status | uint32 | Specifies whether the Xlog corresponding to the current entry has been completely copied to the WAL buffer.<br>• **0**: Not copied.<br>• **1**: Copied |

- gs_walwriter_flush_position()

  Description: Outputs the refresh position of WALs.

  Return type: record

  **Table 12-70** gs_walwriter_flush_position parameters

| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Output parameter | last_flush_status_entry | int32 | Subscript index obtained after the Xlog flushes the tblEntry of the last flushed disk. |
| Output parameter | last_scanned_lrc | int32 | LRC obtained after the Xlog flushes the last tblEntry scanned last time. |
| Output parameter | curr_lrc | int32 | Latest LRC usage in the WALInsertStatusEntry status table. The LRC indicates the LRC value corresponding to the WALInsertStatusEntry when the next Xlog record is written. |
| Output parameter | curr_byte_pos | uint64 | The latest Xlog position after the Xlog is written to the WAL file, which is also the next Xlog insertion point. |
| Output parameter | prev_byte_size | uint32 | Length of the previous Xlog record. |

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| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Output parameter | flush_result | uint64 | Position of the current global Xlog flush. |
| Output parameter | send_result | uint64 | Xlog sending position on the current host. |
| Output parameter | shm_rqst_write_pos | uint64 | Write position of the LogwrtRqst request in the XLogCtl recorded in the shared memory. |
| Output parameter | shm_rqst_flush_pos | uint64 | Flush position of the LogwrtRqst request in the XLogCtl recorded in the shared memory. |
| Output parameter | shm_result_write_pos | uint64 | Write position of the LogwrtResult request in the XLogCtl recorded in the shared memory. |
| Output parameter | shm_result_flush_pos | uint64 | Flush position of the LogwrtResult request in the XLogCtl recorded in the shared memory. |
| Output parameter | curr_time | text | Current time. |

- gs_walwriter_flush_stat(int operation)

  Description: Collects statistics on the frequency of writing and synchronizing WALs, data volume, and Xlog file information.

  Return type: record

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**Table 12-71** gs_walwriter_flush_stat parameters

| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Input parameter | operation | int | • **–1**: Disables the statistics function. (Default value)<br>• **0**: Enables the statistics function.<br>• **1**: Queries statistics.<br>• **2**: Resets statistics. |
| Output parameter | write_times | uint64 | Number of times that the Xlog calls the **write** API. |
| Output parameter | sync_times | uint64 | Number of times that the Xlog calls the **sync** API. |
| Output parameter | total_xlog_sync_bytes | uint64 | Total number of backend thread requests for writing data to Xlogs. |
| Output parameter | total_actual_xlog_sync_bytes | uint64 | Total number of Xlogs that call the **sync** API for disk flushing. |
| Output parameter | avg_write_bytes | uint32 | Number of Xlogs written each time the **XLogWrite** API is called. |
| Output parameter | avg_actual_write_bytes | uint32 | Number of Xlogs written each time the **write** API is called. |
| Output parameter | avg_sync_bytes | uint32 | Average number of Xlogs for requesting the **sync** API each time. |
| Output parameter | avg_actual_sync_bytes | uint32 | Actual number of Xlogs for disk flushing by calling the **sync** API each time. |
| Output parameter | total_write_time | uint64 | Total time for calling the **write** API (unit: μs). |

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| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Output parameter | total_sync_time | uint64 | Total time for calling the **sync** API (unit: μs). |
| Output parameter | avg_write_time | uint32 | Average time for calling the **write** API each time (unit: μs). |
| Output parameter | avg_sync_time | uint32 | Average time for calling the **sync** API each time (unit: μs). |
| Output parameter | curr_init_xlog_segno | uint64 | ID of the latest Xlog segment file. |
| Output parameter | curr_open_xlog_segno | uint64 | ID of the Xlog segment file that is being written. |
| Output parameter | last_reset_time | text | Time when statistics were last collected. |
| Output parameter | curr_time | text | Current time. |

- pg_ls_tmpdir()

  Description: Returns the name, size, and last modification time of each file in the temporary directory (**pgsql_tmp**) of the default tablespace.

  Parameter: nan

  Return type: record

  Note: Only the system administrator or monitoring administrator can execute this function.

| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Output parameter | name | text | File name |
| Output parameter | size | int8 | File size (unit: byte) |

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| | | | |
|---|---|---|---|
| Output parameter | modification | timestamptz | Last file modification time |

- pg_ls_tmpdir(oid)

  Description: Returns the name, size, and last modification time of each file in the temporary directory (**pgsql_tmp**) of the specified tablespace.

  Parameter: oid

  Return type: record

  Note: Only the system administrator or monitoring administrator can execute this function.

| Category | Parameter | Type | Description |
|---|---|---|---|
| Input parameter | oid | oid | Tablespace ID |
| Output parameter | name | text | File name |
| Output parameter | size | int8 | File size (unit: byte) |
| Output parameter | modification | timestamptz | Last file modification time |

- pg_ls_waldir()

  Description: Returns the name, size, and last modification time of each file in the WAL directory.

  Parameter: nan

  Return type: record

  Note: Only the system administrator or monitoring administrator can execute this function.

| Category | Parameter | Type | Description |
|---|---|---|---|
| Output parameter | name | text | File name |
| Output parameter | size | int8 | File size (unit: byte) |
| Output parameter | modification | timestamptz | Last file modification time |

- gs_undo_dump_xid(undo_xid xid)

  Description: Parses undo records based on the XID.

  Return type: record

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**Table 12-72** gs_undo_dump_xid parameter description

| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Input parameter | undo_xid | xid | XID |
| Output parameter | undoptr | xid | Start position of the undo record to be parsed |
| Output parameter | xactid | text | XID |
| Output parameter | cid | text | Command ID |
| Output parameter | reloid | text | Relation OID |
| Output parameter | relfilenode | text | Relfinode of the file |
| Output parameter | utype | text | Undo record type |
| Output parameter | blkprev | text | Position of the previous undo record in the same block |
| Output parameter | blockno | text | Block number |
| Output parameter | uoffset | text | Undo record offset |
| Output parameter | prevurp | text | Position of the previous undo record |
| Output parameter | payloadlen | text | Length of the undo record data |
| Output parameter | oldxactid | text | Previous XID |

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| Category | Parameter | Type | Description |
| --- | --- | --- | --- |
| Output parameter | partitionoid | text | Partition OID |
| Output parameter | tablespace | text | Tablespace |
| Output parameter | alreadyread_bytes | text | Length of the read undo record |
| Output parameter | prev_undorec_len | text | Length of the previous undo record |
| Output parameter | td_id | text | ID of the transaction directory |
| Output parameter | reserved | text | Whether to save the information |
| Output parameter | flag | text | Flag 1 |
| Output parameter | flag2 | text | Flag 2 |
| Output parameter | t_hoff | text | Length of the undo record data header |

- gs_write_term_log(void)

  Description: Writes a log to record the current **term** value of a DN. The standby DN returns **false**. After the data is successfully written to the primary DN, **true** is returned.

  Return type: Boolean

## 12.5.27 Statistics Information Functions

Statistics information functions are divided into the following two categories: functions that access a database by using the OID of each table or index in the database to mark the database for which statistics are generated; functions that access a server identified by the server process ID whose value ranges from 1 to the number of currently active servers.

- pg_stat_get_db_conflict_tablespace(oid)

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Description: Specifies the number of queries canceled due to a conflict between the restored tablespace and the deleted tablespace in the database.

Return type: bigint

- pg_control_group_config()

  Description: Prints Cgroup configurations on the current node. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pg_stat_get_db_stat_reset_time(oid)

  Description: Specifies the most recent time when database statistics were reset. It is initialized to the system time during the first connection to each database. The reset time is updated when you call **pg_stat_reset** in the database and execute **pg_stat_reset_single_table_counters** on any table or index in the database.

  Return type: timestamptz

- pg_stat_get_function_total_time(oid)

  Description: Specifies the total wall clock time spent on the function, in microseconds. The time spent on this function call is included.

  Return type: bigint

- pg_stat_get_xact_tuples_returned(oid)

  Description: Specifies the number of rows read through sequential scans when parameters are in a table in the current transaction or the number of index entries returned when parameters are in an index.

  Return type: bigint

- pg_stat_get_xact_numscans(oid)

  Description: Specifies the number of sequential scans performed when parameters are in a table in the current transaction or the number of index scans performed when parameters are in an index.

  Return type: bigint

- pg_stat_get_xact_blocks_fetched(oid)

  Description: Specifies the number of disk block fetch requests for a table or an index in the current transaction.

  Return type: bigint

- pg_stat_get_xact_blocks_hit(oid)

  Description: Specifies the number of disk block fetch requests for a table or an index found in cache in the current transaction.

  Return type: bigint

- pg_stat_get_xact_function_calls(oid)

  Description: Specifies the number of times the function is called in the current transaction.

  Return type: bigint

- pg_stat_get_xact_function_self_time(oid)

  Description: Specifies the time spent only on this function in the current transaction. The time spent on this function call is not included.

  Return type: bigint

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- pg_stat_get_xact_function_total_time(oid)

  Description: Specifies the total wall clock time spent on this function in the current transaction, in microseconds. The time spent on this function call is included.

  Return type:

- pg_lock_status()

  Description: Queries information about locks held by open transactions. All users can execute this function.

  Return type: For details, see the return result of **15.3.126 PG_LOCKS**, which is obtained by querying this function.

- pg_stat_get_wal_senders()

  Description: Queries WAL sender information on the primary node.

  Return type: setofrecord

- pgxc_get_senders_catchup_time()

  Description: Queries whether a standby DN in the log catchup state exists in the CN instance query cluster and details about the log catchup state.

  Return type: setofrecord

- pg_stat_get_stream_replications()

  Description: Queries the primary-standby replication status.

  Return type: setofrecord

- pg_stat_get_db_numbackends(oid)

  Description: Specifies the number of active server processes in a database.

  Return type: integer

- pg_stat_get_db_xact_commit(oid)

  Description: Specifies the number of transactions committed in a database.

  Return type: bigint

- pg_stat_get_db_xact_rollback(oid)

  Description: Specifies the number of transactions rolled back in a database.

  Return type: bigint

- pg_stat_get_db_blocks_fetched(oid)

  Description: Specifies the number of disk block fetch requests in a database.

  Return type: bigint

- pg_stat_get_db_blocks_hit(oid)

  Description: Specifies the number of disk block fetch requests found in cache in a database.

  Return type: bigint

- pg_stat_get_db_tuples_returned(oid)

  Description: Specifies the number of tuples returned for a database.

  Return type: bigint

- pg_stat_get_db_tuples_fetched(oid)

  Description: Specifies the number of tuples fetched for a database.

  Return type: bigint

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- pg_stat_get_db_tuples_inserted(oid)

  Description: Specifies the number of tuples inserted into a database.

  Return type: bigint

- pg_stat_get_db_tuples_updated(oid)

  Description: Specifies the number of tuples updated in a database.

  Return type: bigint

- pg_stat_get_db_tuples_deleted(oid)

  Description: Specifies the number of tuples deleted from a database.

  Return type: bigint

- pg_stat_get_db_conflict_lock(oid)

  Description: Specifies the number of lock conflicts in a database.

  Return type: bigint

- pg_stat_get_db_deadlocks(oid)

  Description: Specifies the number of deadlocks in a database.

  Return type: bigint

- pg_stat_get_numscans(oid)

  Description: Specifies the number of rows read by sequential scans if parameters are in a table, or the number of index rows if parameters are in an index.

  Return type: bigint

- pg_stat_get_role_name(oid)

  Description: Obtains the username based on the user OID. Only users with the **sysadmin** or **monitor admin** permission can access the information.

  Return type: text

  Example:

  ```
  openGauss=# select pg_stat_get_role_name(10);
   pg_stat_get_role_name
  -----------------------
   aabbcc
  (1 row)
  ```

- pg_stat_get_tuples_returned(oid)

  Description: Specifies the number of rows read by sequential scans if parameters are in a table, or the number of index rows if parameters are in an index.

  Return type: bigint

- pg_stat_get_tuples_fetched(oid)

  Description: Specifies the number of table rows fetched by bitmap scans if parameters are in a table, or the number of table rows fetched by simple index scans if parameters are in an index.

  Return type: bigint

- pg_stat_get_tuples_inserted(oid)

  Description: Specifies the number of rows inserted into a table.

  Return type: bigint

- pg_stat_get_tuples_updated(oid)

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Description: Specifies the number of rows updated in a table.

Return type: bigint

- pg_stat_get_tuples_deleted(oid)

  Description: Specifies the number of rows deleted from a table.

  Return type: bigint

- pg_stat_get_tuples_changed(oid)

  Description: Specifies the total number of inserted, updated, and deleted rows after a table was last analyzed or autoanalyzed.

  Return type: bigint

- pg_stat_get_tuples_hot_updated(oid)

  Description: Specifies the number of rows hot updated in a table.

  Return type: bigint

- pg_stat_get_live_tuples(oid)

  Description: Specifies the number of live rows in a table.

  Return type: bigint

- pg_stat_get_dead_tuples(oid)

  Description: Specifies the number of dead rows in a table.

  Return type: bigint

- pg_stat_get_blocks_fetched(oid)

  Description: Specifies the number of disk block fetch requests for a table or an index.

  Return type: bigint

- pg_stat_get_blocks_hit(oid)

  Description: Specifies the number of disk block requests found in cache for a table or an index.

  Return type: bigint

- pg_stat_get_partition_tuples_inserted(oid)

  Description: Specifies the number of rows inserted into the corresponding table partition.

  Return type: bigint

- pg_stat_get_partition_tuples_updated(oid)

  Description: Specifies the number of rows updated in the corresponding table partition.

  Return type: bigint

- pg_stat_get_partition_tuples_deleted(oid)

  Description: Specifies the number of rows deleted from the corresponding table partition.

  Return type: bigint

- pg_stat_get_partition_tuples_changed(oid)

  Description: Specifies the total number of inserted, updated, and deleted rows after a table partition was last analyzed or autoanalyzed.

  Return type: bigint

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- pg_stat_get_partition_live_tuples(oid)

  Description: Specifies the number of live rows in a table partition.

  Return type: bigint
- pg_stat_get_partition_dead_tuples(oid)

  Description: Specifies the number of dead rows in a table partition.

  Return type: bigint
- pg_stat_get_xact_tuples_fetched(oid)

  Description: Specifies the number of tuple rows scanned in a transaction.

  Return type: bigint
- pg_stat_get_xact_tuples_inserted(oid)

  Description: Specifies the number of tuples inserted into the active subtransactions related to a table.

  Return type: bigint
- pg_stat_get_xact_tuples_deleted(oid)

  Description: Specifies the number of tuples deleted from the active subtransactions related to a table.

  Return type: bigint
- pg_stat_get_xact_tuples_hot_updated(oid)

  Description: Specifies the number of tuples hot updated in the active subtransactions related to a table.

  Return type: bigint
- pg_stat_get_xact_tuples_updated(oid)

  Description: Specifies the number of tuples updated in the active subtransactions related to a table.

  Return type: bigint
- pg_stat_get_xact_partition_tuples_inserted(oid)

  Description: Specifies the number of tuples inserted into the active subtransactions related to a table partition.

  Return type: bigint
- pg_stat_get_xact_partition_tuples_deleted(oid)

  Description: Specifies the number of tuples deleted from the active subtransactions related to a table partition.

  Return type: bigint
- pg_stat_get_xact_partition_tuples_hot_updated(oid)

  Description: Specifies the number of tuples hot updated in the active subtransactions related to a table partition.

  Return type: bigint
- pg_stat_get_xact_partition_tuples_updated(oid)

  Description: Specifies the number of tuples updated in the active subtransactions related to a table partition.

  Return type: bigint
- pg_stat_get_last_vacuum_time(oid)

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Description: Specifies the most recent time when the user manually cleared a table or when the autovacuum thread was started to clear a table.

Return type: timestamptz

- pg_stat_get_last_autovacuum_time(oid)

  Description: Specifies the most recent time when the autovacuum daemon was started to clear a table.

  Return type: timestamptz

- pg_stat_get_vacuum_count(oid)

  Description: Specifies the number of times a table is manually cleared by the user.

  Return type: bigint

- pg_stat_get_autovacuum_count(oid)

  Description: Specifies the number of times the autovacuum daemon is started to clear a table.

  Return type: bigint

- pg_stat_get_last_analyze_time(oid)

  Description: Specifies the most recent time when the user manually analyzed a table or when the autovacuum thread was started to analyze a table.

  Return type: timestamptz

- pg_stat_get_last_autoanalyze_time(oid)

  Description: Specifies the most recent time when the autovacuum daemon was started to analyze a table.

  Return type: timestamptz

- pg_stat_get_analyze_count(oid)

  Description: Specifies the number of times a table is manually analyzed by the user.

  Return type: bigint

- pg_stat_get_autoanalyze_count(oid)

  Description: Specifies the number of times a table is analyzed by the autovacuum daemon.

  Return type: bigint

- pg_total_autovac_tuples(bool)

  Description: Returns tuple records related to the total autovac, such as **nodename**, **nspname**, **relname**, and tuple IUDs. The input parameters specify whether to query **relation** and **local** information, respectively.

  Return type: setofrecord

- pg_autovac_status(oid)

  Description: Returns autovac information, such as **nodename**, **nspname**, **relname**, **analyze**, **vacuum**, thresholds for the ANALYZE and VACUUM operations, and the number of analyzed or vacuumed tuples. Only users with the **sysadmin** permission can use this function.

  Return type: setofrecord

- pg_autovac_timeout(oid)

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Description: Returns the number of consecutive timeouts during the autovac operation on a table. If the table information is invalid or the node information is abnormal, **NULL** is returned.

Return type: bigint

- pg_autovac_coordinator(oid)

  Description: Returns the name of the CN performing the autovac operation on a table. If the table information is invalid or the node information is abnormal, **NULL** is returned.

  Return type: text

- pg_stat_get_last_data_changed_time(oid)

  Description: Returns the time when INSERT, UPDATE, DELETE, or EXCHANGE/TRUNCATE/DROP PARTITION was performed last time on a table. The data in the **last_data_changed** column of the **15.3.149 PG_STAT_ALL_TABLES** view is calculated by using this function. The performance of obtaining the last modification time by using the view is poor when the table has a large amount of data. In this case, you are advised to use this function.

  Return type: timestamptz

- pg_stat_set_last_data_changed_time(oid)

  Description: Manually changes the time when INSERT, UPDATE, DELETE, or EXCHANGE/TRUNCATE/DROP PARTITION was performed last time on a table.

  Return type: void

- pg_backend_pid()

  Description: Specifies the thread ID of the server thread attached to the current session.

  Return type: integer

- pg_stat_get_activity(integer)

  Description: Returns a record about the background process with the specified PID. A record for each active background process in the system is returned if **NULL** is specified. The returned result does not contain the **connection_info** column. The initial user, system administrators, and users with the **monadmin** permission can view all data. Common users can query only their own data.

  Example:

```
openGauss=# select * from pg_stat_get_activity(139881386280704);
 datid |       pid       | sessionid | usesysid | application_name | state  |
query                      | waiting |          xact_start           |          query_start          |
    backend_start         |         state_change          | client_addr | client_hostname | client_port | enqueue
|     query_id      |   srespool   | global_sessionid | unique_sql_id | trace_id
-------+-----------------+-----------+----------+------------------+--------
+-----------------------------------------------------+---------+-------------------------------
+---------------------------------+-----
-------------------------+-----------------------------+-------------+-----------------+-------------+---------
+------------------+--------------+-----------------+---------------+----------
 16545 | 139881386280704 |        69 |       10 | gsql             | active | select * from
pg_stat_get_activity(139881386280704); | f       | 2022-01-18 19:43:05.167718+08 | 2022-01-18
19:43:05.167718+08 | 2022
-01-18 19:42:33.513507+08 | 2022-01-18 19:43:05.16773+08 |              |                 |          -1 |         |
72620543991624410 | default_pool | 1938253334#69#0  |    3751941862 |
(1 row)
```

  Return type: setofrecord

- pg_stat_get_activity_with_conninfo(integer)

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Description: Returns a record about the background process with the specified PID. A record for each active background process in the system is returned if **NULL** is specified. The initial user, system administrators, and users with the **monadmin** permission can view all data. Common users can query only their own data.

```
openGauss=# select * from pg_stat_get_activity_with_conninfo(139881386280704);
 datid |       pid       | sessionid | usesysid | application_name | state  |
query                              | waiting |          xact_start           |          query_start
       |         backend_start         |         state_change          | client_addr | client_hostname | client_port
| enqueue |     query_id      |
      connection_info                                                       |   srespool   | global_sessionid |
unique_sql_id | trace_id
-------+-----------------+-----------+----------+------------------+--------
+-----------------------------------------------------------------------+---------+-------------------------------
+----------------------
--------+--------------------------------+-------------------------------+-------------+-----------------
+-------------+---------+-------------------+-------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------+--------------
+-----------------+---------------+----------
 16545 | 139881386280704 |        69 |       10 | gsql             | active | select * from
pg_stat_get_activity_with_conninfo(139881386280704); | f       | 2022-01-18 19:45:20.125433+08 |
2022-01-18 19:45:20.12
5433+08 | 2022-01-18 19:42:33.513507+08 | 2022-01-18 19:45:20.125469+08 |             |
|          -1 |         | 72620543991624470 | {"driver_name":"libpq","driver_version":"(GaussDB Vxxx
RxxxCxx build 5dde2050) compiled at 2022-01-11 14:38:20 commit 3320 last mr 7176 debug"} |
default_pool | 1938253334:69#0  |    3858105710 |
(1 row)
```

Return type: setofrecord

- pg_stat_get_activity_ng(integer)

  Description: Returns a record about the active backend thread with the specified PID. A record for each active backend thread is returned if **NULL** is specified. System administrators and users with the **monadmin** permission can view all data. Common users can query only their own data.

  Return type: setofrecord

  The following table describes return fields.

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | Database OID |
| pid | bigin it | Background thread ID |
| sessioni d | bigin it | Session ID |
| node_gr oup | text | Logical cluster of the user to which the data belongs (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

- pg_user_iostat(text)

  Description: Displays the I/O load management information about the job currently executed by the user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

  Return type: record

  The following table describes return fields.

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| Name | Type | Description |
| --- | --- | --- |
| userid | oid | User ID |
| min_curr_iops | int4 | Minimum I/O of the current user across each DN. The IOPS is counted by ones for column storage and by ten thousands for row storage. |
| max_curr_iops | int4 | Maximum I/O of the current user across each DN. The IOPS is counted by ones for column storage and by ten thousands for row storage. |
| min_peak_iops | int4 | Minimum peak I/O of the current user across each DN. The IOPS is counted by ones for column storage and by ten thousands for row storage. |
| max_peak_iops | int4 | Maximum peak I/O of the current user across each DN. The IOPS is counted by ones for column storage and by ten thousands for row storage. |
| io_limits | int4 | I/O limit set for the resource pool specified by the user. The IOPS is counted by ones for column storage and by ten thousands for row storage. |
| io_priority | text | I/O priority set by the user. The IOPS is counted by ones for column storage and by ten thousands for row storage. |
| curr_io_limits | int4 | Real-time value of **io_limits** when **io_priority** is used to control I/Os |

- pg_stat_get_function_calls(oid)

  Description: Specifies the number of times the function has been called.

  Return type: bigint

- pg_stat_get_function_self_time(oid)

  Description: Specifies the time spent on only this function. The time spent on nested functions to call other functions is excluded.

  Return type: bigint

- pg_stat_get_backend_idset()

  Description: Sets the number of currently active server processes (from 1 to the number of active server processes).

  Return type: setofinteger

- pg_stat_get_backend_pid(integer)

  Description: Specifies the ID of the given server thread.

  Return type: bigint

- pg_stat_get_backend_dbid(integer)

  Description: Specifies the ID of the database connected to the given server process.

  Return type: oid

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- pg_stat_get_backend_userid(integer)

  Description: Specifies the user ID of the given server process. This function can be called only by the system administrator.

  Return type: oid

- pg_stat_get_backend_activity(integer)

  Description: Queries the current activity of the given server process. The query result can be obtained only when the user who calls this function is a system administrator or the same user as that of the session being queried and **track_activities** is enabled.

  Return type: text

- pg_stat_get_backend_waiting(integer)

  Description: Returns a true value if the given server process is waiting for a lock, but only when the user who calls this function is a system administrator or the same user as that of the session being queried and **track_activities** is enabled.

  Return type: Boolean

- pg_stat_get_backend_activity_start(integer)

  Description: Specifies the time when the given server process's currently executing query is started only when the user who calls this function is a system administrator or the same user as that of the session being queried and **track_activities** is enabled.

  Return type: timestamp with time zone

- pg_stat_get_backend_xact_start(integer)

  Description: Specifies the time when the given server process's currently executing transaction is started only when the user who calls this function is a system administrator or the same user as that of the session being queried and **track_activities** is enabled.

  Return type: timestamp with time zone

- pg_stat_get_backend_start(integer)

  Description: Specifies the time when the given server process is started. If the current user is neither a system administrator nor the same user as that of the session being queried, **NULL** is returned.

  Return type: timestamp with time zone

- pg_stat_get_backend_client_addr(integer)

  Description: Specifies the IP address of the client connected to the given server process. If the connection is over a Unix domain socket, or if the current user is neither a system administrator nor the same user as that of the session being queried, **NULL** is returned.

  Return type: inet

- pg_stat_get_backend_client_port(integer)

  Description: Specifies the TCP port number of the client connected to the given server process. If the connection is over a Unix domain socket, **–1** is returned. If the current user is neither a system administrator nor the same user as that of the session being queried, **NULL** is returned.

  Return type: integer

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- pg_stat_get_bgwriter_timed_checkpoints()

  Description: Specifies the time when the background writer starts scheduled checkpoints (because the time specified by **checkpoint_timeout** has expired).

  Return type: bigint

- pg_stat_get_bgwriter_requested_checkpoints()

  Description: Specifies the time when the background writer starts checkpoints based on requests from the backend because the value specified by **checkpoint_segments** has been exceeded or the **CHECKPOINT** command has been executed.

  Return type: bigint

- pg_stat_get_bgwriter_buf_written_checkpoints()

  Description: Specifies the number of buffers written by the background writer during checkpoints.

  Return type: bigint

- pg_stat_get_bgwriter_buf_written_clean()

  Description: Specifies the number of buffers written by the background writer for routine cleaning of dirty pages.

  Return type: bigint

- pg_stat_get_bgwriter_maxwritten_clean()

  Description: Specifies the time when the background writer stops its cleaning scan because it has written more buffers than those specified by the **bgwriter_lru_maxpages** parameter.

  Return type: bigint

- pg_stat_get_buf_written_backend()

  Description: Specifies the number of buffers written by the backend process because a new buffer needs to be allocated.

  Return type: bigint

- pg_stat_get_buf_alloc()

  Description: Specifies the total number of the allocated buffers.

  Return type: bigint

- pg_stat_clear_snapshot()

  Description: Discards the current statistics snapshot. Only users with the **sysadmin** or **monitoradmin** permission can execute this function.

  Return type: void

- pg_stat_reset()

  Description: Resets all statistics counters for the current database to zero (requiring system administrator permissions).

  Return type: void

- gs_stat_reset()

  Description: Resets all statistics counters for the current database on each node to zero (requiring system administrator permissions).

  Return type: void

- pg_stat_reset_shared(text)

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Description: Resets all statistics counters for the current database on each node in a shared cluster to zero (requiring system administrator permissions).

Return type: void

- pg_stat_reset_single_table_counters(oid)

  Description: Resets statistics on a single table or index in the current database to zero (requiring system administrator permissions).

  Return type: void

- pg_stat_reset_single_function_counters(oid)

  Description: Resets statistics on a single function in the current database to zero (requiring system administrator permissions).

  Return type: void

- pg_stat_session_cu(int, int, int)

  Description: Obtains the compression unit (CU) hit statistics on sessions running on the current node.

  Return type: record

- gs_get_stat_session_cu(text, int, int, int)

  Description: Obtains the CU hit statistics on all sessions running in a cluster.

  Return type: record

- gs_get_stat_db_cu(text, text, bigint, bigint, bigint)

  Description: Obtains the CU hit statistics on a database in a cluster.

  Return type: record

- pg_stat_get_cu_mem_hit(oid)

  Description: Obtains the number of memory CU hits of a column-store table in the current database on the current node.

  Return type: bigint

- pg_stat_get_cu_hdd_sync(oid)

  Description: Obtains the times CU is synchronously read from a disk by a column-store table in the current database on the current node.

  Return type: bigint

- pg_stat_get_cu_hdd_asyn(oid)

  Description: Obtains the times CU is asynchronously read from a disk by a column-store table in the current database on the current node.

  Return type: bigint

- pg_stat_get_db_cu_mem_hit(oid)

  Description: Obtains the number of memory CU hits in a database on the current node.

  Return type: bigint

- pg_stat_get_db_cu_hdd_sync(oid)

  Description: Obtains the times CU is synchronously read from a disk in a database on the current node.

  Return type: bigint

- pgxc_get_wlm_current_instance_info(text, int default null)

  Description: Queries the current resource usage of each node in a cluster on a CN and reads the data that is not stored in the

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**GS_WLM_INSTANCE_HISTORY** system catalog in the memory. The input parameters are the node name (**ALL**, **C**, **D**, or *Instance name*) and the maximum number of records returned by each node. The return value is **GS_WLM_INSTANCE_HISTORY**.

Return type: setofrecord

- pgxc_get_wlm_history_instance_info(text, TIMESTAMP, TIMESTAMP, int default null)

  Description: Queries the historical resource usage in a cluster on a CN and reads data from the **GS_WLM_INSTANCE_HISTORY** system catalog. The input parameters are the node name (**ALL**, **C**, **D**, or *Instance name*), start time, end time, and maximum number of records returned by each instance. The return value is **GS_WLM_INSTANCE_HISTORY**.

  Return type: setofrecord

- pg_stat_get_db_cu_hdd_asyn(oid)

  Description: Obtains the times CU is asynchronously read from a disk in a database on the current node.

  Return type: bigint

- pgxc_fenced_udf_process(integer)

  Description: Displays the number of UDF master and worker processes. Only users with the **sysadmin** or **monadmin** permission can execute this function. If the input parameter is set to **1**, the number of master processes is queried. If the input parameter is set to **2**, the number of worker processes is queried. If the input parameter is set to **3**, all worker processes are killed.

  Return type: text

- fenced_udf_process()

  Description: Displays the number of local UDF master and worker processes.

  Return type: record

- total_cpu()

  Description: Obtains the CPU time used by the current node, in jiffies.

  Return type: bigint

- total_memory()

  Description: Obtains the size of the virtual memory used by the current node, in KB.

  Return type: bigint

- pgxc_terminate_all_fenced_udf_process()

  Description: Kills all UDF worker processes. Only users with the **sysadmin** or **monadmin** permission can execute this function.

  Return type: Boolean

- GS_ALL_NODEGROUP_CONTROL_GROUP_INFO(text)

  Description: Provides Cgroup information for all logical clusters. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Before calling this function, you need to specify the name of the logical cluster to be queried. For example, to query the Cgroup information for the **'installation'** logical cluster, run the following command:

  ```
  SELECT * FROM GS_ALL_NODEGROUP_CONTROL_GROUP_INFO('installation')
  ```

  Return type: record

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The following table describes return fields.

| Name | Type | Description |
| --- | --- | --- |
| name | text | Cgroup name |
| type | text | Cgroup type |
| gid | bigint | Cgroup ID |
| classgid | bigint | ID of the class Cgroup to which a workload Cgroup belongs |
| class | text | Class Cgroup |
| workload | text | Workload Cgroup |
| shares | bigint | CPU quota allocated to a Cgroup |
| limits | bigint | Limit of CPUs allocated to a Cgroup |
| wdlevel | bigint | Workload Cgroup level |
| cpucores | text | Usage of CPU cores in a Cgroup |

- gs_get_nodegroup_tablecount(name)

  Description: Obtains the total number of user tables in all databases in a logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

  Return type: integer

- pgxc_max_datanode_size(name)

  Description: Obtains the maximum disk space occupied by database files on all DNs in a logical cluster. The unit is byte. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

  Return type: bigint

- gs_check_logic_cluster_consistency()

  Description: Checks whether the system information of all logical clusters in the system is consistent. If no record is returned, the information is consistent. Otherwise, the node group information on CNs and DNs in the logical cluster is inconsistent. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) This function cannot be called during redistribution in scale-in or scale-out.

  Return type: record

- gs_check_tables_distribution()

  Description: Checks whether the user table distribution in the system is consistent. If no record is returned, table distribution is consistent. This function cannot be called during redistribution in scale-in or scale-out.

  Return type: record

- pg_stat_bad_block(text, int, int, int, int, int, timestamp with time zone, timestamp with time zone)

  Description: Obtains damage information about pages or CUs after the current node is started.

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Return type: record

- pgxc_stat_bad_block(text, int, int, int, int, int, timestamp with time zone, timestamp with time zone)

  Description: Obtains damage information about pages or CUs after all nodes in the cluster are started.

  Return type: record

- pg_stat_bad_block_clear()

  Description: Deletes the page or CU damage information that is read and recorded on the node (requiring system administrator permissions).

  Return type: void

- pgxc_stat_bad_block_clear

  Description: Deletes the page or CU damage information that is read and recorded on all nodes in the cluster (requiring system administrator permissions).

  Return type: void

- pgxc_log_comm_status(void)

  Description: When the TCP proxy communication is used, the PGXC system view exports the communication layer status of DNs to each log file.

  Return type: void

- gs_respool_exception_info(pool text)

  Description: Queries the query rule of a specified resource pool.

  Return type: record

- gs_control_group_info(pool text)

  Description: Queries information about Cgroups associated with a resource pool. Only users with the **sysadmin** permission can execute this function.

  Return type: record

  The following information is displayed:

| Attribute | Value | Description |
| --- | --- | --- |
| name | class_a:workload_a1 | Class name and workload name |
| class | class_a | Class Cgroup name |
| workload | workload_a1 | Workload Cgroup name |
| type | DEFWD | Cgroup type (**Top**, **CLASS**, **BAKWD**, **DEFWD**, or **TSWD**) |
| gid | 87 | Cgroup ID |
| shares | 30 | Percentage of CPU resources to those on the parent node |
| limits | 0 | Percentage of CPU cores to those on the parent node |
| rate | 0 | Allocation ratio in Timeshare |

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| Attribute | Value | Description |
| --- | --- | --- |
| cpucores | 0-3 | Number of CPU cores |

- gs_all_control_group_info()

  Description: Collects information about all Cgroups in the database. For details about the columns returned by the function, see **16.3.48 GS_ALL_CONTROL_GROUP_INFO**.

  Return type: record

- gs_get_control_group_info()

  Description: Collects information about all Cgroups. For details about the columns returned by the function, see **16.3.53 GS_GET_CONTROL_GROUP_INFO**. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- get_instr_workload_info(integer)

  Description: Obtains the transaction volume and time information on the current CN.

  Return type: record

| Attribute | Value | Description |
| --- | --- | --- |
| user_oid | 10 | User ID |
| commit_counter | 4 | Number of frontend transactions that were committed |
| rollback_counter | 1 | Number of frontend transactions that were rolled back |
| resp_min | 949 | Minimum response time of frontend transactions (unit: μs) |
| resp_max | 201891 | Maximum response time of frontend transactions (unit: μs) |
| resp_avg | 43564 | Average response time of frontend transactions (unit: μs) |
| resp_total | 217822 | Total response time of frontend transactions (unit: μs) |
| bg_commit_counter | 910 | Number of background transactions that were committed |
| bg_rollback_counter | 0 | Number of background transactions that were rolled back |

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| Attribute | Value | Description |
| --- | --- | --- |
| bg_resp_min | 97 | Minimum response time of background transactions (unit: μs) |
| bg_resp_max | 678080687 | Maximum response time of background transactions (unit: μs) |
| bg_resp_avg | 327847884 | Average response time of background transactions (unit: μs) |
| bg_resp_total | 298341575300 | Total response time of background transactions (unit: μs) |

- pv_instance_time()

  Description: Obtains the time consumed in each key phase on the current node.

  Return type: record

| Stat_name Attribute | Value | Description |
| --- | --- | --- |
| DB_TIME | 1062385 | Total end-to-end wall time consumed by all threads (unit: μs) |
| CPU_TIME | 311777 | Total CPU time consumed by all threads (unit: μs) |
| EXECUTION_TIME | 380037 | Total time consumed on the executor (unit: μs) |
| PARSE_TIME | 6033 | Total time consumed for parsing SQL statements (unit: μs) |
| PLAN_TIME | 173356 | Total time consumed for generating an execution plan (unit: μs) |
| REWRITE_TIME | 2274 | Total time consumed for rewriting queries (unit: μs) |
| PL_EXECUTION_TIME | 0 | Total time consumed for executing PL/SQL statements (unit: μs) |
| PL_COMPILATION_TIME | 557 | Total time consumed for compiling SQL statements (unit: μs) |
| NET_SEND_TIME | 1673 | Total time consumed for sending data over the network (unit: μs) |

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| Stat_name Attribute | Value | Description |
| --- | --- | --- |
| DATA_IO_TIME | 426622 | Total time consumed for reading and writing data (unit: μs) |

- DBE_PERF.get_global_instance_time()

  Description: Provides the time consumed in each key phase in the entire cluster. The time consumed can be queried only on the CN.

  Return type: record

- get_instr_unique_sql()

  Description: Obtains information about execution statements (normalized SQL statements) on the current node. Only users with the **sysadmin** or **monitor admin** permission can query this function.

  Return type: record

- get_instr_wait_event(integer)

  Description: Obtains the statistics on wait events on the current node.

  Return type: record

- get_instr_user_login()

  Description: Obtains the number of user login and logout times on the current node. Only users with the **sysadmin** or **monitor admin** permission can query this function.

  Return type: record

- get_instr_rt_percentile(integer)

  Description: Obtains the response time distribution for 80% and 95% SQL statements in the CCN. The unified cluster information is stored on the CCN. The query result from other nodes is **0**.

  Return type: record

- get_node_stat_reset_time()

  Description: Obtains statistics on reset (restart, primary-standby switchover, and database deletion) time of the current node.

  Return type: record

- gs_session_memory_detail_tp()

  Description: Collects statistics on thread memory usage by the MemoryContext node. When **enable_thread_pool** is set to **on**, this view contains memory usage of all threads and sessions.

  Return type: record

- create_wlm_operator_info(int flag)

  Description: Clears top SQL operator-level statistics recorded in the current memory. If the input parameter is greater than 0, the information is archived to **gs_wlm_operator_info** and **gs_wlm_ec_operator_info**. Otherwise, the information is not archived. Only users with the **sysadmin** permission can execute this function.

  Return type: int

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- create_wlm_session_info(int flag)

  Description: Clears top SQL query statement-level statistics recorded in the current memory. If the input parameter is greater than 0, the information is archived to **gs_wlm_session_query_info_all**. Otherwise, the information is not archived. Only users with the **sysadmin** permission can execute this function.

  Return type: int

- pg_stat_get_wlm_session_info(int flag)

  Description: Obtains top SQL query statement-level statistics recorded in the current memory. If the input parameter is not 0, the information is cleared from the memory. Only users with the **system admin** or **monitor admin** permission can execute this function.

  Return type: record

- gs_paxos_stat_replication()

  Description: Queries the standby node information on the primary node. Currently, the distributed mode is not supported.

- get_paxos_replication_info()

  Description: Queries the primary-standby replication information. Currently, the distributed mode is not supported.

- gs_wlm_get_resource_pool_info(int)

  Description: Obtains the resource usage statistics of all users. The input parameter is of the int type and can be any int value or **NULL**.

  Return type: record

- gs_wlm_get_all_user_resource_info()

  Description: Obtains the resource usage statistics of all users. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- gs_wlm_get_user_info(int)

  Description: Obtains information about all users. The input parameter is of the int type and can be any int value or **NULL**. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- gs_wlm_get_workload_records()

  Description: Obtains all job information in dynamic load management. This function is valid only when dynamic load management is enabled. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

  Return type: record

- gs_wlm_persistent_user_resource_info()

  Description: Archives all user resource usage statistics to the **gs_wlm_user_resource_history** system catalog. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- gs_wlm_readjust_user_space(oid)

  Description: Corrects the storage space usage of all users. Only the administrator can execute this function.

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Return type: record

- gs_wlm_readjust_user_space_through_username(text name)

  Description: Corrects the storage space usage of a specified user. Common users can use this function to correct only their own storage space usage. Only the administrator can correct the storage space usage of all users. If the value of **name** is **0000**, the storage space usage of all users needs to be corrected.

  Return type: record

- gs_wlm_readjust_user_space_with_reset_flag(text name, boolean isfirst)

  Description: Corrects the storage space usage of a specified user. If the input parameter **isfirst** is set to **true**, statistics are collected from 0. Otherwise, statistics are collected from the previous result. Common users can use this function to correct only their own storage space usage. Only the administrator can correct the storage space usage of all users. If the value of **name** is **0000**, the storage space usage of all users needs to be corrected.

  Return type: record

- gs_wlm_session_respool(bigint)

  Description: Obtains the session resource pool information about all backend threads. The input parameter is of the bigint type and can be set to any bigint value or **NULL**.

  Return type: record

- gs_total_nodegroup_memory_detail

  Description: Returns statistics on memory usage of the logical cluster in the current database, in the unit of MB. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

  NOTE

  If **enable_memory_limit** is set to **off**, this function cannot be used.

  Return type: setof record

**Table 12-73** Return value description

| Name | Type | Description |
| --- | --- | --- |
| ngname | text | Name of the logical cluster |

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| Name | Type | Description |
| --- | --- | --- |
| memorytype | text | Memory type. The value must be one of the following:<br>• **ng_total_memory**: total memory of the logical cluster<br>• **ng_used_memory**: memory usage of the logical cluster<br>• **ng_estimate_memory**: estimated memory usage of the logical cluster<br>• **ng_foreignrp_memsize**: total memory of the external resource pool of the logical cluster<br>• **ng_foreignrp_usedsize**: memory usage of the external resource pool of the logical cluster<br>• **ng_foreignrp_peaksize**: peak memory usage of the external resource pool of the logical cluster<br>• **ng_foreignrp_mempct**: percentage of the external resource pool of the logical cluster to the total memory of the logical cluster<br>• **ng_foreignrp_estmsize**: estimated memory usage of the external resource pool of the logical cluster |
| memorymbytes | integer | Size of allocated memory |

- gs_io_wait_status()

  Description: Returns the real-time statistics on I/O control on the current node.

  Return type: setof record

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| device_name | text | Name of the data disk mounted to the node |
| read_per_second | float | Number of read operations completed per second |
| write_per_second | float | Number of write operations completed per second |
| write_ratio | float | Ratio of the disk write I/Os to the total I/Os |
| io_util | float | Percentage of the I/O time to the total CPU time per second |
| total_io_util | integer | Level of the CPU time occupied by the last three I/Os. The value ranges from 0 to 6. |

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| Name | Type | Description |
| --- | --- | --- |
| tick_count | integer | Interval for updating disk I/O information. The value is fixed to 1 second. The value is cleared each time before data is read. |
| io_wait_list_len | integer | Size of the I/O request thread wait queue. If the value is **0**, no I/O is under control. |

- gs_get_shared_memctx_detail(text)

  Description: Returns the memory allocation details of the specified memory context, including the file, line number, and size of each memory allocation (the size of the same line in the same file is accumulated). Only the memory context queried through the **pg_shared_memory_detail** view can be queried. The input parameter is the memory context name (that is, the **contextname** column in the result returned by the **pg_shared_memory_detail** view). Only users with the sysadmin or monitor admin permission can query this function.

  Return type: setof record

| Name | Type | Description |
| --- | --- | --- |
| file | text | Name of the file where the memory is allocated to |
| line | int8 | Line number of the code in the file where the memory is allocated to |
| size | int8 | Size of the allocated memory. The value is accumulated if the memory is allocated for multiple times to the same line in the same file. |

  NOTE

  This view is not supported in the Lite release version.

- gs_get_session_memctx_detail(text)

  Description: Returns the memory allocation details of the specified memory context, including the file, line number, and size of each memory allocation (the size of the same line in the same file is accumulated). This function is valid only in thread pool mode. Only the memory context queried through the **pv_session_memory_context** view can be queried. The input parameter is the memory context name (that is, the **contextname** column in the result returned by the **pv_session_memory_context** view). Only users with the sysadmin or monitor admin permission can query this function.

  Return type: setof record

| Name | Type | Description |
| --- | --- | --- |
| file | text | Name of the file where the memory is allocated to |

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| Name | Type | Description |
| --- | --- | --- |
| line | int8 | Line number of the code in the file where the memory is allocated to |
| size | int8 | Size of the allocated memory, in bytes. The value is accumulated if the memory is allocated for multiple times to the same line of the same file. |

NOTE

This view takes effect only in thread pool mode and is not supported in the Lite release version.

- gs_get_thread_memctx_detail(tid,text)

  Description: Returns the memory allocation details of the specified memory context, including the file, line number, and size of each memory allocation (the size of the same line in the same file is accumulated). Only the memory context queried through the **pv_thread_memory_context** view can be queried. The first input parameter is the thread ID (the **tid** column of the data returned by **pv_thread_memory_context**), and the second parameter is the memory context name (the **contextname** column of the data returned by **pv_thread_memory_context**). Only users with the sysadmin or monitor admin permission can query this function.

  Return type: setof record

| Name | Type | Description |
| --- | --- | --- |
| file | text | Name of the file where the memory is allocated to |
| line | int8 | Line number of the code in the file where the memory is allocated to |
| size | int8 | Size of the allocated memory, in bytes. The value is accumulated if the memory is allocated for multiple times to the same line of the same file. |

NOTE

This view is not supported in the Lite release version.

- gs_get_history_memory_detail(cstring)

  Description: Queries historical memory snapshot information. The input parameter type is cstring. The value can be **NULL** or the name of the memory snapshot log file.

  a. If the value of the input parameter is **NULL**, the list of all memory snapshot log files on the current node is displayed.

  b. If the value of the input parameter is the name of the memory snapshot log file in the list queried in **a**, the detailed information about the memory snapshot recorded in the log file is displayed.

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c. If you enter any other input parameter, the system displays a message indicating that the input parameter is incorrect or the file fails to be opened.

Only users with the sysadmin or monitor admin permission can query this function.

Return type: text

| Name | Type | Description |
| --- | --- | --- |
| memory_info | text | Memory information. If the input parameter of the function is set to **NULL**, the memory snapshot file list is displayed. If the input parameter is set to the name of the memory snapshot file, the content of the file is displayed. |

- gs_stat_get_hotkeys_info()

  NOTE

  If the GUC parameter **enable_hotkeys_collection** is set to **off**, the **gs_stat_get_hotkeys_info** and **global_stat_get_hotkeys_info** functions as well as the **global_stat_hotkeys_info** view cannot be queried. The use of the **gs_stat_clean_hotkeys** and **global_stat_clean_hotkeys** interfaces is not affected.

  Description: Obtains the hotspot key statistics on the current node.

  Return type: record

```
openGauss=# select * from gs_stat_get_hotkeys_info() order by count, hash_value;
 database_name | schema_name |     table_name     | key_value | hash_value | count
---------------+-------------+--------------------+-----------+------------+-------
 regression    | public      | hotkey_single_col | {22}      | 1858004829 |     2
 regression    | public      | hotkey_single_col | {11}      | 2011968649 |     2
(2 rows)
```

  Table 1 Return value description

| Name | Type | Description |
| --- | --- | --- |
| database_name | text | Name of the database where the hotspot key is located |
| schema_name | text | Name of the schema where the hotspot key is located |
| table_name | text | Name of the table where the hotspot key is located |
| key_value | text | Value of the hotspot key |
| hash_value | bigint | Hash value of the hotspot key in the database. If the table is a list or range distribution table, the value of this field is **0**. |
| count | bigint | Frequency of accessing the hotspot key |

- gs_stat_clean_hotkeys()

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NOTE

- Hotspot key detection is designed for high-concurrency and heavy-traffic scenarios. In the scenario where the access is performed for several times, the clearing query result may be inaccurate.
- The clearing interface is designed to clear only the statistics in the LRU queue but not the historical data in the FIFO. Therefore, if the historical key value in the FIFO is accessed again after the clearing, the historical key value is still processed as a hotspot key. This rule also applies to **global_stat_clean_hotkeys**.

Description: Clears statistics on hotspot keys on the current node.

Return type: Boolean

```
openGauss=# select * from gs_stat_clean_hotkeys();
 gs_stat_clean_hotkeys
-----------------------
 t
(1 row)
```

- global_stat_get_hotkeys_info()

  NOTE

  Run the **select * from global_stat_hotkeys_info minus select * from global_stat_get_hotkeys_info()** command during service execution. The value may not be **0** due to time difference.

  Description: Obtains statistics on hotspot keys in the entire cluster.

  Return type: record

```
openGauss=# select * from global_stat_get_hotkeys_info() order by count, hash_value;
 database_name | schema_name |    table_name     | key_value | hash_value | count
---------------+-------------+-------------------+-----------+------------+-------
 regression    | public      | hotkey_single_col | {22}      | 1858004829 |     2
 regression    | public      | hotkey_single_col | {11}      | 2011968649 |     2
(2 rows)
```

- global_stat_clean_hotkeys()

  Description: Clears statistics on hotspot keys in the entire cluster.

  Return type: Boolean

```
openGauss=# select * from global_stat_clean_hotkeys();
 global_stat_clean_hotkeys
-----------------------
 t
(1 row)
```

- global_comm_get_recv_stream()

  Description: Obtains the status of the stream received by all communication libraries on all DNs. For details about the columns returned by the function, see **15.3.116 PG_COMM_RECV_STREAM**.

  Return type: record

- global_comm_get_send_stream()

  Description: Obtains the status of the stream sent by all communication libraries on all DNs. For details about the columns returned by the function, see **15.3.117 PG_COMM_SEND_STREAM**.

  Return type: record

- global_comm_get_status()

  Description: Obtains the communication library status on all DNs. For details about the columns returned by the function, see **15.3.118 PG_COMM_STATUS**.

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Return type: record

- global_comm_client_info()

  Description: Obtains information about active client connections of global nodes. For details about the columns returned by the function, see **15.3.29 COMM_CLIENT_INFO**.

  Return type: record

- global_comm_get_client_info()

  Description: Obtains information about client connections of global nodes. For details about the columns returned by the function, see **15.3.29 COMM_CLIENT_INFO**.

  Return type: record

- pgxc_get_wlm_ec_operator_history()

  Description: Displays the operator information when the execution of ExtensionConnector (EC) jobs cached on all CNs is complete. The information is cleared every 3 minutes. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pgxc_get_wlm_ec_operator_info()

  Description: Displays the operator information when the execution of EC jobs on all CNs is complete. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pgxc_get_wlm_ec_operator_statistics()

  Description: Displays the operator information when EC jobs on all CNs are being executed. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pgxc_get_wlm_operator_history()

  Description: Displays the operator information when the execution of jobs cached on all CNs is complete. The information is cleared every 3 minutes. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pgxc_get_wlm_operator_info()

  Description: Displays the operator information when the execution of jobs on all CNs is complete. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pgxc_get_wlm_operator_statistics()

  Description: Displays the operator information when jobs on all CNs are being executed. Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pgxc_get_wlm_session_history()

  Description: Displays the load management information when the execution of jobs cached on all CNs is complete. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The

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information is cleared every 3 minutes. Only users with the **sysadmin** permission can execute this function.

Return type: record

- pgxc_get_wlm_session_info()

  Description: Displays the load management information when the execution of jobs cached on all CNs is complete. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pgxc_get_wlm_session_info_bytime(tag text, begin timestamp, end timestamp, limit int)

  Description: Displays load management information of jobs whose start or end time is within a time range on all CNs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only users with the **sysadmin** permission can execute this function.

  Parameter description:

  **tag**: The value can only be **'start_time'** or **'finish_time'**, indicating that the query is restricted by the start time or end time of the job.

  **begin**: start time of a time range

  **end**: end time of a time range

  **limit**: number of returned records

  Return type: record

- pgxc_get_wlm_session_statistics()

  Description: Displays load management information when jobs on all CNs are being executed. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only users with the **sysadmin** permission can execute this function.

  Return type: record

- pgxc_stat_activity()

  Description: Displays information about all CNs in the current cluster queried by the current user. Only users with the **sysadmin** or **monitor admin** permission can execute this function, and common users can view only their own information.

  Return type: record

| Name | Type | Description |
| --- | --- | --- |
| coorname | text | Name of a CN in the current cluster |
| datid | oid | OID of the database that the user session connects to in the background |
| datname | text | Name of the database that the user session connects to in the background |
| pid | bigint | Backend thread ID |
| sessionid | bigint | Session ID |

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| Name | Type | Description |
| --- | --- | --- |
| usesysid | oid | OID of the user logged in to the background |
| usename | text | Name of the user logged in to the background |
| application_name | text | Name of the application connected to the background |
| client_addr | inet | IP address of the client connected to the background. If this column is null, it indicates either that the client is connected via a Unix socket on the server machine or that this is an internal process, such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column is not null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with the background (**–1** if a Unix socket is used) |
| backend_start | timestamp with time zone | Time when this process was started, that is, when the client connected to the server |
| xact_start | timestamp with time zone | Time when the current transaction was started (null if no transactions are active) If the current query is the first of its transaction, the value of this column is the same as that of the **query_start** column. |
| query_start | timestamp with time zone | Time when the currently active query was started, or time when the last query was started if the value of **state** is not **active** |
| state_change | timestamp with time zone | Time when **state** was last modified |
| waiting | boolean | Whether the background is currently waiting for a lock. If it is, the value is **true**. |

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| Name | Type | Description |
| --- | --- | --- |
| enqueue | text | Queuing state of a statement.<br>Possible values are:<br>• **waiting in queue**: The statement is in the queue.<br>• **Empty**: The statement is being executed. |
| state | text | Overall state of the background.<br>Possible values are:<br>• **active**: The background is executing a query.<br>• **idle**: The background is waiting for a new client command.<br>• **idle in transaction**: The background is in a transaction, but there is no statement being executed in the transaction.<br>• **idle in transaction** (aborted): The background is in a transaction, but there are statements failed in the transaction.<br>• **fastpath function call**: The background is executing a fast-path function.<br>• **disabled**: This state is reported if **track_activities** is disabled in the background.<br>**NOTE**<br>Only system administrators can view the session state of their accounts. The state information of other accounts is empty. For example, after user **judy** is connected to the database, the state information of user **joe** and the initial user **omm** in **pgxc_stat_activity** is empty.<br>SELECT datname, usename, usesysid, state,pid FROM pgxc_stat_activity;<br>datname \| usename \| usesysid \| state \| pid<br>----------+---------+----------+--------+-----------------<br>postgres \| omm \| 10 \| \| 139968752121616<br>postgres \| omm \| 10 \| \| 139968903116560<br>db_tpcds \| judy \| 16398 \| active \| 139968391403280<br>postgres \| omm \| 10 \| \| 139968643069712<br>postgres \| omm \| 10 \| \| 139968680818448<br>postgres \| joe \| 16390 \| \| 139968563377936<br>(6 rows) |

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| Name | Type | Description |
| --- | --- | --- |
| resource_pool | name | Resource pool used by the user |
| query_id | bigint | ID of a query |
| query | text | Latest query in the background If the value of **state** is **active**, this column shows the ongoing query. In all other states, it shows the last query that was executed. |
| global_sessionid | text | Global session ID |
| unique_sql_id | bigint | Unique SQL statement ID |
| trace_id | text | Driver-specific trace ID, which is associated with an application request |

- pgxc_stat_activity_with_conninfo()

  Description: Displays query information about the current user on all CNs in the current cluster. For details, see the **pgxc_stat_activity** view. Only users with the **sysadmin** or **monitor admin** permission can execute this function, and common users can view only their own information.

  Return type: record

- pgxc_stat_all_tables()

  Description: Displays statistics on a row in each table (including TOAST tables) on each node. Only users with the **sysadmin** or **monitor admin** permission can execute this function.

  Return type: record

- pgxc_get_thread_wait_status()

  Description: Queries the call hierarchy between threads generated by all SQL statements on each node in a cluster and the block waiting status of each thread.

  Return type: record

- pgxc_wlm_get_workload_records()

  Description: Displays the status information when jobs on all CNs are being executed. Only system administrators can execute this function.

  Return type: record

- pv_session_memory

  Description: Collects statistics on memory usage at the session level, including all the memory allocated to Postgres and stream threads on DNs for jobs currently executed by users.

  NOTE

  If **enable_memory_limit** is set to **off**, this function cannot be used.

  Return type: record

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**Table 12-74** Return value description

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Thread start time and ID |
| init_mem | integer | Memory allocated to the currently executed jobs before they enter the executor, in MB |
| used_mem | integer | Memory allocated to the currently executed jobs, in MB |
| peak_mem | integer | Peak memory allocated to the currently executed jobs, in MB |

- dbe_perf.gs_stat_activity_timeout(int)

  Description: Obtains information about query jobs whose execution time exceeds the timeout threshold on the current node. The correct result can be returned only when the GUC parameter **track_activities** is set to **on**. The timeout threshold ranges from 0 to 2147483.

  Return type: setof record

| Name | Type | Description |
| --- | --- | --- |
| database | name | Name of the database connected to the user session |
| pid | bigint | Backend thread ID |
| sessionid | bigint | Session ID |
| usesysid | oid | OID of the user logged in to the background |
| application_name | text | Name of the application connected to the background |
| query | text | Query that is being executed in the background |
| xact_start | timestamptz | Time when the current transaction is started |
| query_start | timestamptz | Time when the current query starts |
| query_id | bigint | Query statement ID |

- dbe_perf.global_stat_activity_timeout(int)

  Description: Obtains information about query jobs whose execution time exceeds the timeout threshold in the current system (all CNs). The correct result can be returned only when the GUC parameter **track_activities** is set to **on**. The timeout threshold ranges from 0 to 2147483.

  Return type: setof record

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| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Name of the CN connected to the user session |
| database | name | Name of the database connected to the user session |
| pid | bigint | Backend thread ID |
| sessionid | bigint | Session ID |
| usesysid | oid | OID of the user logged in to the background |
| application_name | text | Name of the application connected to the background |
| query | text | Query that is being executed in the background |
| xact_start | timestamptz | Time when the current transaction is started |
| query_start | timestamptz | Time when the current query starts |
| query_id | bigint | Query statement ID |

- dbe_perf.get_average_value()

  Description: Obtains statistics on reset (restart, primary-standby switchover, and database deletion) time of the current node.

  Return type: record

- DBE_PERF.get_global_active_session()

  Description: Displays a summary of samples in the **ACTIVE SESSION PROFILE** memory on all nodes.

  Return type: record

- DBE_PERF.get_global_os_runtime()

  Description: Displays the running status of the current OS. This function can be queried only on CNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_os_threads()

  Description: Provides thread status information on all normal nodes in the entire cluster. The information can be queried only on CNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_os_threads()

  Description: Provides thread status information on all normal nodes in the entire cluster. The information can be queried only on CNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

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Return type: record

- DBE_PERF.get_summary_workload_sql_count()

  Description: Provides the count information of SELECT, UPDATE, INSERT, DELETE, DDL, DML, and DCL in different loads in the entire cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_workload_sql_elapse_time()

  Description: Provides SELECT, UPDATE, INSERT, DELETE, and response time information (TOTAL, AVG, MIN, and MAX) in different loads in the entire cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_workload_transaction()

  Description: Obtains the transaction volume and time information on all nodes in the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_session_stat()

  Description: Obtains the session status information on all nodes in the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

  NOTE

  The status information contains the following items: commit, rollback, sql, table_scan, blocks_fetched, physical_read_operation, shared_blocks_dirtied, local_blocks_dirtied, shared_blocks_read, local_blocks_read, blocks_read_time, blocks_write_time, sort_imemory, sort_idisk, cu_mem_hit, cu_hdd_sync_read, and cu_hdd_asyread

- DBE_PERF.get_global_session_time()

  Description: Provides the time consumed in each key phase on each node in the entire cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_session_memory()

  Description: Aggregates statistics on memory usage at the session level on each node in the unit of MB, including all the memory allocated to Postgres and stream threads on DNs for jobs currently executed by users. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_session_memory_detail()

  Description: Aggregates statistics on thread memory usage on each node by the MemoryContext node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

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- DBE_PERF.get_global_session_stat_activity()

  Description: Aggregates information about running threads on each node in the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_thread_wait_status()

  Description: Aggregates the blocking waiting status of the backend thread and auxiliary thread on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_wlm_controlgroup_ng_config()

  Description: Collects information about all Cgroups in the database. After a cluster is created, by default, you must have the **sysadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_wlm_workload_runtime()

  Description: Aggregates the status information about jobs executed by the current user on each CN. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_operator_ec_history()

  Description: Aggregates the historical status information about the current user's EC operators on each CN. After a cluster is created, by default, you must have the **monadmin** or **sysadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_operator_ec_history_table()

  Description: Aggregates the historical status information (persistent) of the current user's EC operators on each CN. After a cluster is created, by default, you must have the **monadmin** or **sysadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_operator_ec_runtime()

  Description: Aggregates the real-time status information about the current user's EC operators on each CN. After a cluster is created, by default, you must have the **monadmin** or **sysadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_operator_history_table()

  Description: Aggregates the operator records (persistent) after jobs are executed by the current user on all CNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_operator_history()

  Description: Aggregates the operator records after jobs are executed by the current user on all CNs. After a cluster is created, by default, you must have the **monadmin** or **sysadmin** permission to query this function.

  Return type: record

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- DBE_PERF.get_global_operator_runtime()

  Description: Aggregates real-time operator records of jobs executed by the current user on all CNs. After a cluster is created, by default, you must have the **monadmin** or **sysadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statement_complex_history()

  Description: Aggregates the historical records of complex queries executed by the current user on all CNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statement_complex_history_table()

  Description: Aggregates the historical records of complex queries (persistent) executed by the current user on all CNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statement_complex_runtime()

  Description: Aggregates real-time information about complex queries executed by the current user on all CNs. After a cluster is created, by default, you must have the **monadmin** or **sysadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_memory_node_detail()

  Description: Aggregates the memory usage of a database on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_shared_memory_detail()

  Description: Aggregates the usage information about the shared memory contexts on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_comm_delay()

  Description: Aggregates the communication library delay status on all DNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_comm_recv_stream()

  Description: Aggregates the status of the stream received by the communication library on all DNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_comm_send_stream()

  Description: Aggregates the status of the stream sent by the communication library on all DNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

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- DBE_PERF.get_global_comm_status()

  Description: Aggregates the status of the communication library on all DNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statio_all_indexes

  Description: Aggregates index information and I/O statistics in the current database on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_local_toastname_and_toastindexname()

  Description: Provides the mapping between the name and index of the local TOAST table and its associated tables.

  Return type: record

- DBE_PERF.get_summary_statio_all_indexes

  Description: Collects I/O statistics on specific indexes, covering all index lines in the current database on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statio_all_sequences

  Description: Provides I/O status information about all sequences in the namespace. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statio_all_tables

  Description: Aggregates I/O statistics on each table in the database on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_statio_all_tables

  Description: Collects statistics on I/Os of each table in the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_local_toast_relation()

  Description: Provides the mapping between the name of the local TOAST table and its associated tables.

  Return type: record

- DBE_PERF.get_global_statio_sys_indexes()

  Description: Aggregates I/O status information about all system catalog indexes in namespaces on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_statio_sys_indexes()

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Description: Collects statistics on I/O status information about all system catalog indexes in namespaces on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

Return type: record

- DBE_PERF.get_global_statio_sys_sequences()

  Description: Provides I/O status information about all system catalog sequences in namespaces. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statio_sys_tables()

  Description: Provides I/O status information about all system catalogs in the namespaces on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_statio_sys_tables()

  Description: Aggregates I/O status information about all system catalogs in the namespaces of the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statio_user_indexes()

  Description: Provides I/O status information about all user relationship table indexes in the namespaces on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_statio_user_indexes()

  Description: Aggregates I/O status information about all user relationship table indexes in the namespaces of the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statio_user_sequences()

  Description: Provides I/O status information about all user sequences in the namespaces on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statio_user_tables()

  Description: Provides I/O status information about all user relationship tables in the namespaces on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_statio_user_tables()

  Description: Aggregates I/O status information about all user relationship tables in the namespaces of the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_stat_db_cu()

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Description: Collects statistics on the CU hit ratio of all databases on each cluster node in a view. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

Return type: record

- DBE_PERF.get_global_dn_stat_all_tables()

  Description: Aggregates statistics on all tables in the database on each DN. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_cn_stat_all_tables()

  Description: Aggregates statistics on all tables in the database on each CN. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_dn_stat_all_tables()

  Description: Collects statistics on all tables in the database on each DN. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_cn_stat_all_tables()

  Description: Collects statistics on all tables in the database on each CN. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_all_indexes()

  Description: Aggregates statistics on all indexes in the database on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_stat_all_indexes()

  Description: Collects statistics on all indexes in the database on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_sys_tables()

  Description: Aggregates statistics on the system catalogs of all the namespaces in the **pg_catalog** or **information_schema** schema on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_stat_sys_tables()

  Description: Collects statistics on the system catalogs of all the namespaces in the **pg_catalog** or **information_schema** schema on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

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- DBE_PERF.get_global_stat_sys_indexes()

  Description: Aggregates index status information about all system catalogs in the **pg_catalog** or **information_schema** schema on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_stat_sys_indexes()

  Description: Collects index status information about all system catalogs in the **pg_catalog** or **information_schema** schema on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_user_tables()

  Description: Aggregates status information about user-defined ordinary tables in all namespaces. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_stat_user_tables()

  Description: Collects status information about user-defined ordinary tables in all namespaces. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_user_indexes()

  Description: Aggregates status information about the indexes of user-defined ordinary tables in all databases. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_stat_user_indexes()

  Description: Collects status information about the indexes of user-defined ordinary tables in all databases. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_database()

  Description: Aggregates statistics on databases on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_database_conflicts()

  Description: Collects statistics on databases on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_xact_all_tables()

  Description: Aggregates transaction status information about all ordinary tables and TOAST tables in namespaces. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

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Return type: record

- DBE_PERF.get_summary_stat_xact_all_tables()

  Description: Collects transaction status information about all ordinary tables and TOAST tables in the namespace. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_xact_sys_tables()

  Description: Aggregates transaction status information about system catalogs in namespaces on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_stat_xact_sys_tables()

  Description: Collects transaction status information about system catalogs in namespaces on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_xact_user_tables()

  Description: Aggregates transaction status information about user tables in namespaces on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_stat_xact_user_tables()

  Description: Collects transaction status information about user tables in namespaces on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_user_functions()

  Description: Aggregates transaction status information about user-defined functions in namespaces on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_xact_user_functions()

  Description: Collects transaction status information about user-defined functions in namespaces on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_stat_bad_block()

  Description: Aggregates information about the failure to read files such as tables and indexes on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_file_redo_iostat()

  Description: Collects information about the failure to read files such as tables and indexes on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

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Return type: record

- DBE_PERF.get_global_file_iostat()

  Description: Aggregates I/O statistics on data files on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_locks()

  Description: Aggregates lock information on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_replication_slots()

  Description: Aggregates logical replication information on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_bgwriter_stat()

  Description: Aggregates statistics on the backend write process activities on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_replication_stat()

  Description: Aggregates status information about log synchronization on all nodes, such as the location where the sender sends logs and the location where the receiver receives logs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_pooler_status()

  Description: Aggregates cache connection status in the pooler on all CNs. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_transactions_running_xacts()

  Description: Aggregates information about running transactions on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_transactions_running_xacts()

  Description: Collects information about running transactions on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_transactions_prepared_xacts()

  Description: Aggregates information about transactions that are currently prepared for two-phase commit on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

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Return type: record

- DBE_PERF.get_summary_transactions_prepared_xacts()

  Description: Collects information about transactions that are currently prepared for two-phase commit on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_statement()

  Description: Aggregates the status of historical statements executed on each node. After a cluster is created, by default, you must have the **monadmin** or **sysadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_statement_count()

  Description: Aggregates SELECT, UPDATE, INSERT, DELETE, and response time information (TOTAL, AVG, MIN, and MAX) on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_config_settings()

  Description: Aggregates GUC parameter settings on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_wait_events()

  Description: Aggregates status information about the wait events on each node. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_statement_responsetime_percentile()

  Description: Obtains the response time distribution for 80% and 95% SQL statements in the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_summary_user_login()

  Description: Collects statistics on the number of user login and logout times on each node in the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.get_global_record_reset_time()

  Description: Aggregates statistics on reset (restart, primary-standby switchover, and database deletion) time in the cluster. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- DBE_PERF.track_memory_context(context_list text)

  Description: Sets the memory context whose memory application details need to be collected. The input parameter contains the memory context names,

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which are separated by commas (,), for example, **ThreadTopMemoryContext, SessionCacheMemoryContext**. Note that the memory context names are context-sensitive. In addition, the length of a single memory context is 63, and the exceeded part is truncated. The maximum number of memory contexts for collection at a time is 16. If the number of memory contexts exceeds 16, the setting fails. Each time this function is called, the previous collection result is cleared. When the input parameter is set to **""**, the collection function is disabled. Only the initial user or a user with the **monadmin** permission can execute this function.

Return type: Boolean

- DBE_PERF.track_memory_context_detail()

  Description: Obtains the memory application details of the memory context specified by the **DBE_PERF.track_memory_context** function. For details, see the **DBE_PERF.track_memory_context_detail** view. Only the initial user or a user with the **monadmin** permission can execute this function.

  Return type: record

- DBE_PERF.global_io_wait_info()

  Description: Queries real-time I/O control statistics on all CNs and DNs.

  Return type: record

- pg_stat_get_mem_mbytes_reserved(tid)

  Description: Collects statistics on variables related to resource management, which is used only for fault locating.

  Parameter: thread ID

  Return type: text

- gs_wlm_user_resource_info(name text)

  Description: Queries a user's resource quota and resource usage. Common users can query only their own information. Administrators can query information about all users.

  Return type: record

- pg_stat_get_file_stat()

  Description: Collects statistics on data file I/Os to indicate I/O performance and detect performance problems such as abnormal I/O operations.

  Return type: record

- pg_stat_get_redo_stat()

  Description: Displays statistics on the replay of session thread logs.

  Return type: record

- pg_stat_get_status(int8)

  Description: Tests the block waiting status about the backend thread and auxiliary thread of the current instance.

  Return type: record

- get_local_rel_iostat()

  Description: Queries the accumulated I/O status of data files on the current node.

  Return type: record

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- DBE_PERF.get_global_rel_iostat()

  Description: Aggregates I/O statistics on data files on all nodes. After a cluster is created, by default, you must have the **monadmin** permission to query this function.

  Return type: record

- pg_catalog.plancache_status()

  Description: Displays status information about the global plan cache on the current node. The information returned by the function is the same as that in **16.2.18.2 GLOBAL_PLANCACHE_STATUS**.

  Return type: record

- DBE_PERF.global_plancache_status()

  Description: Displays status information about the global plan cache on all nodes. For details about the information returned by the function, see **16.2.18.2 GLOBAL_PLANCACHE_STATUS**.

  Return type: record

- pg_catalog.prepare_statement_status() (Discarded)

  Description: Displays status information about the PREPARE statement on the current node. The information returned by the function is the same as that in **16.2.18.4 GLOBAL_PREPARE_STATEMENT_STATUS (Discarded)**.

  Return type: record

- DBE_PERF.global_prepare_statement_status() (Discarded)

  Description: Displays status information about the **PREPARE** statement on all nodes. For details about the information returned by the function, see **16.2.18.4 GLOBAL_PREPARE_STATEMENT_STATUS (Discarded)**.

  Return type: record

- DBE_PERF.global_threadpool_status()

  Description: Displays status information about worker threads and sessions in thread pools on all nodes. For details about the information returned by the function, see **16.2.7.14 GLOBAL_THREADPOOL_STATUS**.

  Return type: record

- comm_check_connection_status

  Description: Returns the connection status between the CN and all active nodes (CNs and primary DNs). This function can be queried only on CNs and can be used by common users.

  Parameter: nan

  Return type: node_name text, remote_name text, remote_host text, remote_port integer, is_connected boolean, and no_error_occur boolean

- DBE_PERF.global_comm_check_connection_status

  Description: Returns the connection status between all CNs and all active nodes (CNs and primary DNs). This function can be queried only on CNs. Permission control is inherited from the **DBE_PERF** schema.

  Parameter: nan

  Return type: node_name text, remote_name text, remote_host text, remote_port integer, is_connected boolean, and no_error_occur boolean

- create_wlm_instance_statistics_info

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Description: Saves the historical monitoring data of the current instance persistently.

Parameter: nan

Return type: integer

- remote_candidate_stat()

  Description: Displays the number of pages in the candidate buffer chain of the instance and buffer eviction information, including the normal buffer pool and segment buffer pool.

  Return type: record

  **Table 12-75** remote_candidate_stat parameter description

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| candidate_slots | integer | Number of pages in the candidate buffer chain of the current normal buffer pool |
| get_buf_from_list | bigint | Number of times that pages are obtained from the candidate buffer chain during buffer eviction in the current normal buffer pool |
| get_buf_clock_sweep | bigint | Number of times that pages are obtained from the original eviction solution during buffer eviction in the current normal buffer pool |
| seg_candidate_slots | integer | Number of pages in the candidate buffer chain of the current segment buffer pool |
| seg_get_buf_from_list | bigint | Number of times that pages are obtained from the candidate buffer chain during buffer eviction in the current segment buffer pool |
| seg_get_buf_clock_sweep | bigint | Number of times that pages are obtained from the original eviction solution during buffer eviction in the current segment buffer pool |

- remote_ckpt_stat()

  Description: Displays the checkpoint information and log flushing information about all instances in the cluster (unavailable on DNs, except for the current node).

  Return type: record

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**Table 12-76** remote_ckpt_stat parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| ckpt_redo_point | text | Checkpoint in the current instance |
| ckpt_clog_flush_num | int8 | Number of Clog flushing pages from the startup time to the current time |
| ckpt_csnlog_flush_num | int8 | Number of CSN log flushing pages from the startup time to the current time |
| ckpt_multixact_flush_num | int8 | Number of MultiXact flushing pages from the startup time to the current time |
| ckpt_predicate_flush_num | int8 | Number of predicate flushing pages from the startup time to the current time |
| ckpt_twophase_flush_num | int8 | Number of two-phase flushing pages from the startup time to the current time |

- remote_double_write_stat()

  Description: Displays doublewrite file status of all instances in the cluster (unavailable on DNs, except for the current node).

  Return type: record

  **Table 12-77** remote_double_write_stat parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| curr_dwn | int8 | Sequence number of the doublewrite file |
| curr_start_page | int8 | Start page for restoring the doublewrite file |
| file_trunc_num | int8 | Number of times that the doublewrite file is reused |
| file_reset_num | int8 | Number of reset times after the doublewrite file is full |
| total_writes | int8 | Total number of I/Os of the doublewrite file |

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| Parameter | Type | Description |
| --- | --- | --- |
| low_threshold_writes | int8 | Number of I/Os for writing the doublewrite file with low efficiency (the number of I/O flushing pages at a time is less than 16.) |
| high_threshold_writes | int8 | Number of I/Os for writing the doublewrite file with high efficiency (the number of I/O flushing pages at a time is more than 421.) |
| total_pages | int8 | Total number of pages that are flushed to the doublewrite file area |
| low_threshold_pages | int8 | Number of pages that are flushed with low efficiency |
| high_threshold_pages | int8 | Number of pages that are flushed with high efficiency |
| file_id | int8 | ID of the doublewrite file |

- remote_single_flush_dw_stat()

  Description: Displays the single-page doublewrite file eviction status of all instances in the cluster (unavailable on DNs, except for the current node).

  Return type: record

  **Table 12-78** remote_single_flush_dw_stat parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| curr_dwn | integer | Sequence number of the doublewrite file |
| curr_start_page | integer | Start position of the doublewrite file |
| total_writes | bigint | Total number of data write pages in the doublewrite file |
| file_trunc_num | bigint | Number of times that the doublewrite file is reused |
| file_reset_num | bigint | Number of reset times after the doublewrite file is full |

- remote_pagewriter_stat()

  Description: Displays the page flushing information and checkpoint information about all instances in the cluster (unavailable on DNs, except for the current node).

  Return type: record

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**Table 12-79** remote_pagewriter_stat parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| pgwr_actual_flush_total_num | int8 | Total number of dirty pages flushed from the startup time to the current time |
| pgwr_last_flush_num | int4 | Number of dirty pages flushed in the previous batch |
| remain_dirty_page_num | int8 | Estimated number of dirty pages that are not flushed |
| queue_head_page_rec_lsn | text | **recovery_lsn** of the first dirty page in the dirty page queue in the current instance |
| queue_rec_lsn | text | **recovery_lsn** of the dirty page queue in the current instance |
| current_xlog_insert_lsn | text | Write position of Xlogs in the current instance |
| ckpt_redo_point | text | Checkpoint in the current instance |

- remote_recovery_status()

  Description: Displays log flow control information about the primary and standby nodes (unavailable on DNs, except for the current node).

  Return type: record

**Table 12-80** remote_recovery_status parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Node name (including the primary and standby nodes) |
| standby_node_name | text | Name of the standby node |
| source_ip | text | IP address of the primary node |
| source_port | int4 | Port number of the primary node |
| dest_ip | text | IP address of the standby node |
| dest_port | int4 | Port number of the standby node |

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| Parameter | Type | Description |
| --- | --- | --- |
| current_rto | int8 | Current log flow control time of the standby node (unit: s) |
| target_rto | int8 | Expected flow control time of the standby node specified by the corresponding GUC parameter (unit: s) |
| current_sleep_time | int8 | Sleep time required by the primary node to achieve the expected flow control time (unit: μs) |

- remote_rto_status()

  Description: Displays log flow control information about the primary and standby nodes (unavailable on DNs, except for the current node).

  Return type: record

  **Table 12-81** remote_rto_status parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Node name (including the primary and standby nodes) |
| rto_info | text | Flow control information, including the current log flow control time (unit: second) of the standby node, the expected flow control time (unit: second) specified by the GUC parameter, and the sleep time required by the primary node to achieve the expected flow control time (unit: μs) |

- remote_redo_stat()

  Description: Displays the log replay status of all instances in the cluster (unavailable on DNs, except for the current node).

  Return type: record

  **Table 12-82** remote_redo_stat parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| redo_start_ptr | int8 | Start point for replaying the current instance logs |

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| Parameter | Type | Description |
| --- | --- | --- |
| redo_start_time | int8 | Start time (UTC) when the current instance logs are replayed |
| redo_done_time | int8 | End time (UTC) when the current instance logs are replayed |
| curr_time | int8 | Current time (UTC) of the current instance |
| min_recovery_point | int8 | Position of the minimum consistency point of the current instance logs |
| read_ptr | int8 | Position for reading the current instance logs |
| last_replayed_read_ptr | int8 | Position for replaying the current instance logs |
| recovery_done_ptr | int8 | Replay position after the current instance is started |
| read_xlog_io_counter | int8 | Number of I/Os when the current instance reads and replays logs |
| read_xlog_io_total_dur | int8 | Total I/O latency when the current instance reads and replays logs |
| read_data_io_counter | int8 | Number of data page I/O reads during replay in the current instance |
| read_data_io_total_dur | int8 | Total I/O latency of data page reads during replay in the current instance |
| write_data_io_counter | int8 | Number of data page I/O writes during replay in the current instance |
| write_data_io_total_dur | int8 | Total I/O latency of data page writes during replay in the current instance |
| process_pending_counter | int8 | Number of synchronization times of log distribution threads during replay in the current instance |

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| Parameter | Type | Description |
| --- | --- | --- |
| process_pending_total_dur | int8 | Total synchronization latency of log distribution threads during replay in the current instance |
| apply_counter | int8 | Number of synchronization times of replay threads during replay in the current instance |
| apply_total_dur | int8 | Total synchronization latency of replay threads during replay in the current instance |
| speed | int8 | Log replay rate of the current instance |
| local_max_ptr | int8 | Maximum number of replay logs received by the local host after the current instance is started |
| primary_flush_ptr | int8 | Position where the host flushes logs to a disk |
| worker_info | text | Replay thread information of the current instance. If concurrent replay is disabled, this parameter is left empty. |

- PGXC_GTM_SNAPSHOT_STATUS()

  Description: Queries transaction information on the current GTM. This function is supported only in GTM mode.

  Return type: record

  The following table describes return parameters.

  **Table 12-83** PGXC_GTM_SNAPSHOT_STATUS return parameters

| Name | Type | Description |
| --- | --- | --- |
| xmin | xid | Minimum XID of the running transactions |
| xmax | xid | XID of the transaction next to the executed transaction with the maximum XID |
| csn | integer | Sequence number of the transaction to be committed |
| oldestxmin | xid | Minimum XID of the executed transactions |

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| Name | Type | Description |
| --- | --- | --- |
| xcnt | integer | Number of the running transactions |
| running_xids | text | XID of the running transaction |

- pg_stat_get_partition_tuples_hot_updated

  Description: Returns statistics on the number of hot updated tuples in a partition with a specified partition ID.

  Parameter: oid

  Return type: bigint

- pv_os_run_info

  Description: Displays the running status of the current OS. For details about the fields, see **15.3.217 PV_OS_RUN_INFO**.

  Parameter: nan

  Return type: setof record

- pv_session_stat

  Description: Collects session status information by session thread or AutoVacuum thread. For details about the fields, see **15.3.222 PV_SESSION_STAT**.

  Parameter: nan

  Return type: setof record

- pv_session_time

  Description: Collects statistics on the running time of session threads and the time consumed in each execution phase. For details about the fields, see **15.3.223 PV_SESSION_TIME**.

  Parameter: nan

  Return type: setof record

- pg_stat_get_db_temp_bytes

  Description: Collects statistics on the total amount of data written to temporary files through database query. All temporary files are counted, regardless of why the temporary files were created and regardless of the **log_temp_files** setting.

  Parameter: oid

  Return type: bigint

- pg_stat_get_db_temp_files

  Description: Queries the number of temporary files created in the database. All temporary files are counted, regardless of why the temporary files were created (for example, sorting or hashing) and regardless of the **log_temp_files** setting.

  Parameter: oid

  Return type: bigint

- local_redo_time_count()

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Description: Returns statistics on time consumed in each process of each replay thread on the current node (valid data exists only on the standby node).

The return values are as follows:

**Table 12-84** local_redo_time_count return parameters

| Field | Description |
| --- | --- |
| thread_name | Thread name |
| step1_total | Total duration of step 1. The process of each thread is as follows:<br>Ultimate RTO:<br>● **batch redo**: obtains a log from a queue.<br>● **redo manager**: obtains a log from a queue.<br>● **redo worker**: obtains a log from a queue.<br>● **trxn manager**: reads a log from a queue.<br>● **trxn worker**: reads a log from a queue.<br>● **read worker**: reads an Xlog page (overall) from a file.<br>● **read page worker**: obtains a log from a queue.<br>● **startup**: obtains a log from a queue.<br>Parallel replay:<br>● **page redo**: obtains a log from a queue.<br>● **startup**: reads a log. |
| step1_count | Number of accumulated execution times of step 1 |

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| Field | Description |
| --- | --- |
| step2_total | Total duration of step 2. The process of each thread is as follows:<br>Ultimate RTO:<br>• **batch redo**: processes logs (overall).<br>• **redo manager**: processes logs (overall).<br>• **redo worker**: processes logs (overall).<br>• **trxn manager**: processes logs (overall).<br>• **trxn worker**: processes logs (overall).<br>• **redo worker**: specifies the time required for reading the Xlog page.<br>• **read page worker**: generates and sends LSN forwarders.<br>• **startup**: checks whether to replay to the specified position.<br>Parallel replay:<br>**page redo**: processes logs (overall).<br>**startup**: checks whether to replay to the specified position. |
| step2_count | Number of accumulated execution times of step 2 |
| step3_total | Total duration of step 3. The process of each thread is as follows:<br>Ultimate RTO:<br>• **batch redo**: updates the standby state.<br>• **redo manager**: processes data logs.<br>• **redo worker**: replays page logs (overall).<br>• **trxn manager**: updates the flush LSN.<br>• **trxn worker**: replays logs.<br>• **redo worker**: pushes the Xlog segment.<br>• **read page worker**: obtains a new item.<br>• **startup**: collects statistics on the wait time of the delayed replay feature.<br>Parallel replay:<br>• **page redo**: updates the standby state.<br>• **startup**: collects statistics on the wait time of the delayed replay feature. |
| step3_count | Number of accumulated execution times of step 3 |

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| Field | Description |
| --- | --- |
| step4_total | Total duration of step 4. The process of each thread is as follows:<br>Ultimate RTO:<br>• **batch redo**: parses Xlogs.<br>• **redo manager**: processes DDL.<br>• **redo worker**: reads data pages.<br>• **trxn manager**: synchronizes the wait time.<br>• **trxn worker**: updates the LSN of the current thread.<br>• **read page worker**: stores logs in the distribution thread.<br>• **startup**: distributes logs (overall).<br>Parallel replay:<br>• **page redo**: replays undo logs.<br>• **startup**: distributes logs (overall). |
| step4_count | Number of accumulated execution times of step 4 |
| step5_total | Total duration of step 5. The process of each thread is as follows:<br>Ultimate RTO:<br>• **batch redo**: distributes logs to the redo manager.<br>• **redo manager**: distributes logs to redo workers.<br>• **redo worker**: replays data page logs.<br>• **trxn manager**: distributes data to the trxn worker.<br>• **trxn worker**: forcibly synchronizes the wait time.<br>• **read page worker**: updates the LSN of the current thread.<br>• **startup**: decodes logs.<br>Parallel replay:<br>• **page redo**: replays sharetrxn logs.<br>• **startup**: replays logs. |
| step5_count | Number of accumulated execution times of step 5. |

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| Field | Description |
| --- | --- |
| step6_total | Total duration of step 6. The process of each thread is as follows:<br>Ultimate RTO:<br>• **redo worker**: replays non-data page logs.<br>• **trxn manager**: updates global LSNs.<br>• **read page worker**: performs CRC on logs.<br>Parallel replay:<br>• **page redo**: replays synctrxn logs.<br>• **startup**: forcibly synchronizes the wait time. |
| step6_count | Number of accumulated execution times of step 6 |
| step7_total | Total duration of step 7. The process of each thread is as follows:<br>Ultimate RTO:<br>• **redo manager**: creates tablespaces.<br>• **redo worker**: updates FSM.<br>Parallel replay:<br>**page redo**: replays a single log. |
| step7_count | Number of accumulated execution times of step 7 |
| step8_total | Total duration of step 8. The process of each thread is as follows:<br>Ultimate RTO:<br>**redo worker**: forcibly synchronizes the wait time.<br>Parallel replay:<br>**page redo**: All workers replay redo logs. |
| step8_count | Number of accumulated execution times of step 8 |
| step9_total | Total duration of step 9. The process of each thread is as follows:<br>Ultimate RTO:<br>None<br>Parallel replay:<br>**page redo**: Multiple workers replay redo logs. |
| step9_count | Number of accumulated execution times of step 9 |

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- local_xlog_redo_statics()

  Description: Returns the statistics on each type of logs that have been replayed on the current node (valid data exists only on the standby node).

  The return values are as follows:

  **Table 12-85** local_xlog_redo_statics parameter description

| Field | Description |
| --- | --- |
| xlog_type | Log type |
| rmid | Resource manager ID |
| info | xlog operation |
| num | Number of logs |
| extra | Valid values are available for page replay logs and xact logs. The page replay logs indicate the number of pages read from the disk. The xact logs indicate the number of deleted files. |

- remote_bgwriter_stat()

  Description: Displays information about pages flushed by the bgwriter threads of all instances in the cluster, number of pages in the candidate buffer chain, and buffer eviction information (not available on the DN, except for the current node).

  Return type: record

  **Table 12-86** remote_bgwriter_stat parameter description

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| bgwr_actual_flush_total_num | bigint | Total number of dirty pages flushed by the bgwriter thread from the startup time to the current time |
| bgwr_last_flush_num | integer | Number of dirty pages flushed by the bgwriter thread in the previous batch |
| candidate_slots | integer | Number of pages in the current candidate buffer chain |
| get_buffer_from_list | bigint | Number of times that pages are obtained from the candidate buffer chain during buffer eviction |

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| Parameter | Type | Description |
| --- | --- | --- |
| get_buf_clock_sweep | bigint | Number of times that pages are obtained from the original eviction solution during buffer eviction |

Example:

The **pg_backend_pid** function shows the ID of the current background service thread.

```
openGauss=# SELECT pg_backend_pid();
 pg_backend_pid
-----------------
 139706243217168
(1 row)
```

The **pg_stat_get_backend_pid** function shows the ID of a given backend thread.

```
openGauss=# SELECT pg_stat_get_backend_pid(1);
 pg_stat_get_backend_pid
-------------------------
        139706243217168
(1 row)
```

- gs_stack()

  Description: Displays the call stack of a thread. To query this function, you must have the **sysadmin** or **monadmin** permission.

  Parameter: tid, which indicates the thread ID. **tid** is an optional parameter. If it is specified, the function returns the call stack of the thread corresponding to **tid**. If it is not specified, the function returns the call stacks of all threads.

  Return value: If **tid** is specified, the return value is **text**. If **tid** is not specified, the return value is **setof record**.

  Example:

```
openGauss=# SELECT gs_stack(139663481165568);
                           gs_stack
-----------------------------------------------------------------------
 __poll + 0x2d                                                        +
 WaitLatchOrSocket(Latch volatile*, int, int, long) + 0x29f        +
 WaitLatch(Latch volatile*, int, long) + 0x2e                    +
 JobScheduleMain() + 0x90f                                      +
 int GaussDbThreadMain<(knl_thread_role)9>(knl_thread_arg*) + 0x456+
 InternalThreadFunc(void*) + 0x2d                                +
 ThreadStarterFunc(void*) + 0xa4                                 +
 start_thread + 0xc5                                           +
 clone + 0x6d                                                 +
(1 row)
```

# 12.5.28 Trigger Functions

- pg_get_triggerdef(oid)

  Description: Obtains the definition information of a trigger.

  Parameter: OID of the trigger to be queried

  Return type: text

- pg_get_triggerdef(oid, boolean)

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Description: Obtains the definition information of a trigger.

Parameter: OID of the trigger to be queried and whether it is displayed in pretty mode

Return type: text

## 12.5.29 Hash Function

- bucketabstime (value, flag)

  Description: Hashes the value in the abstime format and finds the corresponding hash bucket.

  Parameter: **value** indicates the value to be converted, which is of the abstime type. **flag** is of the int type, indicating the data distribution mode. The value **0** indicates hash distribution.

  Return type: int32

  Example:

```
openGauss=# select bucketabstime('2011-10-01 10:10:10.112',1);
 bucketabstime
---------------
         13954
(1 row)
```

- bucketbool (value, flag)

  Description: Hashes the value in the bool format and finds the corresponding hash bucket.

  Parameter: **value** indicates the value to be converted, which is of the bool type. **flag** is of the int type, indicating the data distribution mode. The value **0** indicates hash distribution.

  Return type: int32

  Example:

```
openGauss=# select bucketbool(true,1);
 bucketbool
------------
          1
(1 row)
openGauss=# select bucketbool(false,1);
 bucketbool
------------
          0
(1 row)
```

- bucketbpchar(value, flag)

  Description: Hashes the value in the bpchar format and finds the corresponding hash bucket.

  Parameter: **value** indicates the value to be converted, which is of the bpchar type. **flag** is of the int type, indicating the data distribution mode. The value **0** indicates hash distribution.

  Return type: int32

  Example:

```
openGauss=# select bucketbpchar('test',1);
 bucketbpchar
--------------
         9761
(1 row)
```

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- bucketbytea (value, flag)

  Description: Hashes the value in the bytea format and finds the corresponding hash bucket.

  Parameter: **value** indicates the value to be converted, which is of the bytea type. **flag** is of the int type, indicating the data distribution mode. The value **0** indicates hash distribution.

  Return type: int32

  Example:

  ```
  openGauss=# select bucketbytea('test',1);
   bucketbytea
  -------------
         9761
  (1 row)
  ```

- bucketcash (value, flag)

  Description: Hashes the value in the money format and finds the corresponding hash bucket.

  Parameter: **value** indicates the value to be converted, which is of the money type. **flag** is of the int type, indicating the data distribution mode. The value **0** indicates hash distribution.

  Return type: int32

  Example:

  ```
  openGauss=# select bucketcash(10::money,1);
   bucketcash
  ------------
        8468
  (1 row)
  ```

- getbucket (value, flag)

  Description: Obtains the hash bucket from the distribution column.

  **value** indicates the value to be entered, which can be of the following types:

  "char", abstime, bigint, boolean,bytea, character varying, character, date, double precision, int2vector, integer, interval, money, name, numeric, nvarchar2, oid, oidvector, raw, real, record, reltime, smalldatetime, smallint,text, time with time zone, time without time zone, timestamp with time zone, timestamp without time zone, tinyint, uuid

  **flag** is of the int type, indicating the data distribution mode.

  Return type: integer

  Example:

  ```
  openGauss=# select getbucket(10,'H');
   getbucket
  -----------
      14535
  (1 row)

  openGauss=# select getbucket(11,'H');
   getbucket
  -----------
      13449
  (1 row)

  openGauss=# select getbucket(11,'R');
   getbucket
  -----------
      13449
  (1 row)
  ```

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```
openGauss=# select getbucket(12,'R');
 getbucket
-----------
      9412
(1 row)
```

- hash_array(anyarray)

  Description: Hashes an array, obtains the result of an array element using the hash function, and returns the combination result.

  Parameter: data of the anyrange type.

  Return type: integer

  Example:

```
openGauss=# select hash_array(ARRAY[[1,2,3],[1,2,3]]);
 hash_array
------------
 -382888479
(1 row)
```

- hash_group(key)

  Description: Calculates the hash value of each column in the Group Clause in the streaming engine. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.)

  Parameter: **key** indicates the value of each column in the Group Clause.

  Return type: 32-bit hash value

  Example:

```
Perform the following steps in sequence.
openGauss=# CREATE TABLE tt(a int, b int,c int,d int);
NOTICE:  The 'DISTRIBUTE BY' clause is not specified. Using 'a' as the distribution column by default.
HINT:  Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
CREATE TABLE
openGauss=# select * from tt;
 a | b | c | d
---+---+---+---
(0 rows)

openGauss=# insert into tt values(1,2,3,4);
INSERT 0 1
openGauss=# select * from tt;
 a | b | c | d
---+---+---+---
 1 | 2 | 3 | 4
(1 row)

openGauss=# insert into tt values(5,6,7,8);
INSERT 0 1
openGauss=# select * from tt;
 a | b | c | d
---+---+---+---
 1 | 2 | 3 | 4
 5 | 6 | 7 | 8
(2 rows)

openGauss=# select hash_group(a,b) from tt where a=1 and b=2;
 hash_group
------------
  990882385
(1 row)
```

- hash_numeric(numeric)

  Description: Calculates the hash value of numeric data.

  Parameter: data of the numeric type.

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Return type: integer

Example:

```
openGauss=# select hash_numeric(30);
 hash_numeric
--------------
   -282860963
(1 row)
```

- hash_range(anyrange)

  Description: Calculates the hash value of a range.

  Parameter: data of the anyrange type.

  Return type: integer

  Example:

```
openGauss=# select hash_range(numrange(1.1,2.2));
 hash_range
------------
  683508754
(1 row)
```

- hashbpchar(character)

  Description: Calculates the hash value of bpchar.

  Parameter: data of the character type.

  Return type: integer

  Example:

```
openGauss=# select hashbpchar('hello');
 hashbpchar
-------------
 -1870292951
(1 row)
```

- hashchar(char)

  Description: Converts char and Boolean data into hash values.

  Parameter: data of the char or bool type.

  Return type: integer

  Example:

```
openGauss=# select hashbpchar('hello');
 hashbpchar
-------------
 -1870292951
(1 row)

openGauss=# select hashchar('true');
  hashchar
------------
 1686226652
(1 row)
```

- hashenum(anyenum)

  Description: Converts enumerated values to hash values.

  Parameter: data of the anyenum type.

  Return type: integer

  Example:

```
openGauss=# CREATE TYPE b1 AS ENUM('good', 'bad', 'ugly');
CREATE TYPE
openGauss=# call hashenum('good'::b1);
  hashenum
```

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```
------------
 1821213359
(1 row)
```

- hashfloat4(real)

  Description: Converts float4 values to hash values.

  Parameter: data of the real type.

  Return type: integer

  Example:

```
openGauss=# select hashfloat4(12.1234);
 hashfloat4
------------
 1398514061
(1 row)
```

- hashfloat8(double precision)

  Description: Converts float8 values to hash values.

  Parameter: data of the double precision type.

  Return type: integer

  Example:

```
openGauss=# select hashfloat8(123456.1234);
 hashfloat8
------------
 1673665593
(1 row)
```

- hashinet(inet)

  Description: Supports hash indexing on inet/cidr and returns the hash value of inet.

  Parameter: data of the inet type.

  Return type: integer

  Example:

```
openGauss=# select hashinet('127.0.0.1'::inet);
  hashinet
-------------
 -1435793109
(1 row)
```

- hashint1(tinyint)

  Description: Converts INT1 values to hash values.

  Parameter: data of the tinyint type.

  Return type: uint32

  Example:

```
openGauss=# select hashint1(20);
  hashint1
-------------
 -2014641093
(1 row)
```

- hashint2(smallint)

  Description: Converts INT2 values to hash values.

  Parameter: data of the smallint type.

  Return type: uint32

  Example:

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```
openGauss=# select hashint2(20000);
 hashint2
------------
 -863179081
(1 row)
```

- bucketchar
  Description: Calculates the hash value of the input parameter.
  Parameter: char, integer
  Return type: integer
- bucketdate
  Description: Calculates the hash value of the input parameter.
  Parameter: date, integer
  Return type: integer
- bucketfloat4
  Description: Calculates the hash value of the input parameter.
  Parameter: real, integer
  Return type: integer
- bucketfloat8
  Description: Calculates the hash value of the input parameter.
  Parameters: double precision, integer
  Return type: integer
- bucketint1
  Description: Calculates the hash value of the input parameter.
  Parameter: tinyint, integer
  Return type: integer
- bucketint2
  Description: Calculates the hash value of the input parameter.
  Parameter: smallint, integer
  Return type: integer
- bucketint2vector
  Description: Calculates the hash value of the input parameter.
  Parameter: int2vector, integer
  Return type: integer
- bucketint4
  Description: Calculates the hash value of the input parameter.
  Parameter: integer, integer
  Return type: integer
- bucketint8
  Description: Calculates the hash value of the input parameter.
  Parameter: bigint, integer
  Return type: integer
- bucketinterval
  Description: Calculates the hash value of the input parameter.

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Parameter: interval, integer
Return type: integer

- bucketname
  Description: Calculates the hash value of the input parameter.
  Parameter: name, integer
  Return type: integer
- bucketnumeric
  Description: Calculates the hash value of the input parameter.
  Parameter: numeric, integer
  Return type: integer
- bucketnvarchar2
  Description: Calculates the hash value of the input parameter.
  Parameter: nvarchar2, integer
  Return type: integer
- bucketoid
  Description: Calculates the hash value of the input parameter.
  Parameters: oid, integer
  Return type: integer
- bucketoidvector
  Description: Calculates the hash value of the input parameter.
  Parameter: oidvector, integer
  Return type: integer
- bucketraw
  Description: Calculates the hash value of the input parameter.
  Parameter: raw, integer
  Return type: integer
- bucketreltime
  Description: Calculates the hash value of the input parameter.
  Parameter: reltime, integer
  Return type: integer
- bucketsmalldatetime
  Description: Calculates the hash value of the input parameter.
  Parameter: smalldatetime, integer
  Return type: integer
- buckettext
  Description: Calculates the hash value of the input parameter.
  Parameter: text, integer
  Return type: integer
- buckettime
  Description: Calculates the hash value of the input parameter.
  Parameter: time without time zone, integer

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Return type: integer

- buckettimestamp
  Description: Calculates the hash value of the input parameter.
  Parameter: timestamp without time zone, integer
  Return type: integer
- buckettimestamptz
  Description: Calculates the hash value of the input parameter.
  Parameter: timestamp with time zone, integer
  Return type: integer
- buckettimetz
  Description: Calculates the hash value of the input parameter.
  Parameter: time with time zone, integer
  Return type: integer
- bucketuuid
  Description: Calculates the hash value of the input parameter.
  Parameter: uuid, integer
  Return type: integer
- bucketvarchar
  Description: Calculates the hash value of the input parameter.
  Parameter: character varying, integer
  Return type: integer

## 12.5.30 Prompt Message Function

- report_application_error
  Description: This function can be used to throw errors during PL execution.
  Return type: void

  **Table 12-87** report_application_error parameter description

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| log | text | Content of an error message. | Yes |
| code | int4 | Error code corresponding to an error message. The value ranges from –20999 to –20000. | No |

## 12.5.31 Fault Injection System Function

gs_fault_inject(int64, text, text, text, text, text)

Description: This function cannot be called. WARNING information "unsupported fault injection" is reported when this function is called, which does not affect or change the database.

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Parameter: fault injection of the int64 type (**0**: CLOG extended page; **1**: CLOG page reading; **2**: forcible deadlock)

- If the first input parameter of text is set to **2** and the second input parameter of text is set to **1**, the second input parameter deadlock occurs. Other input parameters are not deadlocked. When the first input parameter is **0** or **1**, the second input parameter indicates the number of the start page from which the CLOG starts to be extended or read.
- The third input parameter of text indicates the number of extended or read pages when the first input parameter is **0** or **1**.
- The fourth to sixth input parameters of text are reserved.

Return type: int64

## 12.5.32 Redistribution Parameters

The following functions are system functions used by **gs_redis** during redistribution. Do not call them unless absolutely necessary.

- pg_get_redis_rel_end_ctid(text, name, int, int)
- pg_get_redis_rel_start_ctid(text, name, int, int)
- pg_enable_redis_proc_cancelable()
- pg_disable_redis_proc_cancelable()
- pg_tupleid_get_blocknum(tid)
- pg_tupleid_get_offset(tid)
- pg_tupleid_get_ctid_to_bigint (ctid)

The following functions and OIDs are all for time series tables.

- redis_ts_table(oid)

Description: Moves data from the old table (for example, **redis_old_cpu**) to the new table (**redis_new_cpu**) from the last partition of the timeline, deletes the partition if the partition of **redis_old_cpu** is empty, deletes the old table when only one partition is left, and restores the table to the original CPU table. This function is called by the following job and does not need to be manually called.

Return type: void

**Table 12-88** redis_ts_table parameter description

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| old_oid | oid | ID of **redis_old_cpu**. | Yes |

- cancel_unuse_redis()

Description: Cancels redistribution of a time series table.

Return value: void

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- submit_redis_task(oid, interval)

Description: Calls the **redis_ts_table** function. Only one job can be called for a table. For modification, stop the job and call it again.

Parameter: The CPU table is used as an example. For details, see **Table 12-89**.

Return type: void

**Table 12-89** submit_redis_task parameter description

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| old_oid | oid | ID of **redis_old_cpu**. | Yes |
| schedule_interval | interval | This parameter is used to calculate the input value of **interval_time** in **dbe_task.submit**, indicating the interval for executing the job. | No |

- submit_all_redis_task(interval)

Description: Calls the **submit_redis_task** function for all tables that are not redistributed in the currently connected database.

Return type: void

**Table 12-90** Parameter description

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| schedule_interval | interval | This parameter has the same meaning as the input parameter **schedule_interval** of **submit_redis_task**. | No |

- cancel_redis_task(oid)

Description: Stops the job for transferring a table after the table has been transferred.

Parameter: OID of **redis_old_cpu** (using the cpu table as an example).

Return type: void

- cancel_all_redis_task()

Description: Stops all the jobs that are being transferred for all the time series tables connected to the database.

Return type: void

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- submit_cancel_redis_task(interval)

Description: Creates jobs for all time series tables connected to the database and calls the **cancel_redis_task** function.

Parameter: interval for calling the job. The default value is **1h**.

Return type: void

- flush_depend_rule(oid)

Description: Take the CPU table as an example. If a user directly executes some SQL statements on the **redis_old_cpu** and **redis_new_cpu** tables, the original rules cannot work properly. In this case, you can use this function to recreate related rules. The statements for creating rules are in the **pg_rules** system catalog, and you are advised to perform only allowed operations. If you directly run SQL statements on **redis_new_cpu** and **redis_old_cpu**, unknown errors may occur.

Parameter: OID of the CPU table.

Return type: void

## 12.5.33 Distribution Column Recommendation Functions

Distribution column recommendation is used to recommend distribution columns and distribution modes in a distributed database. The purpose is to reduce the labor cost of selecting distribution columns during service migration or rollout.

- sqladvisor.init(char, boolean, boolean, boolean, int, int)

Description: Initializes parameters.

Return type: Boolean

**Table 12-91** Parameter description of init

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| kind | char | Recommendation type. Currently, this parameter can only be set to **D**. | Yes |
| isUseCost | boolean | Indicates whether optimizers are used. If data is available, optimizers are used. | Yes |
| isUseCollect | boolean | Indicates whether the analysis is started from the collected load. The default value is **false**. | No |
| isConstraintPrimaryKey | boolean | Indicates whether primary key constraints are retained. The default value is **true**. | No |
| sqlCount | int | Number of collected SQL statements. The default value is **10000**. The value ranges from 1 to 100000. | No |

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| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| maxMemory | int | Maximum memory occupied by distribution column recommendation. The default value is **1024**. The value ranges from 1 to 10240, in MB. | No |

- sqladvisor.set_weight_params(real, real, real)

Description: Sets the weight of different components in heuristic rules. A default parameter is set when the init function is invoked. This function does not need to be invoked during analysis.

Return type: Boolean

**Table 12-92** Parameter description of set_weight_params

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| joinWeight | real | Weight of JOIN. The value ranges from 0 to 1000. | Yes |
| goupbyWeight | real | Weight of GROUP BY. The value ranges from 0 to 1000. | Yes |
| qualWeight | real | Weight of predicate. The value ranges from 0 to 1000. | Yes |

NOTE

This function is optional. When the init function is executed, the default weights of JOIN, GROUP BY, and predicate are preset to 1.0, 0.1, and 0.05, respectively.

- sqladvisor.set_cost_params(bigint, boolean, text)

Description: Parameter that can be set in the Whtif cost model.

Return type: Boolean

**Table 12-93** Parameter description of set_cost_params

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| maxTime | bigint | Maximum recommendation duration, in minutes. If the value is less than or equal to **0**, the duration is not limited by default. | Yes |

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| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| isTotalSQL | boolean | Indicates whether all SQL statements are used for calculation. The value **true** indicates that all SQL statements are used for calculation. The value **false** indicates that SQL statements whose cost is too high or too low are filtered out based on the percentile. | Yes |
| compressLevel | text | Search space size of the recommendation algorithm. The options are **low**, **med**, and **high**. | Yes |

NOTE

- This function is optional. When the init function is executed, **maxTime** is preset to **–1**, **isTotalSQL** is preset to **true**, and **compressLevel** is preset to **high**.
- A lower compression level indicates longer time, and it is more likely that a better result can be achieved.

- sqladvisor.assign_table_type(text)

Description: Specifies a table as a replication table.

Parameter: table name

Return type: Boolean

NOTE

The specified replication table must be used before **analyze_query** and **analyze_workload** are invoked.

- sqladvisor.analyze_query(text, int)

Description: Imports SQL statements to be recommended and analyzes the components of the statements.

Return type: Boolean

**Table 12-94** Parameter description of analyze_query

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| query | text | SQL statement | Yes |
| frequency | int | Frequency of a statement in the load. The default value is **1**. The value ranges from 1 to 2147483647. | No |

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NOTE

- If the value of the **query** parameter contains special characters, such as single quotation marks ('), you can use single quotation marks (') to escape the special characters.
- This function is not supported in semi-online mode.

- sqladvisor.analyze_workload()

Description: Analyzes the load information collected online.

Return type: Boolean

- sqladvisor.get_analyzed_result(text)

Description: Obtains beneficial components extracted from the current table.

Parameter: text

Return type: record

The following table describes return fields.

| Name | Type | Description |
| --- | --- | --- |
| schema_name | text | Schema name |
| table_name | text | Table name |
| col_name | text | Column name |
| operator | text | Operator type |
| count | int | Number of times that an operator is used |

- sqladvisor.run()

Description: Performs calculation and analysis based on the specified schema and input SQL statements.

Return type: Boolean

- sqladvisor.get_distribution_key()

Description: Obtains the recommendation result.

NOTE

The analysis result is saved in a session. If the session disconnects, the result will be lost.

Return type: record

The following table describes return fields.

| Name | Type | Description |
| --- | --- | --- |
| db_name | text | Database name |
| schema_name | text | Schema name |
| table_name | text | Table name |
| distribution_type | text | Recommended distribution type |
| distribution_key | text | Recommended distribution column |
| start_time | timestamp | Recommended start time |
| end_time | timestamp | Recommended end time |
| cost_improve | text | Cost increase brought by the recommendation result |
| comment | text | Comment |

- sqladvisor.clean()

Description: Clears all the memory in the recommendation process of a session.

Return type: Boolean

- sqladvisor.start_collect_workload(int, int)

Description: Starts online load collection.

Return type: Boolean

**Table 12-95** Parameter description of start_collect_workload

| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| sqlCount | int | Maximum number of SQL statements for online load collection. The value ranges from 1 to 100000 and the default value is **10000**. | Yes |

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| Parameter | Type | Description | Mandatory or Not |
| --- | --- | --- | --- |
| maxMemory | int | Maximum memory occupied by online load collection. The default value is **1024**. The value ranges from 1 to 10240, in MB. | Yes |

**NOTICE**

- The online collection function can be invoked only by the system administrator.
- The load of only one database can be collected at a time.
- Currently, only common SQL statements as well as DML and DQL statements in stored procedures are supported.

- sqladvisor.end_collect_workload()

Description: Disables online load collection.

Return type: Boolean

**NOTICE**

- The online collection function can be disabled only by the system administrator.

- sqladvisor.clean_workload()

Description: Clears the memory in the load.

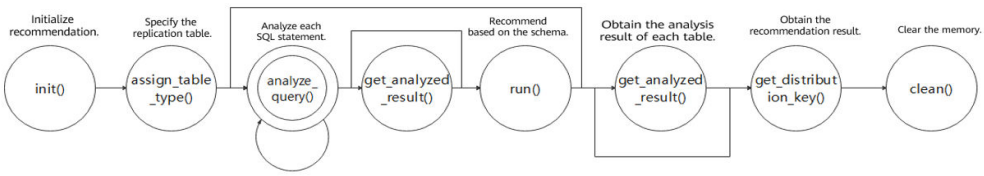
Return type: Boolean

**NOTICE**

- The function of clearing memory in the load can be invoked only by the system administrator.
- You must manually execute the cleanup function.

## Suggestions

- Invoke state machines in the heuristic or WhatIf cost recommendation mode.




- Invoke state machines in semi-online recommendation mode.

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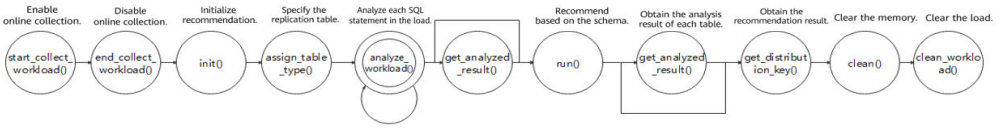


# 12.5.34 Other System Functions

- The GaussDB built-in functions and operators are inherited from the open-source PGXC/PG. For details about the functions listed in this section, see the official documents of PGXC/PG at the following URL:

  http://postgres-xc.sourceforge.net/docs/1_1/functions.html

  https://www.postgresql.org/docs/9.2/functions.html

| _pg_char_max_length | _pg_char_octet_length | _pg_datetime_precision | _pg_expandarray | _pg_index_position | _pg_interval_type | _pg_numeric_precision |
|---|---|---|---|---|---|---|
| _pg_numeric_precision_radix | _pg_numeric_scale | _pg_truetypid | _pg_truetypmod | q | abs | abstime |
| abstimeeq | abstimege | abstimegt | abstimein | abstimele | abstimelt | abstimene |
| abstimeout | abstimerecv | abstimesend | aclcontains | acldefault | aclexplode | aclinsert |
| aclitemeq | aclitemin | aclitemout | aclremove | acos | age | akeys |
| any_in | any_out | anyarray_in | anyarray_out | anyarray_recv | anyarray_send | anyelement_in |
| anyelement_out | anyenum_in | anyenum_out | anynonarray_in | anynonarray_out | anyrange_in | anyrange_out |
| anytextcat | area | areajoinsel | areasel | array_agg | array_agg_finalfn | array_agg_transfn |
| array_append | array_cat | array_dims | array_eq | array_fill | array_ge | array_gt |
| array_in | array_larger | array_le | array_length | array_lower | array_lt | array_ndims |
| array_ne | array_out | array_prepend | array_recv | array_send | array_smaller | array_to_json |
| array_to_string | array_typanalyze | array_upper | arraycontained | arraycontains | arraycontjoinsel | arraycontsel |

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| | | | | | | |
|---|---|---|---|---|---|---|
| arrayoverlap | ascii | asin | atan | atan2 | avals | avg |
| big5_to_euc_tw | big5_to_mic | big5_to_utf8 | bit | bit_and | bit_in | bit_length |
| bit_or | bit_out | bit_recv | bit_send | bitand | bitcat | bitcmp |
| biteq | bitge | bitgt | bitle | bitlt | bitne | bitnot |
| bitor | bitshiftleft | bitshiftright | bittypmodin | bittypmodout | bitxor | bool |
| bool_and | bool_or | booland_statefunc | booleq | boolge | boolgt | boolin |
| boolle | boollt | boolne | boolor_statefunc | boolout | boolrecv | boolsend |
| box | box_above | box_above_eq | box_add | box_below | box_below_eq | box_center |
| box_contain | box_contain_pt | box_contained | box_distance | box_div | box_eq | box_ge |
| box_gt | box_in | box_intersect | box_le | box_left | box_lt | box_mul |
| box_out | box_overabove | box_overbelow | box_overlap | box_overleft | box_overright | box_recv |
| box_right | box_same | box_send | box_sub | bpchar | bpchar_larger | bpchar_pattern_ge |
| bpchar_pattern_gt | bpchar_pattern_le | bpchar_pattern_lt | bpchar_smaller | bpchar_sortsupport | bpcharcmp | bpchareq |
| bpcharge | bpchargt | bpcharclike | bpcharicnlike | bpcharicregexeq | bpcharicregexne | bpcharin |
| bpcharle | bpcharlike | bpcharlt | bpcharne | bpcharnlike | bpcharout | bpcharrecv |
| bpcharregexeq | bpcharregexne | bpcharsend | bpchartypmodin | bpchartypmodout | broadcast | btabstimecmp |

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| | | | | | | |
|---|---|---|---|---|---|---|
| btarraycmp | btbeginscan | btboolcmp | btbpchar_pattern_cmp | btbuild | btbuildempty | btbulkdelete |
| btcanreturn | btcharcmp | btcostestimate | btendscan | btfloat48cmp | btfloat4cmp | btfloat4sortsupport |
| btfloat84cmp | btfloat8cmp | btfloat8sortsupport | btgetbitmap | btgettuple | btinsert | btint24cmp |
| btint28cmp | btint2cmp | btint2sortsupport | btint42cmp | btint48cmp | btint4cmp | btint4sortsupport |
| btint82cmp | btint84cmp | btint8cmp | btint8sortsupport | btmarkpos | btnamecmp | btnamesortsupport |
| btoidcmp | btoidsortsupport | btoidvectorcmp | btoptions | btrecordcmp | btreltimecmp | btrescan |
| btrestrpos | btrim | bttext_pattern_cmp | bttextcmp | bttextsortsupport | bttidcmp | bttintervalcmp |
| btvacuumcleanup | bytea_sortsupport | bytea_string_agg_finalfn | bytea_string_agg_transfn | byteacat | byteacmp | byteaeq |
| byteage | byteagt | byteain | byteale | bytealike | bytealt | byteane |
| byteanlike | byteaout | byteasend | cash_cmp | cash_div_cash | cash_div_flt4 | cash_div_flt8 |
| cash_div_int2 | cash_div_int4 | cash_div_int8 | cash_eq | cash_ge | cash_gt | cash_in |
| cash_le | cash_lt | cash_mi | cash_mul_flt4 | cash_mul_flt8 | cash_mul_int2 | cash_mul_int4 |
| cash_mul_int8 | cash_ne | cash_out | cash_pl | cash_recv | cash_send | cashlarger |
| cashsmaller | cbrt | ceil | ceiling | center | char | char_length |
| character_length | chareq | charge | chargt | charin | charle | charlt |
| charne | charout | charrecv | charsend | chr | cideq | |

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| cidin | cidout | cidr | cidr_in | cidr_out | cidr_recv | cidr_send |
|---|---|---|---|---|---|---|
| cidrecv | cidsend | circle | circle_above | circle_add_pt | circle_below | circle_center |
| circle_contain | circle_contain_pt | circle_contained | circle_distance | circle_div_pt | circle_eq | circle_ge |
| circle_gt | circle_in | circle_le | circle_left | circle_lt | circle_mul_pt | circle_ne |
| circle_out | circle_overabove | circle_overbelow | circle_overlap | circle_overleft | circle_overright | circle_recv |
| circle_right | circle_same | circle_send | circle_sub_pt | clock_timestamp | close_lb | close_ls |
| close_lseg | close_pb | close_pl | close_ps | close_sb | close_sl | col_description |
| concat | concat_ws | contjoinsel | contsel | convert | convert_from | convert_to |
| corr | cos | cot | count | covar_pop | covar_samp | cstring_in |
| cstring_out | cstring_recv | cstring_send | cume_dist | current_database | current_query | current_schema |
| xpath_exists | current_setting | current_user | currtid | currtid2 | currval | cursor_to_xml |
| cursor_to_xmlschema | database_to_xml | database_to_xml_and_xmlschema | database_to_xmlschema | date | date_cmp | date_cmp_timestamp |
| date_cmp_timestamptz | date_eq | date_eq_timestamp | date_eq_timestamptz | date_ge | date_ge_timestamp | date_ge_timestamptz |
| date_gt | date_gt_timestamp | date_gt_timestamptz | date_in | date_larger | date_le | date_le_timestamp |

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| | | | | | | |
|---|---|---|---|---|---|---|
| date_le_timestamptz | date_lt | date_lt_timestamp | date_lt_timestamptz | date_mi | date_mi_interval | date_mii |
| date_ne | date_ne_timestamp | date_ne_timestamptz | date_out | date_pl_interval | date_pli | date_recv |
| date_send | date_smaller | date_sortsupport | daterange_canonical | daterange_subdiff | datetime_pl | datetimetz_pl |
| dcbrt | decode | defined | degrees | delete | dense_rank | dexp |
| diagonal | diameter | dispell_init | dispell_lexize | dist_cpoly | dist_lb | dist_pb |
| dist_pc | dist_pl | dist_ppath | dist_ps | dist_sb | dist_sl | div |
| dlog1 | dlog10 | domain_in | domain_recv | dpow | dround | dsimple_init |
| dsimple_lexize | dsnowball_init | dsnowball_lexize | dsqrt | dsynonym_init | dsynonym_lexize | dtrunc |
| each | enum_ne | enum_out | enum_range | enum_recv | enum_send | enum_smaller |
| eqjoinsel | eqsel | euc_cn_to_mic | euc_cn_to_utf8 | euc_jis_2004_to_shift_jis_2004 | euc_jis_2004_to_utf8 | euc_jp_to_mic |
| euc_jp_to_sjis | euc_jp_to_utf8 | euc_kr_to_mic | euc_kr_to_utf8 | euc_tw_to_big5 | euc_tw_to_mic | euc_tw_to_utf8 |
| every | exist | exists_all | exists_any | exp | factorial | family |
| fdw_handler_in | fdw_handler_out | fetchval | first_value | float4 | float4_accum | float48div |
| float48eq | float48ge | float48gt | float48le | float48lt | float48mi | float48mul |
| float48ne | float48pl | float4abs | float4div | float4eq | float4ge | float4gt |

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| | | | | | | |
|---|---|---|---|---|---|---|
| float4in | float4larger | float4le | float4lt | float4mi | float4mul | float4ne |
| float4out | float4pl | float4recv | float4send | float4smaller | float4um | float4up |
| float8 | float8_accum | float8_avg | float8_collect | float8_corr | float8_covar_pop | float8_covar_samp |
| float8_regr_accum | float8_regr_avgx | float8_regr_avgy | float8_regr_collect | float8_regr_intercept | float8_regr_r2 | float8_regr_slope |
| float8_regr_sxx | float8_regr_sxy | float8_regr_syy | float8_stddev_pop | float8_stddev_samp | float8_var_pop | float8_var_samp |
| float84div | float84eq | float84ge | float84gt | float84le | float84lt | float84mi |
| float84mul | float84ne | float84pl | float8abs | float8div | float8eq | float8ge |
| float8gt | float8in | float8larger | float8le | float8lt | float8mi | float8mul |
| float8ne | float8out | float8pl | float8recv | float8send | float8smaller | float8um |
| float8up | floor | flt4_mul_cash | flt8_mul_cash | fmgr_c_validator | fmgr_internal_validator | fmgr_sql_validator |
| format | format_type | gb18030_to_utf8 | gbk_to_utf8 | generate_series | generate_subscripts | get_bit |
| get_byte | get_current_ts_config | get_global_gs_asp | get_large_table_name | gin_clean_pending_list | gin_cmp_prefix | gin_cmp_tslexeme |
| gin_extract_tsquery | gin_extract_tsvector | gin_tsquery_consistent | gin_tsquery_triconsistent | ginarrayconsistent | ginarrayextract | ginarraytriconsistent |
| ginbeginscan | ginbuild | ginbuildempty | ginbulkdelete | gincostestimate | ginendscan | gingetbitmap |

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| | | | | | | |
|---|---|---|---|---|---|---|
| gininsert | ginmarkpos | ginoptions | ginqueryarrayextract | ginrescan | ginrestrpos | ginvacuumcleanup |
| gist_box_compress | gist_box_consistent | gist_box_decompress | gist_box_penalty | gist_box_picksplit | gist_box_same | gist_box_union |
| gist_circle_compress | gist_circle_consistent | gist_point_compress | gist_point_consistent | gist_point_distance | gist_poly_compress | gist_poly_consistent |
| gistbeginscan | gistbuild | gistbuildempty | gistbulkdelete | gistcostestimate | gistendscan | gistgetbitmap |
| gistgettuple | gistinsert | gistmarkpos | gistoptions | gistrescan | gistrestrpos | gistvacuumcleanup |
| gtsquery_compress | gtsquery_consistent | gtsquery_decompress | gtsquery_penalty | gtsquery_picksplit | gtsquery_same | gtsquery_union |
| gtsvector_compress | gtsvector_consistent | gtsvector_decompress | gtsvector_penalty | gtsvector_picksplit | gtsvector_same | gtsvector_union |
| gtsvectorin | gtsvectorout | has_tablespace_privilege | has_type_privilege | hash_aclitem | hashbeginscan | hashbuild |
| hashbuildempty | hashbulkdelete | hashcostestimate | hashendscan | hashgetbitmap | hashgettuple | hashinsert |
| hashint2vector | hashint4 | hashint8 | hashmacaddr | hashmarkpos | hashname | hashoid |
| hashoidvector | hashoptions | hashrescan | hashrestrpos | hashtext | hashvacuumcleanup | hashvarlena |
| host | hostmask | iclikejoinsel | iclikesel | icnlikejoinsel | icnlikesel | icregexeqjoinsel |
| icregexeqsel | icregexnejoinsel | icregexnesel | inet_client_addr | inet_client_port | inet_in | inet_out |
| inet_recv | inet_send | inet_server_addr | inet_server_port | inetand | inetmi | inetmi_int8 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| inetnot | inetor | inetpl | initcap | int2_accum | int2_avg_accum | int2_mul_cash |
| int2_sum | int24div | int24eq | int24ge | int24gt | int24le | int24lt |
| int24mi | int24mul | int24ne | int24pl | int28div | int28eq | int28ge |
| int28gt | int28le | int28lt | int28mi | int28mul | int28ne | int28pl |
| int2abs | int2and | int2div | int2eq | int2ge | int2gt | int2in |
| int2larger | int2le | int2lt | int2mi | int2mod | int2mul | int2ne |
| int2not | int2or | int2out | int2pl | int2recv | int2send | int2shl |
| int2shr | int2smaller | int2um | int2up | int2vectoreq | int2vectorin | int2vectorout |
| int2vectorrecv | int2vectorsend | int2xor | int4_accum | int4_avg_accum | int4_mul_cash | int4_sum |
| int42div | int42eq | int42ge | int42gt | int42le | int42lt | int42mi |
| int42mul | int42ne | int42pl | int48div | int48eq | int48ge | int48gt |
| int48le | int48lt | int48mi | int48mul | int48ne | int48pl | int4abs |
| int4and | int4div | int4eq | int4ge | int4gt | int4in | int4inc |
| int4larger | int4le | int4lt | int4mi | int4mod | int4mul | int4ne |
| int4not | int4or | int4out | int4pl | int4range | int4range_canonical | int4range_subdiff |
| int4recv | int4send | int4shl | int4shr | int4smaller | int4um | int4up |
| int4xor | int8 | int8_avg | int8_avg_accum | int8_avg_collect | int8_mul_cash | int8_sum |
| int8_sum_to_int8 | int8+1635:1668_accum | int82div | int82eq | int82ge | int82gt | int82le |

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| | | | | | | |
|---|---|---|---|---|---|---|
| int82lt | int82mi | int82mul | int82ne | int82pl | int84div | int84eq |
| int84ge | int84gt | int84le | int84lt | int84mi | int84mul | int84ne |
| int84pl | int8abs | int8and | int8div | int8eq | int8ge | int8gt |
| int8in | int8inc | int8inc_any | int8inc_float8_float8 | int8larger | int8le | int8lt |
| int8mi | int8mod | int8mul | int8ne | int8not | int8or | int8out |
| int8pl | int8pl_inet | int8range | int8range_canonical | int8range_subdiff | int8recv | int8send |
| int8shl | int8shr | int8smaller | int8um | int8up | int8xor | integer_pl_date |
| inter_lb | inter_sb | inter_sl | internal_in | internal_out | interval | interval_accum |
| interval_avg | interval_cmp | interval_collect | interval_div | interval_eq | interval_ge | interval_gt |
| interval_hash | interval_in | interval_larger | interval_le | interval_lt | interval_mi | interval_mul |
| interval_ne | interval_out | interval_pl | interval_pl_date | interval_pl_time | interval_pl_timestamp | interval_pl_timestamptz |
| interval_pl_timetz | interval_recv | interval_send | interval_smaller | interval_transform | interval_um | intervaltypmodin |
| intervaltypmodout | intinterval | isexists | ishorizontal | iso_to_koi8r | iso_to_mic | iso_to_win1251 |
| iso_to_win866 | iso8859_1_to_utf8 | iso8859_to_utf8 | isparallel | isperp | isvertical | johab_to_utf8 |
| jsonb_in | jsonb_out | jsonb_recv | jsonb_send | - | - | - |
| json_in | json_out | json_recv | json_send | justify_days | justify_hours | justify_interval |
| koi8r_to_iso | koi8r_to_mic | koi8r_to_utf8 | koi8r_to_win1251 | koi8r_to_win866 | koi8u_to_utf8 | language_handler_in |

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| language_handler_out | latin1_to_mic | latin2_to_mic | latin2_to_win1250 | latin3_to_mic | latin4_to_mic | like_escape |
|---|---|---|---|---|---|---|
| likejoinsel | likesel | line | line_distance | line_eq | line_horizontal | line_in |
| line_interpt | line_intersect | line_out | line_parallel | line_perp | line_recv | line_send |
| line_vertical | ln | lo_close | lo_creat | lo_create | lo_export | lo_import |
| lo_lseek | lo_open | lo_tell | lo_truncate | lo_unlink | log | loread |
| lower | lower_inc | lower_inf | lowrite | lpad | lseg | lseg_center |
| lseg_distance | lseg_eq | lseg_ge | lseg_gt | lseg_horizontal | lseg_in | lseg_interpt |
| lseg_intersect | lseg_le | lseg_length | lseg_lt | lseg_ne | lseg_out | lseg_parallel |
| lseg_perp | lseg_recv | lseg_send | lseg_vertical | ltrim | macaddr_and | macaddr_cmp |
| macaddr_eq | macaddr_ge | macaddr_gt | macaddr_in | macaddr_le | macaddr_lt | macaddr_ne |
| macaddr_not | macaddr_or | macaddr_out | macaddr_recv | macaddr_send | makeaclitem | masklen |

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| | | | | | | |
|---|---|---|---|---|---|---|
| max | md5<br>The MD5 encryption algorithm has lower security and poses security risks. Therefore, you are advised to use a more secure encryption algorithm. | mic_to_big5 | mic_to_euc_cn | mic_to_euc_jp | mic_to_euc_kr | mic_to_euc_tw |
| mic_to_iso | mic_to_koi8r | mic_to_latin1 | mic_to_latin2 | mic_to_latin3 | mic_to_latin4 | mic_to_sjis |
| mic_to_win1250 | mic_to_win1251 | mic_to_win866 | min | mktinterval | money | mul_d_interval |
| name | nameeq | namege | namegt | nameiclike | nameicnlike | nameicregexeq |
| nameicregexne | namein | namele | namelike | namelt | namene | namenlike |
| nameout | namerecv | nameregexeq | nameregexne | namesend | neqjoinsel | neqsel |
| network_cmp | network_eq | network_ge | network_gt | network_le | network_lt | network_ne |
| network_sub | network_subeq | network_sup | network_supeq | nlikejoinsel | nlikesel | numeric |
| numeric_abs | numeric_accum | numeric_add | numeric_avg | numeric_avg_accum | numeric_avg_collect | numeric_cmp |

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| | | | | | | |
|---|---|---|---|---|---|---|
| numeric_collect | numeric_div | numeric_div_trunc | numeric_eq | numeric_exp | numeric_fac | numeric_ge |
| numeric_gt | numeric_in | numeric_inc | numeric_larger | numeric_le | numeric_ln | numeric_log |
| numeric_lt | numeric_mod | numeric_mul | numeric_ne | numeric_out | numeric_power | numeric_recv |
| numeric_send | numeric_smaller | numeric_sortsupport | numeric_sqrt | numeric_stddev_pop | numeric_stddev_samp | numeric_sub |
| numeric_transform | numeric_uminus | numeric_uplus | numeric_var_pop | numeric_var_samp | numerictypmodin | numerictypmodout |
| numrange_subdiff | oid | oideq | oidge | oidgt | oidin | oidlarger |
| oidle | oidlt | oidne | oidout | oidrecv | oidsend | oidsmaller |
| oidvectoreq | oidvectorge | oidvectorgt | oidvectorin | oidvectorle | oidvectorlt | oidvectorne |
| oidvectorout | oidvectorrecv | oidvectorsend | oidvectortypes | on_pb | on_pl | on_ppath |
| on_ps | on_sb | on_sl | opaque_in | opaque_out | ordered_set_transition | overlaps |
| overlay | path | path_add | path_add_pt | path_center | path_contain_pt | path_distance |
| path_div_pt | path_in | path_inter | path_length | path_mul_pt | path_n_eq | path_n_ge |
| path_n_gt | path_n_le | path_n_lt | path_npoints | path_out | path_recv | path_send |
| path_sub_pt | percentile_cont | percentile_cont_float8_final | percentile_cont_interval_final | pg_char_to_encoding | pg_cursor | pg_encoding_max_length |

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| | | | | | | |
|---|---|---|---|---|---|---|
| pg_encoding_to_char | pg_extension_config_dump | - | - | pg_node_tree_in | pg_node_tree_out | pg_node_tree_recv |
| pg_node_tree_send | pg_prepared_statement | pg_prepared_xact | pg_notify | pg_stat_get_wal_receiver | pg_show_all_settings | pg_stat_get_bgwriter_stat_reset_time |
| pg_stat_get_buf_fsync_backend | pg_stat_get_checkpoint_sync_time | pg_stat_get_checkpoint_write_time | pg_stat_get_db_blk_read_time | pg_stat_get_db_blk_write_time | pg_stat_get_db_conflict_all | pg_stat_get_db_conflict_bufferpin |
| pg_stat_get_db_conflict_snapshot | pg_stat_get_db_conflict_startup_deadlock | pg_switch_xlog | xpath | pg_timezone_abbrevs | pg_timezone_names | pgxc_node_str |
| plpgsql_call_handler | plpgsql_inline_handler | plpgsql_validator | point_above | point_add | point_below | point_distance |
| point_div | point_eq | point_horiz | point_in | point_left | point_mul | point_ne |
| point_out | point_recv | point_right | point_send | point_sub | point_vert | poly_above |
| poly_below | poly_center | poly_contain | poly_contain_pt | poly_contained | poly_distance | poly_in |
| poly_left | poly_npoints | poly_out | poly_overabove | poly_overbelow | poly_overlap | poly_overleft |
| poly_overright | poly_recv | poly_right | poly_same | poly_send | polygon | position |
| positionjoinsel | positionsel | postgresql_fdw_validator | pow | power | prsd_end | prsd_headline |
| prsd_lextype | prsd_nexttoken | prsd_start | pt_contained_circle | pt_contained_poly | query_to_xml | query_to_xml_and_xmlschema |
| query_to_xmlschema | quote_ident | quote_literal | quote_nullable | radians | radius | random |

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| range_adjacent | range_after | range_before | range_cmp | range_contained_by | range_contains | range_contains_elem |
|---|---|---|---|---|---|---|
| range_eq | range_ge | range_gist_compress | range_gist_consistent | range_gist_decompress | range_gist_penalty | range_gist_picksplit |
| range_gist_same | range_gist_union | range_gt | range_in | range_intersect | range_le | range_lt |
| range_minus | range_ne | range_out | range_overlaps | range_overleft | range_overright | range_recv |
| range_send | range_typanalyze | range_union | rank | record_eq | record_ge | record_gt |
| record_in | record_le | record_lt | record_ne | record_out | record_recv | record_send |
| regclass | regclassin | regclassout | regclassrecv | regclassend | regconfigin | regconfigout |
| regconfigrecv | regconfigsend | regdictionaryin | regdictionaryout | regdictionaryrecv | regdictionarysend | regexeqjoinsel |
| regexeqsel | regexnejoinsel | regexnesel | regexp_matches | regexp_replace | regexp_split_to_array | regexp_split_to_table |
| regoperatorin | regoperatorout | regoperatorrecv | regoperatorsend | regoperin | regoperout | regoperrecv |
| regopersend | regprocedurein | regprocedureout | regprocedurerecv | regproceduresend | regprocin | regprocout |
| regprocrecv | regprocsend | regr_avgx | regr_avgy | regr_count | regr_intercept | regr_r2 |
| regr_slope | regr_sxx | regr_sxy | regr_syy | regtypein | regtypeout | regtyperecv |
| regtypesend | reltime | reltimeeq | reltimege | reltimegt | reltimein | reltimele |
| reltimelt | reltimene | reltimeout | reltimerecv | reltimesend | repeat | replace |

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| | | | | | | |
|---|---|---|---|---|---|---|
| reverse | RI_FKey_cascade_del | RI_FKey_cascade_upd | RI_FKey_check_ins | RI_FKey_check_upd | RI_FKey_noaction_del | RI_FKey_noaction_upd |
| RI_FKey_restrict_del | RI_FKey_restrict_upd | RI_FKey_setdefault_del | RI_FKey_setdefault_upd | RI_FKey_setnull_del | RI_FKey_setnull_upd | right |
| round | row_number | row_to_json | rpad | rtrim | scalargtjoinsel | scalargtsel |
| scalarltjoinsel | scalarltsel | schema_to_xml | schema_to_xml_and_xmlschema | schema_to_xmlschema | session_user | set_bit |
| set_byte | set_config | set_masklen | shift_jis_2004_to_euc_jis_2004 | shift_jis_2004_to_utf8 | sjis_to_euc_jp | sjis_to_mic |
| sjis_to_utf8 | smgrin | smgrout | spg_kd_choose | spg_kd_config | spg_kd_inner_consistent | spg_kd_picksplit |
| spg_quad_choose | spg_quad_config | spg_quad_inner_consistent | spg_quad_leaf_consistent | spg_quad_picksplit | spg_text_choose | spg_text_config |
| spg_text_inner_consistent | spg_text_leaf_consistent | spg_text_picksplit | spgbeginscan | spgbuild | spgbuildempty | spgbulkdelete |
| spgcanreturn | spgcostestimate | spgendscan | spggetbitmap | spggettuple | spginsert | spgmarkpos |
| spgoptions | spgrescan | spgrestrpos | spgvacuumcleanup | stddev | stddev_pop | stddev_samp |

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| string_agg | string_agg_finalfn | string_agg_transfn | strip | sum | suppress_redundant_updates_trigger | table_to_xml |
|---|---|---|---|---|---|---|
| table_to_xml_and_xmlschema | table_to_xmlschema | tan | text | text_ge | text_gt | text_larger |
| text_le | text_lt | text_pattern_ge | text_pattern_gt | text_pattern_le | text_pattern_lt | text_smaller |
| textanycat | textcat | texteq | texticlike | texticnlike | texticregexeq | texticregexne |
| textin | textlike | textne | textnlike | textout | textrecv | textregexeq |
| textregexne | textsend | thesaurus_init | thesaurus_lexize | tideq | tidge | tidgt |
| tidin | tidlarger | tidle | tidlt | tidne | tidout | tidrecv |
| tidsend | tidsmaller | time | time_cmp | time_eq | time_ge | time_gt |
| time_hash | time_in | time_larger | time_le | time_lt | time_mi_interval | time_mi_time |
| time_ne | time_out | time_pl_interval | time_recv | time_send | time_smaller | time_transform |
| timedate_pl | timemi | timepl | timestamp | timestamp_cmp | timestamp_cmp_date | timestamp_cmp_timestamptz |
| timestamp_eq | timestamp_eq_date | timestamp_eq_timestamptz | timestamp_ge | timestamp_ge_date | timestamp_ge_timestamptz | timestamp_gt |
| timestamp_gt_date | timestamp_gt_timestamptz | timestamp_hash | timestamp_in | timestamp_larger | timestamp_le | timestamp_le_date |

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| | | | | | | |
|---|---|---|---|---|---|---|
| timestamp_le_timestamptz | timestamp_lt | timestamp_lt_date | timestamp_lt_timestamptz | timestamp_mi | timestamp_mi_interval | timestamp_ne |
| timestamp_ne_date | timestamp_ne_timestamptz | timestamp_out | timestamp_pl_interval | timestamp_recv | timestamp_send | timestamp_smaller |
| timestamp_sortsupport | timestamp_transform | timestamptypmodin | timestamptypmodout | timestamptz | timestamptz_cmp | timestamptz_cmp_date |
| timestamptz_cmp_timestamp | timestamptz_eq | timestamptz_eq_date | timestamptz_eq_timestamp | timestamptz_ge | timestamptz_ge_date | timestamptz_ge_timestamp |
| timestamptz_gt | timestamptz_gt_date | timestamptz_gt_timestamp | timestamptz_in | timestamptz_larger | timestamptz_le | timestamptz_le_date |
| timestamptz_le_timestamp | timestamptz_lt | timestamptz_lt_date | timestamptz_lt_timestamp | timestamptz_mi | timestamptz_mi_interval | timestamptz_ne |
| timestamptz_ne_date | timestamptz_ne_timestamp | timestamptz_out | timestamptz_pl_interval | timestamptz_recv | timestamptz_send | timestamptz_smaller |
| timestamptztypmodin | timestamptztypmodout | timetypmodin | timetypmodout | timetz | timetz_cmp | timetz_eq |
| timetz_ge | timetz_gt | timetz_hash | timetz_in | timetz_larger | timetz_le | timetz_lt |
| timetz_mi_interval | timetz_ne | timetz_out | timetz_pl_interval | timetz_recv | timetz_send | timetz_smaller |
| timetzdate_pl | timetztypmodin | timetztypmodout | timezone (2069) | timezone (1159) | timezone (2037) | timezone (2070) |

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| timezone (1026) | timezone (2038) | tintervalct | tintervaleq | tintervalge | tintervalgt | tintervalin |
|---|---|---|---|---|---|---|
| tintervalle | tintervalleneq | tintervallenge | tintervallengt | tintervallenle | tintervallenlt | tintervallenne |
| tintervallt | tintervalne | tintervalout | tintervalov | tintervalrecv | tintervalsame | tintervalsend |
| tintervalstart | to_ascii (1845) | to_ascii (1847) | to_ascii (1846) | trigger_in | trigger_out | ts_match_qv |
| ts_match_tq | ts_match_tt | ts_match_vq | ts_rank | ts_rank_cd | ts_rewrite | ts_stat |
| ts_token_type | ts_typanalyze | tsmatchjoinsel | tsmatchsel | tsq_mcontained | tsq_mcontains | tsquery_and |
| tsquery_cmp | tsquery_eq | tsquery_ge | tsquery_gt | tsquery_le | tsquery_lt | tsquery_ne |
| tsquery_not | tsquery_or | tsqueryin | tsqueryout | tsqueryrecv | tsquerysend | tsrange |
| tsrange_subdiff | tstzrange | tstzrange_subdiff | tsvector_cmp | tsvector_concat | tsvector_eq | tsvector_ge |
| tsvector_gt | tsvector_le | tsvector_lt | tsvector_ne | tsvector_update_trigger | tsvector_update_trigger_column | tsvectorin |
| tsvectorout | tsvectorrecv | tsvectorsend | txid_current | txid_current_snapshot | txid_snapshot_in | txid_snapshot_out |
| txid_snapshot_recv | txid_snapshot_send | txid_snapshot_xip | txid_snapshot_xmax | txid_snapshot_xmin | txid_visible_in_snapshot | uhc_to_utf8 |
| unique_key_recheck | unknownin | unknownout | unknownrecv | unknownsend | unnest | utf8_to_big5 |
| utf8_to_euc_cn | utf8_to_euc_jis_2004 | utf8_to_euc_jp | utf8_to_euc_kr | utf8_to_euc_tw | utf8_to_gb18030 | utf8_to_gbk |

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| | | | | | | |
|---|---|---|---|---|---|---|
| utf8_to_iso8859 | utf8_to_iso8859_1 | utf8_to_johab | utf8_to_koi8r | utf8_to_koi8u | utf8_to_shift_jis_2004 | utf8_to_sjis |
| utf8_to_uhc | utf8_to_win | uuid_cmp | uuid_eq | uuid_ge | uuid_gt | uuid_hash |
| uuid_in | uuid_le | uuid_lt | uuid_ne | uuid_out | uuid_recv | uuid_send |
| var_pop | var_samp | varbit | varbit_in | varbit_out | varbit_recv | varbit_send |
| varbit_transform | varbitcmp | varbiteq | varbitge | varbitgt | varbitle | varbitlt |
| varbitne | varbittypmodin | varbittypmodout | varchar | varchar_transform | varcharin | varcharout |
| varcharrecv | varcharsend | varchartypmodin | varchartypmodout | variance | void_in | void_out |
| void_recv | void_send | win_to_utf8 | win1250_to_latin2 | win1250_to_mic | win1251_to_iso | win1251_to_koi8r |
| win1251_to_mic | win1251_to_win866 | win866_to_iso | win866_to_koi8r | win866_to_mic | win866_to_win1251 | xideq |
| xideqint4 | xidin | xidout | xidrecv | xidsend | xml | xml_in |
| xml_is_well_formed | xml_is_well_formed_content | xml_is_well_formed_document | xml_out | xml_recv | xml_send | xmlagg |
| xmlcomment | xmlconcat2 | xmlexists | xmlvalidate | - | - | - |

The following table lists the functions used by GaussDB to implement internal system functions. You are not advised to use these functions. If you need to use them, contact Huawei technical support.

- smgreq(a smgr, b smgr)

  Description: Compares two smgrs to check whether they are the same.

  Parameters: smgr, smgr

  Return type: Boolean

- smgrne(a smgr, b smgr)

  Description: Checks whether the two smgrs are different.

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Parameters: smgr, smgr

Return type: Boolean

- spread_collect

  Description: Calculates the difference between the maximum and minimum values in a certain period of time. This function is used for data collection of aggregate functions.

  Parameters: s real[], v real[]

  Return type: real[]

- spread_final

  Description: Calculates the difference between the maximum and minimum values in a certain period of time. This function is used for the final data processing of the aggregate function.

  Parameter: s real[]

  Return type: real

- spread_internal

  Description: Calculates the difference between the maximum and minimum values in a certain period of time. This function is used for the process of aggregate functions.

  Parameters: s real[], v real

  Return type: real[]

- xidin4

  Description: Inputs a 4-byte xid.

  Parameter: cstring

  Return type: xid32

- set_hashbucket_info

  Description: Sets hash bucket information.

  Parameter: text

  Return type: Boolean

- gap_fill_internal

  Description: Returns the first non-NULL value in the parameter list.

  Parameter: s anyelement, v anyelement

  Return type: anyelement

- hs_concat

  Description: Concatenates two pieces of hstore data.

  Parameters: hstore, hstore

  Return type: hstore

- hs_contained

  Description: Determines whether two hstore data records are included. The return value is of the Boolean type.

  Parameters: hstore, hstore

  Return type: Boolean

- hs_contains

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Description: Determines whether two hstore data records are included. The return value is of the Boolean type.

Parameters: hstore, hstore

Return type: Boolean

- hstore

  Description: Converts parameters to the hstore type.

  Parameters: text, text

  Return type: hstore

- hstore_in

  Description: Receives hstore data in string format.

  Parameter: cstring

  Return type: hstore

- hstore_out

  Description: Sends hstore data in string format.

  Parameter: hstore

  Return type: cstring

- hstore_send

  Description: Sends hstore data in bytea format.

  Parameter: hstore

  Return type: bytea

- hstore_to_array

  Description: Sends hstore data in text array format.

  Parameter: hstore

  Return type: text[]

- hstore_to_matrix

  Description: Sends hstore data in text array format.

  Parameter: hstore

  Return type: text[]

- hstore_version_diag

  Description: Sends hstore data in integer array format.

  Parameter: hstore

  Return type: integer

- int1send

  Description: Packs unsigned 1-byte integers into the internal data buffer stream.

  Parameter: tinyint

  Return type: bytea

- is_contain_namespace

  Description: Searches for the table name and namespace split location. If no namespace exists, 0 is returned.

  Parameter: relationname name

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Return type: integer

- is_oid_in_group_members

  Description: Not supported

  Parameter: node_oid oid, group_members oidvector_extend

  Return type: Boolean

- isdefined

  Description: Checks whether a specified key exists.

  Parameters: hstore, text

  Return type: Boolean

- isubmit_on_nodes_internal

  Description: Not supported

  Parameter: job bigint, node_name name, database name, what text, next_date timestamp without time zone, job_interval text

  Return type: integer

- listagg

  Description: aggregate function of the list type

  Parameters: smallint, text

  Return type: text

- log_fdw_validator

  Description: validate function

  Parameter: text[], oid

  Return type: void

- nvarchar2typmodin

  Description: Obtains the typmod information of varchar.

  Parameter: cstring[]

  Return type: integer

- nvarchar2typmodout

  Description: Obtains the typmod information of varchar, constructs a character string, and returns the character string.

  Parameter: integer

  Return type: cstring

- pg_nodes_memmon

  Description: Not supported

  Parameter: nan

  Return type: innernname text, innerusedmem bigint, innertopctxt bigint, nname text, usedmem text, sharedbuffercache text, topcontext text

- read_disable_conn_file

  Description: Reads forbidden connection files.

  Parameter: nan

  Return type: disconn_mode text, disconn_host text, disconn_port text, local_host text, local_port text, redo_finished text

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- regex_like_m

  Description: Regular expression match, which is used to determine whether a character string complies with a specified regular expression.

  Parameters: text, text

  Return type: Boolean

- update_pgjob

  Description: Updates a job.

  Parameter: bigint, "char", bigint, timestamp without time zone, timestamp without time zone, timestamp without time zone, timestamp without time zone, timestamp without time zone, smallint, text

  Return type: void

- enum_cmp

  Description: Enumeration comparison function, which is used to determine whether two enumeration classes are equal and determine their relative sizes.

  Parameter: anyenum, anyenum

  Return type: integer

- enum_eq

  Description: Enumeration comparison function, which is used to implement the = symbol.

  Parameter: anyenum, anyenum

  Return type: Boolean

- enum_first

  Description: Returns the first element in the enumeration class.

  Parameter: anyenum

  Return type: anyenum

- enum_ge

  Description: Enumeration comparison function, which is used to implement the >= symbol.

  Parameter: anyenum, anyenum

  Return type: Boolean

- enum_gt

  Description: Enumeration comparison function, which is used to implement the > sign.

  Parameter: anyenum, anyenum

  Return type: Boolean

- enum_in

  Description: Enumeration comparison function, which is used to determine whether an element is in an enumeration class.

  Parameter: cstring, oid

  Return type: anyenum

- enum_larger

  Description: Enumeration comparison function, which is used to implement the > sign.

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Parameter: anyenum, anyenum

Return type: anyenum

- enum_last

  Description: Returns the last element in the enumeration class.

  Parameter: anyenum

  Return type: anyenum

- enum_le

  Description: Enumeration comparison function, which is used to implement the <= symbol.

  Parameter: anyenum, anyenum

  Return type: Boolean

- enum_lt

  Description: Enumeration comparison function, which is used to implement the < symbol.

  Parameter: anyenum, anyenum

  Return type: Boolean

- enum_smaller

  Description: Enumeration comparison function, which is used to implement the < symbol.

  Parameter: anyenum, anyenum

  Return type: Boolean

- node_oid_name

  Description: Not supported

  Parameter: oid

  Return type: cstring

- pg_buffercache_pages

  Description: Reads data from the shared buffer.

  Parameter: nan

  Return type: bufferid integer, relfilenode oid, bucketid smallint, storage_type oid, reltablespace oid, reldatabase oid, relforknumber smallint, relblocknumber bigint, isdirty boolean, and usage_count smallint

- pg_check_xidlimit

  Description: Checks whether nextxid is greater than or equal to xidwarnlimit.

  Parameter: nan

  Return type: Boolean

- pg_comm_delay

  Description: Displays the delay status of the communication library of a single DN.

  Parameter: nan

  Return type: text, text, integer, integer, integer, integer

- pg_comm_recv_stream

  Description: Displays the receiving stream status of all communication libraries on a single DN.

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Parameter: nan

Return type: text, bigint, text, bigint, integer, integer, integer, text, bigint, integer, integer, integer, bigint, bigint, bigint, bigint, bigint

- pg_comm_send_stream

  Description: Displays the sending stream status of all communication libraries on a single DN.

  Parameter: nan

  Return type: text, bigint, text, bigint, integer, integer, integer, text, bigint, integer, integer, integer, bigint, bigint, bigint, bigint, bigint

- pg_comm_status

  Description: Displays the communication status of a single DN.

  Parameter: nan

  Return type: text, integer, integer, bigint, bigint, bigint, bigint, bigint, integer, integer, integer, integer, integer

- pg_log_comm_status

  Description: Prints some logs on the DN.

  Parameter: nan

  Return type: Boolean

- pg_parse_clog

  Description: Parses clog to obtain the status of xid.

  Parameter: nan

  Return type: xid xid, status text

- pg_pool_ping

  Description: Sets PoolerPing.

  Parameter: Boolean

  Return type: SETOF boolean

- pg_pool_validate

  Description: Compares fields in the **pgxc_node** system catalog to check whether a connection is available.

  Parameter: clear boolean, co_node_name cstring

  Return type: pid bigint, node_name text

- pg_resume_bkp_flag

  Description: Obtains the delay xlong flag for backup and restoration.

  Parameter: slot_name name

  Return type: start_backup_flag boolean, to_delay boolean, ddl_delay_recycle_ptr text, rewind_time text

- pg_stat_get_pooler_status

  Description: Queries the cache connection status in the pooler.

  Parameter: nan

  Return type: text, text, bigint, text, bigint, boolean, text, bigint, bigint, bigint, bigint, bigint

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**Table 12-96** PG_STAT_GET_POOLER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| database_name | text | Database name |
| user_name | text | Username |
| tid | bigint | In non-thread pool logic, this parameter indicates the ID of the thread connected to the CN. In thread pool logic, this parameter indicates the ID of the session connected to the CN. |
| pgoptions | text | Database connection option. For details, see the **options** columns in **6.5.5 Link Parameters**. |
| node_oid | bigint | OID of the node connected |
| in_use | boolean | Whether the connection is currently used.<br>• **t** (true): The connection is in use.<br>• **f** (false): The connection is not in use. |
| session_params | text | GUC session parameter delivered by the connection |
| fdsock | bigint | Local socket |
| remote_pid | bigint | Peer thread ID |
| used_count | bigint | Number of reuse times of a connection |
| idx | bigint | Peer DN ID in the local CN |
| streamid | bigint | Stream ID in the physical connection |

- psortoptions

  Description: Returns the psort attribute.

  Parameter: text[], boolean

  Return type: bytea
- remove_job_class_depend

  Description: Removes the job dependency.

  Parameter: oid

  Return type: void
- sweep_series

  Description: Clears useless timelines outside the time window on a specified table. This function applies only to time series tables with the TTL and period specified. You need to use **search_path** to specify the schema in advance. The default value is **public**. The upper bound of the time window is the invocation time plus a period, and the lower bound is the invocation time minus a TTL.

  Parameter: text

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Return type: void

- sweep_series_preview

  Description: Prints the tag IDs of the useless timelines outside the time window to logs. This function applies only to time series tables with the TTL and period specified. You need to use **search_path** to specify the schema in advance. The default value is **public**. The upper bound of the time window is the invocation time plus a period, and the lower bound is the invocation time minus a TTL. **log_min_message** needs to be set to **DEBUG2**.

  Parameter: text

  Return type: void

- xideq4

  Description: Compares two xids to check whether they are the same.

  Parameter: xid32, xid32

  Return type: Boolean

- xideqint8

  Description: Compares two xids to check whether they are the same.

  Parameter: xid, bigint

  Return type: Boolean

- xidlt

  Description: Returns whether xid1 < xid2 is true.

  Parameter: xid, xid

  Return type: Boolean

- xidlt4

  Description: Returns whether xid1 < xid2 is true.

  Parameter: xid32, xid32

  Return type: Boolean

- get_local_cont_query_stat

  Description: Obtains the statistics of a specified continuous computing view on the local node.

  Parameter: cq_id oid

  Return type: cq oid, w_in_rows int8, w_in_bytes int8, w_out_rows int8, w_out_bytes int8, w_pendings int8, w_errors int8, r_in_rows int8, r_in_bytes int8, r_out_rows int8, r_out_bytes int8, r_errors int8, c_in_rows int8, c_in_bytes int8, c_out_rows int8, c_out_bytes int8, c_pendings int8, c_errors int8

- get_local_cont_query_stats

  Description: Obtains all continuous computing view statistics of the local node.

  Parameter: nan

  Return type: cq oid, w_in_rows int8, w_in_bytes int8, w_out_rows int8, w_out_bytes int8, w_pendings int8, w_errors int8, r_in_rows int8, r_in_bytes int8, r_out_rows int8, r_out_bytes int8, r_errors int8, c_in_rows int8, c_in_bytes int8, c_out_rows int8, c_out_bytes int8, c_pendings int8, c_errors int8

- get_cont_query_stats

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Description: Obtains statistics about all continuous computing views on each DN.

Parameter: nan

Return type: node name, cq oid, w_in_rows int8, w_in_bytes int8, w_out_rows int8, w_out_bytes int8, w_pendings int8, w_errors int8, r_in_rows int8, r_in_bytes int8, r_out_rows int8, r_out_bytes int8, r_errors int8, c_in_rows int8, c_in_bytes int8, c_out_rows int8, c_out_bytes int8, c_pendings int8, c_errors int8

- reset_local_cont_query_stat

  Description: Resets the statistics of a specified continuous computation view on the local node.

  Parameter: cq_id oid

  Return type: Boolean

- reset_local_cont_query_stats

  Description: Resets association statistics on the specified continuous computation view of the local node.

  Parameter: cq_id oid

  Return type: Boolean

- reset_cont_query_stats

  Description: Resets the continuous computation view statistics corresponding to the STREAM object on each DN.

  Parameter: stream_id oid

  Return type: Boolean

- check_cont_query_schema_changed

  Description: Determines the schema change status of a specified continuous computation view.

  Parameter: cq_id oid

  Return type: Boolean

- gs_get_standby_cluster_barrier_status

  Description: Queries the barrier log playback information of the standby CN or DN, including the latest received barrier, LSN of the latest received barrier, barrier played back last time, and target barrier to be played back.

  Parameter: nan

  Return type: barrier_id text, barrier_lsn text, recovery_id text, target_id text

  Note: To call this function, the user must have the SYSADMIN or OPRADMIN permission, and **operate_mode** must be enabled for the O&M administrator role.

- gs_set_standby_cluster_target_barrier_id

  Description: Set the target barrier to be played back.

  Parameter: barrier_id

  Return type: target_id text

  Note: To call this function, the user must have the SYSADMIN or OPRADMIN permission, and **operate_mode** must be enabled for the O&M administrator role.

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- gs_query_standby_cluster_barrier_id_exist

  Description: Queries whether the specified barrier is received by the standby node.

  Parameter: barrier_id

  Return type: Boolean

  Note: To call this function, the user must have the SYSADMIN or OPRADMIN permission, and **operate_mode** must be enabled for the O&M administrator role.

  The following stream functions exist but are not supported. You are not advised to use them.

  streaming_int8_avg_gather, streaming_numeric_avg_gather, streaming_float8_avg_gather, streaming_interval_avg_gather, streaming_int8_sum_gather, and streaming_int2_int4_sum_gather

## 12.5.35 Internal Functions

The following functions of GaussDB use internal data types, which cannot be directly called by users.

- Selection rate calculation functions

| areajoinsel | areasel | arraycontjoinsel | arraycontsel | contjoinsel | contsel | eqjoinsel |
|---|---|---|---|---|---|---|
| eqsel | iclikejoinsel | iclikesel | icnlikejoinsel | icnlikesel | icregexeqjoinsel | icregexeqsel |
| icregexnejoinsel | icregexnesel | likejoinsel | likesel | neqjoinsel | neqsel | nlikejoinsel |
| nlikesel | positionjoinsel | positionsel | regexeqjoinsel | regexeqsel | regexnejoinsel | regexnesel |
| scalargtjoinsel | scalargtsel | scalarltjoinsel | scalarltsel | tsmatchjoinsel | tsmatchsel | - |

- Statistics collection functions

| array_typanalyze | range_typanalyze | ts_typanalyze |
|---|---|---|
| local_rto_stat | remote_rto_stat | - |

- Internal functions for sorting

| bpchar_sortsupport | bytea_sortsupport | date_sortsupport | numeric_sortsupport | timestamp_sortsupport |
|---|---|---|---|---|

- Internal functions for full-text retrieval

| dispell_init | dispell_lexize | dsimple_init | dsimple_lexize | dsnowball_init | dsnowball_lexize | dsynonym_init |
|---|---|---|---|---|---|---|

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| | | | | | | |
|---|---|---|---|---|---|---|
| dsynonym_lexize | gtsquery_compress | gtsquery_consistent | gtsquery_decompress | gtsquery_penalty | gtsquery_picksplit | gtsquery_same |
| gtsquery_union | ngram_end | ngram_lextype | ngram_start | pound_end | pound_lextype | pound_start |
| prsd_end | prsd_headline | prsd_lextype | prsd_start | thesaurus_init | thesaurus_lexize | zhprs_end |
| zhprs_getlexeme | zhprs_lextype | zhprs_start | - | - | - | - |

- Internal type processing functions

| | | | | | | |
|---|---|---|---|---|---|---|
| abstimerecv | euc_jis_2004_to_utf8 | int2recv | line_recv | oidvectorrecv_extend | tidrecv | utf8_to_koi8u |
| anyarray_recv | euc_jp_to_mic | int2vectorrecv | lseg_recv | path_recv | time_recv | utf8_to_shift_jis_2004 |
| array_recv | euc_jp_to_sjis | int4recv | macaddr_recv | pg_node_tree_recv | time_transform | utf8_to_sjis |
| ascii_to_mic | euc_jp_to_utf8 | int8recv | mic_to_ascii | point_recv | timestamp_recv | utf8_to_uhc |
| ascii_to_utf8 | euc_kr_to_mic | internal_out | mic_to_big5 | poly_recv | timestamp_transform | utf8_to_win |
| big5_to_euc_tw | euc_kr_to_utf8 | interval_recv | mic_to_euc_cn | pound_nexttoken | timestamptz_recv | uuid_recv |
| big5_to_mic | euc_tw_to_big5 | interval_transform | mic_to_euc_jp | prsd_nexttoken | timetz_recv | varbit_recv |
| big5_to_utf8 | euc_tw_to_mic | iso_to_koi8r | mic_to_euc_kr | range_recv | tinterval recv | varbit_transform |
| bit_recv | euc_tw_to_utf8 | iso_to_mic | mic_to_euc_tw | rawrecv | tsqueryrecv | varchar_transform |
| boolrecv | float4recv | iso_to_win1251 | mic_to_iso | record_recv | tsvectorrecv | varcharrecv |
| box_recv | float8recv | iso_to_win866 | mic_to_koi8r | regclassrecv | txid_snapshot_recv | void_recv |

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| | | | | | | |
|---|---|---|---|---|---|---|
| bpcharrecv | gb18030_to_utf8 | iso8859_1_to_utf8 | mic_to_latin1 | regconfigrecv | uhc_to_utf8 | win_to_utf8 |
| btoidsortsupport | gbk_to_utf8 | iso8859_to_utf8 | mic_to_latin2 | regdictionaryrecv | unknownrecv | win1250_to_latin2 |
| byteasend | gin_extract_tsvector | johab_to_utf8 | mic_to_latin3 | regoperatorrecv | utf8_to_ascii | win1250_to_mic |
| byteawithoutorderwithequalcolrecv | gtsvector_compress | json_recv | mic_to_latin4 | regoperrecv | utf8_to_big5 | win1251_to_iso |
| cash_recv | gtsvector_consistent | koi8r_to_iso | mic_to_sjis | regprocedurerecv | utf8_to_euc_cn | win1251_to_koi8r |
| charrecv | gtsvector_decompress | koi8r_to_mic | mic_to_win1250 | regprocrecv | utf8_to_euc_jis_2004 | win1251_to_mic |
| cidr_recv | gtsvector_penalty | koi8r_to_utf8 | mic_to_win1251 | regtyperecv | utf8_to_euc_jp | win1251_to_win866 |
| cidrecv | gtsvector_picksplit | koi8r_to_win1251 | mic_to_win866 | reltimerecv | utf8_to_euc_kr | win866_to_iso |
| circle_recv | gtsvector_same | koi8r_to_win866 | namerecv | shift_jis_2004_to_euc_jis_2004 | utf8_to_euc_tw | win866_to_koi8r |
| cstring_recv | gtsvector_union | koi8u_to_utf8 | ngram_nexttoken | shift_jis_2004_to_utf8 | utf8_to_gb18030 | win866_to_mic |
| date_recv | hll_recv | latin1_to_mic | numeric_recv | sjis_to_euc_jp | utf8_to_gbk | win866_to_win1251 |
| domain_recv | hll_trans_recv | latin2_to_mic | numeric_transform | sjis_to_mic | utf8_to_iso8859 | xidrecv |
| euc_cn_to_mic | hstore_recv | latin2_to_win1250 | nvarchar2recv | sjis_to_utf8 | utf8_to_iso8859_1 | xidrecv4 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| euc_cn_to_utf8 | inet_recv | latin3_to_mic | oidrecv | smalldatetime_recv | utf8_to_johab | xml_recv |
| euc_jis_2004_to_shift_jis_2004 | int1recv | latin4_to_mic | oidvectorrecv | textrecv | utf8_to_koi8r | cstore_tid_out |
| numeric_bool | int2vectorin_extend | int2vectorout_extend | int2vectorrecv_extend | int2vectorsend_extend | int8_accum | large_seq_rollback_ntree |
| large_seq_upgrade_ntree | int16eq | int16ge | int16gt | int16in | int16le | int16lt |
| int16mi | int16mul | int16ne | int16out | int16pl | int16recv | int16send |
| int16_bool | i16toi1 | - | - | - | - | - |

- Internal functions for aggregation operations

| | | | | | | |
|---|---|---|---|---|---|---|
| array_agg_finalfn | array_agg_transfn | bytea_string_agg_finalfn | bytea_string_agg_transfn | date_list_agg_noarg2_transfn | date_list_agg_transfn | float4_list_agg_noarg2_transfn |
| float4_list_agg_transfn | float8_list_agg_noarg2_transfn | float8_list_agg_transfn | int2_list_agg_noarg2_transfn | int2_list_agg_transfn | int4_list_agg_noarg2_transfn | int4_list_agg_transfn |
| int8_list_agg_noarg2_transfn | int8_list_agg_transfn | interval_list_agg_noarg2_transfn | interval_list_agg_transfn | list_agg_finalfn | list_agg_noarg2_transfn | list_agg_transfn |
| median | median_float8_finalfn | median_interval_finalfn | median_transfn | mode_final | numeric_list_agg_noarg2_transfn | numeric_list_agg_transfn |
| ordered_set_transition | percentile_cont_float8_final | percentile_cont_interval_final | string_agg_finalfn | string_agg_transfn | timestamp_list_agg_noarg2_transfn | timestamp_list_agg_transfn |

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| | | | | | | |
|---|---|---|---|---|---|---|
| timestamptz_list_agg_noarg2_transfn | timestamptz_list_agg_transfn | checksumtext_agg_transfn | json_agg_transfn | json_agg_finalfn | json_object_agg_transfn | json_object_agg_finalfn |

- Hash internal functions

| | | | | | | |
|---|---|---|---|---|---|---|
| hashbeginscan | hashbuild | hashbuildempty | hashbulkdelete | hashcostestimate | hashendscan | hashgetbitmap |
| hashgettuple | hashinsert | hashmarkpos | hashmerge | hashrescan | hashrestrpos | hashvacuumcleanup |
| hashvarlena | jsonb_hash | - | - | - | - | - |

- Internal functions of the B-tree index

| | | | | | | |
|---|---|---|---|---|---|---|
| cbtreebuild | cbtreecanreturn | cbtreecostestimate | cbtreegetbitmap | cbtreegettuple | btbeginscan | btbuild |
| btbuildempty | btbulkdelete | btcanreturn | btcostestimate | btendscan | btfloat4sortsupport | btfloat8sortsupport |
| btgetbitmap | btgettuple | btinsert | btint2sortsupport | btint4sortsupport | btint8sortsupport | btmarkpos |
| btmerge | btnamesortsupport | btrescan | btrestrpos | bttextsortsupport | btvacuumcleanup | cbtreeoptions |

- Internal functions of the GiST index

| | | | | | | |
|---|---|---|---|---|---|---|
| gist_box_compress | gist_box_consistent | gist_box_decompress | gist_box_penalty | gist_box_picksplit | gist_box_same | gist_box_union |
| gist_circle_compress | gist_circle_consistent | gist_point_compress | gist_point_consistent | gist_point_distance | gist_poly_compress | gist_poly_consistent |
| gistbeginscan | gistbuild | gistbuildempty | gistbulkdelete | gistcostestimate | gistendscan | gistgetbitmap |
| gistinsert | gistmarkpos | gistmerge | gistrescan | gistrestrpos | gistvacuumcleanup | range_gist_compress |

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| range_gist_decompress | range_gist_penalty | range_gist_picksplit | range_gist_same | range_gist_union | spg_kd_choose | spg_kd_config |
|---|---|---|---|---|---|---|
| spg_kd_picksplit | spg_quad_choose | spg_quad_config | spg_quad_inner_consistent | spg_quad_leaf_consistent | spg_quad_picksplit | spg_text_choose |
| spg_text_inner_consistent | spg_text_leaf_consistent | spg_text_picksplit | spgbeginscan | spgbuild | spgbuildempty | spgbulkdelete |
| spgcostestimate | spgendscan | spggetbitmap | spggettuple | spginsert | spgmarkpos | spgmerge |
| spgrestrpos | spgvacuumcleanup | gin_compare_jsonb | gin_extract_jsonb | gin_extract_jsonb_query | gin_consistent_jsonb | gin_triconsistent_jsonb |
| gin_consistent_jsonb_hash | gin_triconsistent_jsonb_hash | gin_extract_jsonb_hash | gin_extract_jsonb_query_hash | - | - | - |

- Internal functions of the GIN index

| gin_cmp_prefix | gin_extract_tsquery | gin_tsquery_consistent | gin_tsquery_triconsistent | ginarrayconsistent | ginarrayextract | ginarraytriconsistent |
|---|---|---|---|---|---|---|
| ginbeginscan | ginbuild | ginbuildempty | ginbulkdelete | gincostestimate | ginendscan | gingetbitmap |
| gininsert | ginmarkpos | ginmerge | ginqueryarrayextract | ginrescan | ginrestrpos | ginvacuumcleanup |
| cginbuild | cgingetbitmap | - | - | - | - | - |

- Internal functions of the Psort index

| psortbuild | psortcanreturn | psortcostestimate | psortgetbitmap | psortgettuple |
|---|---|---|---|---|

- Internal functions of the UB-tree index

| ubtbeginscan | ubtbuild | ubtbuildempty | ubtbulkdelete | ubtcanreturn |
|---|---|---|---|---|

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| | | | | |
|---|---|---|---|---|
| ubtcostestimate | ubtendscan | ubtgetbitmap | ubtgettuple | ubtinsert |
| ubtmarkpos | ubtmerge | ubtoptions | ubtrescan | ubtrestrpos |
| ubtvacuumcleanup | - | - | - | - |

- plpgsql internal function

  plpgsql_inline_handler

- External table-related internal functions

| | | | | | | |
|---|---|---|---|---|---|---|
| dist_fdw_handler | roach_handler | streaming_fdw_handler | dist_fdw_validator | file_fdw_handler | file_fdw_validator | log_fdw_handler |
| gc_fdw_handler | gc_fdw_validator | - | - | - | - | - |

- Internal function related to data skew optimization

  distributed_count

- Internal functions related to table statistics

| | | | |
|---|---|---|---|
| pgxc_get_stat_dirty_tables | pgxc_stat_dirty_tables | get_global_stat_all_tables | get_summary_stat_all_tables |

- Function for reading data remotely

  **gs_read_block_from_remote** is used to read the pages of a non-segment-page table file. By default, only the initial user can view the data. Other users can view the data only after being granted with permissions.

  **gs_read_segment_block_from_remote** is used to read the pages of a segment-page table file. By default, only the initial user can view the data. Other users can view the data only after being granted with permissions.

- Function for reading files remotely

  **gs_read_file_size_from_remote** is used to read the size of a specified file. Before using the **gs_repair_file** function to repair a file, you need to obtain the size of the file from the remote end to verify the missing file information and repair the missing files one by one. By default, only the initial user can view the data. Other users can view the data only after being granted with permissions.

  **gs_read_file_from_remote** is used to read a specified file. After obtaining the file size by using the **gs_read_file_size_from_remote** function, **gs_repair_file** reads the remote file segment by segment using this function. By default, only the initial user can view the data. Other users can view the data only after being granted with permissions.

- View-related reference functions

  adm_hist_sqlstat_func

  adm_hist_sqlstat_idlog_func

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# 12.5.36 AI Feature Functions

- db4ai_predict_by_bool (text, VARIADIC "any")

  Description: Obtains a model whose return value is of the Boolean type for model inference. This function is an internal function. You are advised to use the **PREDICT BY** syntax for inference.

  Parameter: model name and input column name of the inference task

  Return type: Boolean

- db4ai_predict_by_float4(text, VARIADIC "any")

  Description: Obtains a model whose return value is of the float4 type for model inference. This function is an internal function. You are advised to use the **PREDICT BY** syntax for inference.

  Parameter: model name and input column name of the inference task

  Return type: float

- db4ai_predict_by_float8(text, VARIADIC "any")

  Description: Obtains a model whose return value is of the float8 type for model inference. This function is an internal function. You are advised to use the **PREDICT BY** syntax for inference.

  Parameter: model name and input column name of the inference task

  Return type: float

- db4ai_predict_by_int32(text, VARIADIC "any")

  Description: Obtains a model whose return value is of the int32 type for model inference. This function is an internal function. You are advised to use the **PREDICT BY** syntax for inference.

  Parameter: model name and input column name of the inference task

  Return type: int

- db4ai_predict_by_int64(text, VARIADIC "any")

  Description: Obtains a model whose return value is of the int64 type for model inference. This function is an internal function. You are advised to use the **PREDICT BY** syntax for inference.

  Parameter: model name and input column name of the inference task

  Return type: int

- db4ai_predict_by_numeric(text, VARIADIC "any")

  Description: Obtains a model whose return value is of the numeric type for model inference. This function is an internal function. You are advised to use the **PREDICT BY** syntax for inference.

  Parameter: model name and input column name of the inference task

  Return type: numeric

- db4ai_predict_by_text(text, VARIADIC "any")

  Description: Obtains a model whose return value is of the character type for model inference. This function is an internal function. You are advised to use the **PREDICT BY** syntax for inference.

  Parameter: model name and input column name of the inference task

  Return type: text

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- db4ai_predict_by_float8_array(text, VARIADIC "any")

  Description: Obtains a model whose return value is of the character type for model inference. This function is an internal function. You are advised to use the **PREDICT BY** syntax for inference.

  Parameter: model name and input column name of the inference task

  Return type: text

- gs_explain_model(text)

  Description: Obtains the model whose return value is of the character type for text-based model parsing.

  Parameter: model name

  Return type: text

## 12.5.37 Dynamic Data Masking Functions

NOTE

This function is an internal function. For details, see "Database Security > Dynamic Data Anonymization" in *Feature Description*.

- creditcardmasking(col text, letter char default 'x')

  Description: Replaces the digits before the last four bits following the col string with letters.

  Parameter: Character string to be replaced or character string used for replacement

  Return type: text

- basicmailmasking(col text, letter char default 'x')

  Description: Replaces the characters before the first at sign (@) in the col string with letters.

  Parameter: Character string to be replaced or character string used for replacement

  Return type: text

- fullmailmasking(col text, letter char default 'x')

  Description: Replaces the characters (except **@**) before the last period (.) in the col string with letters.

  Parameter: Character string to be replaced or character string used for replacement

  Return type: text

- alldigitsmasking(col text, letter char default '0')

  Description: Replaces the digits in the col string with letters.

  Parameter: Character string to be replaced or character string used for replacement

  Return type: text

- shufflemasking(col text)

  Description: Sorts the characters in the col string out of order.

  Parameter: Character string to be replaced or character string used for replacement

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Return type: text

- randommasking(col text)

  Description: Randomizes the characters in the col string.

  Parameter: Character string to be replaced or character string used for replacement

  Return type: text

- regexpmasking(col text, reg text, replace_text text, pos INTEGER default 0, reg_len INTEGER default -1)

  Description: Replaces the col string with a regular expression.

  Parameters: Character string to be replaced, regular expression, replacement start position, and replacement length.

  Return type: text

## 12.5.38 Hotkey Feature Functions

- gs_stat_get_hotkeys_info()

  Description: Obtains hotkey information queried on the local node.

  Return type: Tuple

  Example:

```
openGauss=# select * from gs_stat_get_hotkeys_info() order by count, hash_value;
 database_name | schema_name |     table_name      | key_value | hash_value | count
---------------+-------------+---------------------+-----------+------------+-------
 regression    | public      | hotkey_single_col | {22}      | 1858004829 |     2
 regression    | public      | hotkey_single_col | {11}      | 2011968649 |     2
(2 rows)
```

- gs_stat_clean_hotkeys()

  Description: Clears hotkey cache and resets hotkey status information.

  Return type: bool, and the return value is always **true**.

  Example:

```
openGauss=# select * from gs_stat_clean_hotkeys();
 gs_stat_clean_hotkeys
-----------------------
 t
(1 row)
```

## 12.5.39 Global SysCache Functions

The current feature is a lab feature. Contact Huawei technical support before using it.

- gs_gsc_table_detail(database_id default NULL, rel_id default NULL)

  Description: Queries the table metadata in the global system cache in a database. The user who calls this function must have the **SYSADMIN** permission.

  Parameter: Specifies the database and table to be queried in the global system cache. The default value **NULL** or value **–1** of **database_id** indicates all databases. The value **0** indicates a shared table. Other values indicate a specified database and a shared table. **rel_id** indicates the OID of a specified table. The default value **NULL** or value **–1** indicates all tables. Other values

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indicate a specified table. If **database_id** does not exist, an error is reported. If **rel_id** does not exist, the query result is empty.

Return type: Tuple

```
select * from gs_gsc_table_detail(-1) limit 1;
database_oid | database_name | reloid |         relname          | relnamespace | reltype | reloftype |
relowner | relam | relfilenode | reltablespace | relhasindex | relisshared | relkind | relnatts | relhasoids |
relhaspkey | parttype | tdhasuids | attnames  | extinfo
--------------+---------------+---------+--------------------------+--------------+---------+-----------+----------
+-------+-------------+---------------+-------------+-------------+---------+----------+------------+------------
+----------+----------+-----------+---------
0 |             |   2676 | pg_authid_rolname_index |          11 |       0 |         0 |       10 |   403 |          0
|         1664 | f           | t           | i       |         1 | f          | f          | n       | f         | 'rolname' |
(1 row)
```

- gs_gsc_catalog_detail(database_id default NULL, rel_id default NULL)

  Description: Queries the system catalog row information in the global system cache in a database. The user who calls this function must have the **SYSADMIN** permission.

  Parameter: Specifies the database and table to be queried in the global system cache. The default value **NULL** or value **–1** of **database_id** indicates all databases. The value **0** indicates a shared table. Other values indicate a specified database and a shared table. **rel_id** indicates the ID of a specified table, including all system catalogs in the system cache. The default value **NULL** or value **–1** indicates all tables. Other values indicate a specified table. If **database_id** does not exist, an error is reported. If **rel_id** does not exist, the result is empty.

  Return type: Tuple

  Example:

```
openGauss=#
select * from gs_gsc_catalog_detail(16574, 1260);
 database_id | database_name | rel_id | rel_name  | cache_id |  self  |  ctid  | infomask | infomask2 |
hash_value | refcount
-------------+---------------+--------+-----------+----------+--------+--------+----------+-----------+------------
+----------
           0 |               |   1260 | pg_authid |       10 | (0, 9) | (0, 9) |    10507 |        26 |  531311568 |
10
           0 |               |   1260 | pg_authid |       11 | (0, 4) | (0, 4) |     2313 |        26 |  365368336 |        1
           0 |               |   1260 | pg_authid |       11 | (0, 9) | (0, 9) |    10507 |        26 | 3911517328 |
10
           0 |               |   1260 | pg_authid |       11 | (0, 7) | (0, 7) |     2313 |        26 | 1317799983 |
1
           0 |               |   1260 | pg_authid |       11 | (0, 5) | (0, 5) |     2313 |        26 | 3664347448 |
1
           0 |               |   1260 | pg_authid |       11 | (0, 1) | (0, 1) |     2313 |        26 |  276477273 |        1
           0 |               |   1260 | pg_authid |       11 | (0, 3) | (0, 3) |     2313 |        26 | 2465837659 |
1
           0 |               |   1260 | pg_authid |       11 | (0, 8) | (0, 8) |     2313 |        26 | 3205288035 |
1
           0 |               |   1260 | pg_authid |       11 | (0, 6) | (0, 6) |     2313 |        26 |  131811687 |        1
           0 |               |   1260 | pg_authid |       11 | (0, 2) | (0, 2) |     2313 |        26 | 1226484587 |
1
(10 rows)
```

- gs_gsc_clean(database_id default NULL)

  Description: Clears the global system cache. Note that data in use will not be cleared. The user who calls this function must have the **SYSADMIN** permission.

  Parameter: Specifies the database whose global system cache needs to be cleared. The default value **NULL** or value **–1** indicates that the global system

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cache of all databases is forcibly cleared. The value **0** indicates that the global system cache of only the shared table is cleared. Other values indicate that the global system cache of a specified database and a specified shared table is cleared. If **database_id** does not exist, an error is reported.

Return type: Boolean

Example:

```
openGauss=# select * from gs_gsc_clean();
gs_gsc_clean
--------------
t
(1 row)
```

- gs_gsc_dbstat_info(database_id default NULL)

  Description: Obtains GSC memory statistics on the local node, including cache query, hit, loading, expiration, and occupied space information of tuples, relations, and partitions, database-level eviction information, thread reference information, and memory usage information. This parameter can be used to locate performance problems. For example, if the value of the hits or searches array is far less than 1, the value of **global_syscache_threshold** may be too small. As a result, the query hit ratio decreases. The user who calls this function must have the **SYSADMIN** permission.

  Parameter: Specifies the global system cache statistics of the database to be queried. Value **NULL** or **–1** indicates that all databases are queried. Value **0** indicates that only the shared table is queried. Other values indicate that a specified database and a specified shared table are queried. If an invalid value is entered, an error is reported, indicating that **database_id** does not exist.

  Return type: Tuple

  Example:

```
openGauss=# select * from gs_gsc_dbstat_info();
database_id | database_name | tup_searches | tup_hits | tup_miss | tup_count | tup_dead | tup_memory
| rel_searches | rel_hits | rel_mis
s | rel_count | rel_dead | rel_memory | part_searches | part_hits | part_miss | part_count | part_dead |
part_memory | total_memory | swa
pout_count | refcount
-------------+---------------+--------------+----------+----------+-----------+----------+------------
+--------------+----------+--------
--+-----------+----------+------------+---------------+-----------+-----------+------------+-----------
+-------------+--------------+----
-----------+----------
          0 |               |          300 |      235 |       31 |        22 |        2 |       9752 |          598 |      108
|       1
8 |        18 |        0 |      77720 |            0 |         0 |         0 |         0 |         0 |          0 |       752912 |
         0 |         0
      16574 | postgres      |         3368 |     2289 |      329 |       273 |        0 |      92593 |         1113 |
524 |       4
8 |        48 |        0 |     340456 |            0 |         0 |         0 |         0 |         0 |          0 |      4124792 |
         0 |        10
(2 rows)
```

# 12.5.40 Data Damage Detection and Repair Functions

- gs_verify_data_file(verify_segment bool)

  Description: Checks whether files in the current database of the current instance are lost. Only whether intermediate segments are lost in the main file of the data table is checked. The default value is **false**, indicating that segment-page table data files are not checked. If this parameter is set to **true**, only segment-page table files are checked. By default, only initial users, users

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with the sysadmin permission, and users with the O&M administrator permission in the O&M mode can view the information. Other users can view the information only after being granted with permissions.

The returned result is as follows:

- Non-segment-page table: **rel_oid** and **rel_name** indicate the table OID and table name of the corresponding file, and **miss_file_path** indicates the relative path of the lost file.
- Segment-page table: All tables are stored in the same file. Therefore, **rel_oid** and **rel_name** cannot display information about a specific table. For a segment-page table, if the first file is damaged, the subsequent files such as .1 and .2 are not checked. For example, if files 3, 3.1, and 3.2 are damaged, only damage of file 3 can be detected. When the number of segment-page files is less than 5, the files that are not generated are also checked during function detection. For example, if there are only files 1 and 2, files 3, 4, and 5 are checked during segment-page file detection. In the following examples, the first is an example of checking a non-segment-page table, and the second is an example of checking a segment-page table.

Parameter description:

- verify_segment

  Specifies the range of files to be checked. **false** indicates that non-segment-page tables are checked. **true** indicates that segment-page tables are checked.

  The value can be **true** or **false** (default value).

Return type: record

Example:

Check a non-segment-page table.

```
openGauss=# select * from gs_verify_data_file();
node_name         | rel_oid |  rel_name    |  miss_file_path
------------------+---------+--------------+------------------
dn_6001_6002_6003 |   16554 |     test     | base/16552/24745
```

Check a segment-page table.

```
openGauss=# select * from gs_verify_data_file(true);
     node_name      | rel_oid | rel_name | miss_file_path
--------------------+---------+----------+----------------
 dn_6001_6002_6003 |       0 | none     | base/16573/2
```

- gs_repair_file(tableoid Oid, path text, timeout int)

  Description: Repairs the file based on the input parameters. This function can be used only by the primary DN that is properly connected to the standby DN. The parameter is set based on the OID and path returned by the **gs_verify_data_file** function. The table OID for a segment-page table ranges from 0 to 4294967295. (The internal verification determines whether a file is a segment-page table file based on the file path. The table OID is not used for a segment-page table file.) If the repair is successful, **true** is returned. If the repair fails, the failure cause is displayed. By default, only initial users, users with the sysadmin permission, and users with the O&M administrator permission in the O&M mode on the primary DN can view the information. Other users can view the information only after being granted with permissions.

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**CAUTION**

1. If a file on a DN is damaged, a verification error at the PANIC level is reported when the DN is promoted to primary. The DN cannot be promoted to primary, which is normal.
2. If a file exists but its size is 0, the file will not be repaired. To repair the file, you need to delete the file whose size is 0 and then repair it.
3. You can delete a file only after the file descriptor is automatically closed. You can manually restart the process or perform a primary/standby switchover.

Parameter description:

- tableoid

  Specifies the OID of the table corresponding to the file to be repaired. Set this parameter based on the **rel_oid** column in the list returned by the **gs_verify_data_file** function.

  Value range: OID ranging from 0 to 4294967295 Note: A negative value will be forcibly converted to a non-negative integer.

- path

  Specifies the path of the file to be repaired. Set this parameter based on the **miss_file_path** column in the list returned by the **gs_verify_data_file** function.

  Value range: a string

- timeout

  Specifies the duration for waiting for standby DN playback. The file to be repaired needs to wait for the standby DN to be played back to the corresponding location on the current primary DN. Set this parameter based on the playback duration of the standby DN.

  Value range: 60s to 3600s

Return type: Boolean

Example:

```
openGauss=# select * from gs_repair_file(16554,'base/16552/24745',360);
gs_repair_file
----------------
t
```

- local_bad_block_info()

  Description: Displays the page damage of the instance. You can read the page from the disk and record the page CRC failure. By default, only initial users, users with the sysadmin permission, users with the monitor administrator permission, users with the O&M administrator permission in the O&M mode, and monitor users can view the information. Other users can view the information only after being granted with permissions. **file_path** indicates the relative path of the damaged file. If the table is a segment-page table, the logical information instead of the actual physical file information is displayed. **block_num** indicates the number of the page where the file is damaged. The page number starts from 0. **check_time** indicates the time when the page damage is detected. **repair_time** indicates the time when the page is repaired.

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Return type: record

Example:

```
openGauss=# select * from local_bad_block_info();
node_name    | spc_node | db_node | rel_node| bucket_node | fork_num | block_num |    file_path     |
check_time            |   repair_time
-----------------+-------+--------+--------+--------------+----------+-----------+-----------------
+--------------------------+-------------------------------
dn_6001_6002_6003|  1663 |  16552 |  24745 |        -1    |    0    | 0        | base/16552/24745 |
2022-01-13 20:19:08.385004+08 | 2022-01-13 20:19:08.407314+08
```

- remote_bad_block_info()

  Description: Queries the page damage of other instances except the current instance when a query is performed on the CN. The recorded data is the same as that of the **local_bad_block_info** function executed on other instances. The execution result on the DN is empty. By default, only initial users, users with the sysadmin permission, users with the monitor administrator permission, users with the O&M administrator permission in the O&M mode, and monitor users can view the information. Other users can view the information only after being granted with permissions.

  Return type: record

- local_clear_bad_block_info()

  Description: Deletes data of repaired pages from **local_bad_block_info**, that is, information whose **repair_time** is not empty. By default, only initial users, users with the sysadmin permission, users with the O&M administrator permission in the O&M mode, and monitor users can view the information. Other users can view the information only after being granted with permissions.

  Return type: Boolean

  Example:

  ```
  openGauss=# select * from local_clear_bad_block_info();
  result
  --------
  t
  ```

- remote_clear_bad_block_info()

  Description: Clears the data of the repaired pages of other instances except the current instance when this function is executed on the CN, that is, information whose **repair_time** is not empty. The execution result on the DN is empty. By default, only initial users, users with the sysadmin permission, users with the O&M administrator permission in the O&M mode, and monitor users can view the information. Other users can view the information only after being granted with permissions.

  Return type: record

- gs_verify_and_tryrepair_page (path text, blocknum Oid, verify_mem bool, is_segment bool)

  Description: Verifies the page specified by the instance. By default, only initial users, users with the sysadmin permission, and users with the O&M administrator permission in the O&M mode on the primary DN can view the information. Other users can view the information only after being granted with permissions. In the command output, **disk_page_res** indicates the verification result of the page on the disk, **mem_page_res** indicates the verification result of the page in the memory, and **is_repair** indicates whether

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the repair function is triggered during the verification. **t** indicates that the page is repaired, and **f** indicates that the page is not repaired.

Note: If a page on a DN is damaged, a verification error at the PANIC level is reported when the DN is promoted to primary. The DN cannot be promoted to primary, which is normal. Damaged pages of hash bucket tables cannot be repaired.

Parameter description:

- path

  Specifies the path of the damaged file. Set this parameter based on the **file_path** column in **local_bad_block_info**.

  Value range: a string

- blocknum

  Specifies the page number of the damaged file. Set this parameter based on the **block_num** column in **local_bad_block_info**.

  Value range: OID ranging from 0 to 4294967295. Note: A negative value will be forcibly converted to a non-negative integer.

- verify_mem

  Specifies whether to verify a specified page in the memory. If this parameter is set to **false**, only pages on the disk are verified. If this parameter is set to **true**, pages in the memory and those on the disk are verified. If a page on the disk is damaged, the system verifies the basic information of the page in the memory and flushes the page to the disk to restore the page. If a page is not found in the memory during memory page verification, the page on the disk is read through the memory API. During this process, if the disk page is faulty, the automatic repair function through remote read is triggered.

  Value range: The value is of a Boolean type and can be **true** or **false**.

- is_segment

  Specifies whether the table is a segment-page table. Set this parameter based on the value of **bucket_node** in **local_bad_block_info**. If the value of **bucket_node** is **–1**, the table is not a segment-page table. In this case, set **is_segment** to **false**. If the value of **bucket_node** is not **–1**, set **is_segment** to **true**.

  Value range: The value is of Boolean type and can be **true** or **false**.

Return type: record

Example:

```
openGauss=# select * from gs_verify_and_tryrepair_page('base/16552/24745',0,false,false);
node_name        |       path       |  blocknum  |         disk_page_res         | mem_page_res | is_repair
-----------------+------------------+------------+-------------------------------+--------------+----------
dn_6001_6002_6003 | base/16552/24745 |     0      | page verification succeeded.|              | f
```

- gs_repair_page(path text, blocknum Oid is_segment bool, timeout int)

  Description: Restores the specified page of the instance. This function can be used only by the primary DN that is properly connected to the standby DN. By default, only initial users, users with the sysadmin permission, and users with the O&M administrator permission in the O&M mode on the primary DN can view the information. Other users can view the information only after being granted with permissions. If the page is successfully restored, **true** is returned. If an error occurs during the restoration, an error message is displayed.

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Note: If a page on a DN is damaged, a verification error at the PANIC level is reported when the DN is promoted to primary. The DN cannot be promoted to primary, which is normal. Damaged pages of hash bucket tables cannot be repaired.

Parameter description:

- path

  Specifies the path of the damaged page. Set this parameter based on the **file_path** column in **local_bad_block_info** or the **path** column in **gs_verify_and_tryrepair_page**.

  Value range: a string

- blocknum

  Specifies the number of the damaged page. Set this parameter based on the **block_num** column in **local_bad_block_info** or the **blocknum** column in **gs_verify_and_tryrepair_page**.

  Value range: OID ranging from 0 to 4294967295. Note: A negative value will be forcibly converted to a non-negative integer.

- is_segment

  Specifies whether the table is a segment-page table. The value of this parameter is determined by the value of **bucket_node** in **local_bad_block_info**. If the value of **bucket_node** is **–1**, the table is not a segment-page table and **is_segment** is set to **false**. If the value of **bucket_node** is not **–1**, **is_segment** is set to **true**.

  Value range: The value is of Boolean type and can be **true** or **false**.

- timeout

  Specifies the duration of waiting for standby DN playback. The page to be repaired needs to wait for the standby DN to be played back to the location of the current primary DN. Set this parameter based on the playback duration of the standby DN.

  Value range: 60s to 3600s

Return type: Boolean

Example:

```
openGauss=# select * from gs_repair_page('base/16552/24745',0,false,60);
result
--------
t
```

# 12.5.41 Obsolete Functions

The following functions in GaussDB have been discarded in the latest version:

| | | | | | | |
|---|---|---|---|---|---|---|
| gs_wlm_get_session_info | gs_wlm_get_user_session_info | check_engine_status | encode_plan_node | model_train_opt | gs_stat_get_wlm_plan_operator_info | track_model_train_opt |

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| | | | | | | |
|---|---|---|---|---|---|---|
| array_extend | dbe_perf.global_slow_query_info | dbe_perf.global_slow_query_info_by_time | dbe_perf.global_slow_query_history | pg_reload_conf | pg_rotate_logfile | gs_stat_ustore |

# 12.6 Expressions

## 12.6.1 Simple Expressions

### Logical Expressions

**12.5.1 Logical Operators** lists the operators and calculation rules of logical expressions.

### Comparative Expressions

**12.5.2 Comparison Operators** lists the common comparative operators.

In addition to comparative operators, you can also use the following sentence structure:

- BETWEEN operator

  **a BETWEEN x AND y** is equivalent to **a >= x AND a <= y**.

  **a NOT BETWEEN x AND y** is equivalent to **a < x OR a > y**.
- To check whether a value is null, use:

  expression IS NULL

  expression IS NOT NULL

  or an equivalent (non-standard) sentence structure:

  expression ISNULL

  expression NOTNULL

**NOTICE**

Do not write **expression=NULL** or **expression<>(!=)NULL**, because **NULL** represents an unknown value, and these expressions cannot determine whether two unknown values are equal.

### Examples

```
openGauss=# SELECT 2 BETWEEN 1 AND 3 AS RESULT;
 result
----------
 t
(1 row)

openGauss=# SELECT 2 >= 1 AND 2 <= 3 AS RESULT;
```

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```
 result
----------
 t
(1 row)

openGauss=# SELECT 2 NOT BETWEEN 1 AND 3 AS RESULT;
 result
----------
 f
(1 row)

openGauss=# SELECT 2 < 1 OR 2 > 3 AS RESULT;
 result
----------
 f
(1 row)

openGauss=# SELECT 2+2 IS NULL AS RESULT;
 result
----------
 f
(1 row)

openGauss=# SELECT 2+2 IS NOT NULL AS RESULT;
 result
----------
 t
(1 row)

openGauss=# SELECT 2+2 ISNULL AS RESULT;
 result
----------
 f
(1 row)

openGauss=# SELECT 2+2 NOTNULL AS RESULT;
 result
----------
 t
(1 row)

openGauss=# SELECT 2+2 IS DISTINCT FROM NULL AS RESULT;
 result
----------
 t
(1 row)

openGauss=# SELECT 2+2 IS NOT DISTINCT FROM NULL AS RESULT;
 result
----------
 f
(1 row)
```

## 12.6.2 Condition Expressions

Data that meets the requirements specified by conditional expressions are filtered during SQL statement execution.

Conditional expressions include the following types:

- CASE

  **CASE** expressions are similar to the **CASE** statements in other coding languages.

  **Figure 12-1** shows the syntax of a **CASE** expression.

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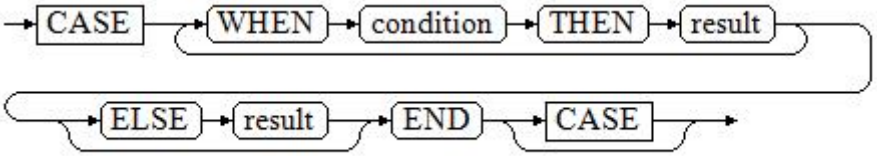
**Figure 12-1** case::=




A **CASE** clause can be used in a valid expression. **condition** is an expression that returns a value of Boolean type.

- If the result is **true**, the result of the **CASE** expression is the required result.
- If the result is false, the following **WHEN** or **ELSE** clauses are processed in the same way.
- If every **WHEN condition** is false, the result of the expression is the result of the **ELSE** clause. If the **ELSE** clause is omitted and has no match condition, the result is NULL.

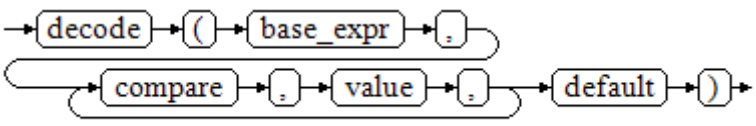
For example:

```
openGauss=# CREATE TABLE tpcds.case_when_t1(CW_COL1 INT) DISTRIBUTE BY HASH (CW_COL1);

openGauss=# INSERT INTO tpcds.case_when_t1 VALUES (1), (2), (3);

openGauss=# SELECT * FROM tpcds.case_when_t1;
 a
---
 1
 2
 3
(3 rows)

openGauss=# SELECT CW_COL1, CASE WHEN CW_COL1=1 THEN 'one' WHEN CW_COL1=2 THEN
'two' ELSE 'other' END FROM tpcds.case_when_t1 ORDER BY 1;
 cw_col1 | case
---------+-------
       1 | one
       2 | two
       3 | other
(3 rows)

openGauss=# DROP TABLE tpcds.case_when_t1;
```

- DECODE

  **Figure 12-2** shows the syntax of a **DECODE** expression.

  **Figure 12-2** decode::=




  Compare each following **compare(n)** with **base_expr**, **value(n)** is returned if a **compare(n)** matches the **base_expr** expression. If base_expr does not match each **compare(n)**, the default value is returned.

  **12.5.24 Conditional Expression Functions** describes the examples.

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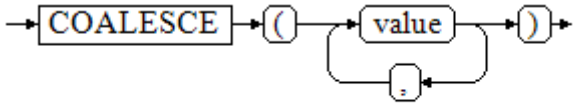
```
openGauss=# SELECT DECODE('A','A',1,'B',2,0);
 case
------
    1
(1 row)
```

- COALESCE

  **Figure 12-3** shows the syntax of a **COALESCE** expression.

  **Figure 12-3** coalesce::=

  **COALESCE** returns its first not-**NULL** value. If all the parameters are **NULL**, **COALESCE** will return **NULL**. This value is replaced by the default value when data is displayed. Like a **CASE** expression, **COALESCE** only evaluates the parameters that are needed to determine the result. That is, parameters to the right of the first not-**NULL** parameter are not evaluated.

  Example

  ```
  openGauss=# CREATE TABLE tpcds.c_tabl(description varchar(10), short_description varchar(10),
  last_value varchar(10))
  DISTRIBUTE BY HASH (last_value);

  openGauss=# INSERT INTO tpcds.c_tabl VALUES('abc', 'efg', '123');
  openGauss=# INSERT INTO tpcds.c_tabl VALUES(NULL, 'efg', '123');

  openGauss=# INSERT INTO tpcds.c_tabl VALUES(NULL, NULL, '123');

  openGauss=# SELECT description, short_description, last_value, COALESCE(description,
  short_description, last_value) FROM tpcds.c_tabl ORDER BY 1, 2, 3, 4;
   description | short_description | last_value | coalesce
  -------------+-------------------+------------+----------
   abc         | efg               | 123        | abc
               | efg               | 123        | efg
               |                   | 123        | 123
  (3 rows)

  openGauss=# DROP TABLE tpcds.c_tabl;
  ```

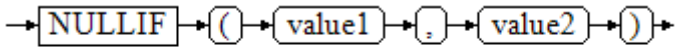
  If **description** is not **NULL**, the value of **description** is returned. Otherwise, parameter **short_description** is calculated. If **short_description** is not **NULL**, the value of **short_description** is returned. Otherwise, parameter **last_value** is calculated. If **last_value** is not **NULL**, the value of **last_value** is returned. Otherwise, **none** is returned.

  ```
  openGauss=# SELECT COALESCE(NULL,'Hello World');
    coalesce
  ---------------
   Hello World
  (1 row)
  ```

- NULLIF

  **Figure 12-4** shows the syntax of a **NULLIF** expression.

  **Figure 12-4** nullif::=

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Only if **value1** is equal to **value2** can **NULLIF** return the **NULL** value. Otherwise, **value1** is returned.

Example

```
openGauss=# CREATE TABLE tpcds.null_if_t1 (
    NI_VALUE1 VARCHAR(10),
    NI_VALUE2 VARCHAR(10)
)DISTRIBUTE BY HASH (NI_VALUE1);

openGauss=# INSERT INTO tpcds.null_if_t1 VALUES('abc', 'abc');
openGauss=# INSERT INTO tpcds.null_if_t1 VALUES('abc', 'efg');

openGauss=# SELECT NI_VALUE1, NI_VALUE2, NULLIF(NI_VALUE1, NI_VALUE2) FROM tpcds.null_if_t1
ORDER BY 1, 2, 3;

 ni_value1 | ni_value2 | nullif
-----------+-----------+--------
 abc       | abc       |
 abc       | efg       | abc
(2 rows)
openGauss=# DROP TABLE tpcds.null_if_t1;
```

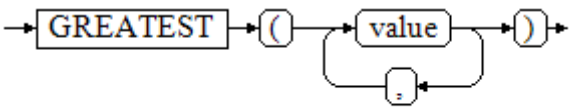
If **value1** is equal to **value2**, **NULL** is returned. Otherwise, **value1** is returned.

```
openGauss=# SELECT NULLIF('Hello','Hello World');
 nullif
--------
 Hello
(1 row)
```

- GREATEST (maximum value) and LEAST (minimum value)

  **Figure 12-5** shows the syntax of a **GREATEST** expression.

  **Figure 12-5** greatest::=

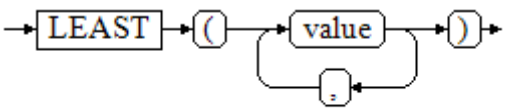
  
  

  You can select the maximum value from any numerical expression list.

  ```
  openGauss=# SELECT greatest(9000,155555,2.01);
   greatest
  ----------
    155555
  (1 row)
  ```

  **Figure 12-6** shows the syntax of a **LEAST** expression.

  **Figure 12-6** least::=

  You can select the minimum value from any numerical expression list.

  Each of the preceding numeric expressions can be converted into a common data type, which will be the data type of the result.

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The NULL values in the list will be ignored. The result is **NULL** only if the results of all expressions are **NULL**.

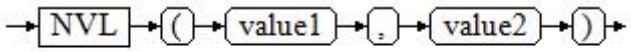
```
openGauss=# SELECT least(9000,2);
 least
-------
     2
(1 row)
```

**12.5.24 Conditional Expression Functions** describes the examples.

- NVL

  **Figure 12-7** shows the syntax of an **NVL** expression.

  **Figure 12-7** nvl::=

  If the value of **value1** is **NULL**, **value2** is returned. Otherwise, **value1** is returned.

  For example:

```
openGauss=# SELECT nvl(null,1);
NVL
-----
 1
(1 row)
openGauss=# SELECT nvl ('Hello World' ,1);
     nvl
---------------
 Hello World
(1 row)
```

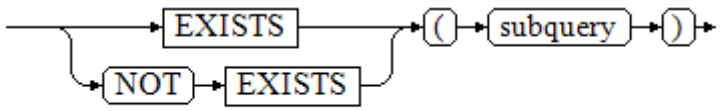
## 12.6.3 Subquery Expressions

Subquery expressions include the following types:

- EXISTS/NOT EXISTS

  **Figure 12-8** shows the syntax of an **EXISTS/NOT EXISTS** expression.

  **Figure 12-8** EXISTS/NOT EXISTS::=

  The parameter of an **EXISTS** expression is an arbitrary **SELECT** statement, or subquery. The subquery is evaluated to determine whether it returns any rows. If it returns at least one row, the result of **EXISTS** is "true". If the subquery returns no rows, the result of **EXISTS** is "false".

  The subquery will generally only be executed long enough to determine whether at least one row is returned, not all the way to completion.

  For example:

```
openGauss=# SELECT sr_reason_sk,sr_customer_sk FROM tpcds.store_returns WHERE EXISTS (SELECT
d_dom FROM tpcds.date_dim WHERE d_dom = store_returns.sr_reason_sk and sr_customer_sk <10);
```

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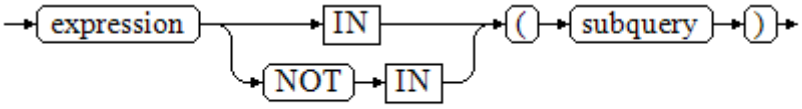
```
sr_reason_sk | sr_customer_sk
--------------+----------------
          13 |              2
          22 |              5
          17 |              7
          25 |              7
           3 |              7
          31 |              5
           7 |              7
          14 |              6
          20 |              4
           5 |              6
          10 |              3
           1 |              5
          15 |              2
           4 |              1
          26 |              3
(15 rows)
```

- IN/NOT IN

  **Figure 12-9** shows the syntax of an **IN/NOT IN** expression.

  **Figure 12-9** IN/NOT IN::=

  The right-hand side is a parenthesized subquery, which must return exactly one column. The left-hand expression is evaluated and compared to each row of the subquery result. The result of **IN** is "true" if any equal subquery row is found. The result is "false" if no equal row is found (including the case where the subquery returns no rows).

  This is in accordance with SQL normal rules for Boolean combinations of null values. If the columns corresponding to two rows equal and are not empty, the two rows are equal to each other. If any columns corresponding to the two rows do not equal and are not empty, the two rows are not equal to each other. Otherwise, the result is **NULL**. If there are no equal right-hand values and at least one right-hand row yields null, the result of **IN** will be null, not false.

  For example:

```
openGauss=# SELECT sr_reason_sk,sr_customer_sk  FROM tpcds.store_returns WHERE sr_customer_sk
IN (SELECT d_dom FROM tpcds.date_dim WHERE d_dom < 10);
sr_reason_sk | sr_customer_sk
--------------+----------------
          10 |              3
          26 |              3
          22 |              5
          31 |              5
           1 |              5
          32 |              5
          32 |              5
           4 |              1
          15 |              2
          13 |              2
          33 |              4
          20 |              4
          33 |              8
           5 |              6
```

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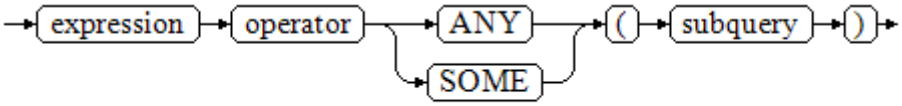
```
        14 |           6
        17 |           7
         3 |           7
        25 |           7
         7 |           7
(19 rows)
```

- ANY/SOME

  **Figure 12-10** shows the syntax of an **ANY/SOME** expression.

  **Figure 12-10** any/some::=

  The right-hand side is a parenthesized subquery, which must return exactly one column. The left-hand expression is evaluated and compared to each row of the subquery result using the given operator, which must yield a Boolean result. The result of **ANY** is "true" if any true result is obtained. The result is "false" if no true result is found (including the case where the subquery returns no rows). **SOME** is a synonym of **ANY**. **IN** can be equivalently replaced with **ANY**.

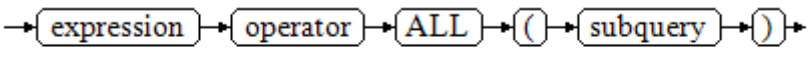
  For example:

```
openGauss=# SELECT sr_reason_sk,sr_customer_sk  FROM tpcds.store_returns WHERE sr_customer_sk
< ANY (SELECT d_dom FROM tpcds.date_dim WHERE d_dom < 10);
sr_reason_sk | sr_customer_sk
--------------+----------------
        26 |           3
        17 |           7
        32 |           5
        32 |           5
        13 |           2
        31 |           5
        25 |           7
         5 |           6
         7 |           7
        10 |           3
         1 |           5
        14 |           6
         4 |           1
         3 |           7
        22 |           5
        33 |           4
        20 |           4
        33 |           8
        15 |           2
(19 rows)
```

- ALL

  **Figure 12-11** shows the syntax of an **ALL** expression.

  **Figure 12-11** all::=

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The right-hand side is a parenthesized subquery, which must return exactly one column. The left-hand expression is evaluated and compared to each row of the subquery result using the given operator, which must yield a Boolean result. The result of **ALL** is "true" if all rows yield true (including the case where the subquery returns no rows). The result is "false" if any false result is found.

For example:

```
openGauss=# SELECT sr_reason_sk,sr_customer_sk  FROM tpcds.store_returns WHERE sr_customer_sk
< all(SELECT d_dom FROMOM tpcds.date_dim WHERE d_dom < 10);
 sr_reason_sk | sr_customer_sk
--------------+----------------
(0 rows)
```

## 12.6.4 Array Expressions

### IN

*expression* **IN** *(value [, ...])*

The parentheses on the right contain an expression list. The expression result on the left is compared with the content in the expression list. If the content in the list meets the expression result on the left, the result of **IN** is **true**. If no result meets the requirements, the result of **IN** is **false**.

For example:

```
openGauss=# SELECT 8000+500 IN (10000, 9000) AS RESULT;
 result
----------
 f
(1 row)
```

**NOTE**

If the expression result is null or the expression list does not meet the expression conditions and at least one empty value is returned for the expression list on the right, the result of **IN** is **null** rather than **false**. This method is consistent with the Boolean rules used when SQL statements return empty values.

### NOT IN

*expression* **NOT IN** *(value [, ...])*

The parentheses on the right contain an expression list. The expression result on the left is compared with the content in the expression list. If the content in the list does not meet the expression result on the left, the result of **NOT IN** is **true**. If any content meets the expression result, the result of **NOT IN** is **false**.

For example:

```
openGauss=# SELECT 8000+500 NOT IN (10000, 9000) AS RESULT;
 result
----------
 t
(1 row)
```

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> **NOTE**
>
> If the query statement result is null or the expression list does not meet the expression conditions and at least one empty value is returned for the expression list on the right, the result of **NOT IN** is **null** rather than **false**. This method is consistent with the Boolean rules used when SQL statements return empty values.

In all situations, **X NOT IN Y** equals to **NOT(X IN Y)**.

## ANY/SOME (array)

*expression operator* **ANY** *(array expression)*

*expression operator* **SOME** *(array expression)*

```
openGauss=# SELECT 8000+500 < SOME (array[10000,9000]) AS RESULT;
 result
----------
 t
(1 row)
openGauss=# SELECT 8000+500 < ANY (array[10000,9000]) AS RESULT;
 result
----------
 t
(1 row)
```

The right-hand side is a parenthesized expression, which must yield an array value. The result of the expression on the left uses operators to compute and compare the results in each row of the array expression. The comparison result must be a Boolean value.

- If at least one comparison result is true, the result of **ANY** is **true**.
- If no comparison result is true, the result of ANY is false.

> **NOTE**
>
> If no comparison result is true and the array expression generates at least one null value, the value of ANY is NULL, rather than false. This method is consistent with the Boolean rules used when SQL statements return empty values.

**SOME** is a synonym of **ANY**.

## ALL (array)

*expression operator* **ALL** *(array expression)*

The right-hand side is a parenthesized expression, which must yield an array value. The result of the expression on the left uses operators to compute and compare the results in each row of the array expression. The comparison result must be a Boolean value.

- The result of **ALL** is **true** if all comparisons yield **true** (including the case where the array has zero elements).
- If one or more comparison results are false, the result of **ALL** is false.

If the array expression yields a null array, the result of **ALL** will be null. If the left-hand expression yields null, the result of **ALL** is ordinarily null (though a non-strict comparison operator could possibly yield a different result). Also, if the right-hand array contains any null elements and no false comparison result is obtained, the result of **ALL** will be null, not true (again, assuming a strict comparison operator).

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This method is consistent with the Boolean rules used when SQL statements return empty values.

```
openGauss=# SELECT 8000+500 < ALL (array[10000,9000]) AS RESULT;
 result
----------
 t
(1 row)
```

## 12.6.5 Row Expressions

Syntax:

*row_constructor operator row_constructor*

Both sides of the row expression are row constructors. The values of both rows must have the same number of fields and they are compared with each other. The row comparison allows operators including =, <>, <, <=, and >= or a similar operator.

The use of operators =<> is slightly different from other operators. If all fields of two rows are not empty and equal, the two rows are equal. If any field in two rows is not empty and not equal, the two rows are not equal. Otherwise, the comparison result is null.

For operators <, <=, >, and > =, the fields in rows are compared from left to right until a pair of fields that are not equal or are empty are detected. If the pair of fields contains at least one null value, the comparison result is null. Otherwise, the comparison result of this pair of fields is the final result.

For example:

```
openGauss=# SELECT ROW(1,2,NULL) < ROW(1,3,0) AS RESULT;
 result
----------
 t
(1 row)
```

# 12.7 Type Conversion

## 12.7.1 Overview

### Background

SQL is a typed language. That is, every data item has an associated data type which determines its behavior and allowed usage. GaussDB has an extensible type system that is more general and flexible than other SQL implementations. Hence, most type conversion behaviors in GaussDB are governed by general rules. This allows the use of mixed-type expressions.

The GaussDB scanner/parser divides lexical elements into five fundamental categories: integers, floating-point numbers, strings, identifiers, and keywords. Constants of most non-numeric types are first classified as strings. The SQL language definition allows specifying type names with constant strings. For example, the query:

```
openGauss=# SELECT text 'Origin' AS "label", point '(0,0)' AS "value";
 label  | value
```

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```
--------+-------
 Origin | (0,0)
(1 row)
```

has two literal constants, of type **text** and **point**. If a type is not specified for a string literal, then the placeholder type **unknown** is assigned initially.

There are four fundamental SQL constructs requiring distinct type conversion rules in GaussDB parser:

- Function calls

  Much of the SQL type system is built around a rich set of functions. Functions can have one or more arguments. Since SQL permits function overloading, the function name alone does not uniquely identify the function to be called. The parser must select the right function based on the data types of the supplied arguments.

- Operators

  SQL allows expressions with prefix and postfix unary (one-argument) operators, as well as binary (two-argument) operators. Like functions, operators can be overloaded, so the same problem of selecting the right operator exists.

- Value storage

  SQL **INSERT** and **UPDATE** statements place the results of expressions into a table. The expressions in the statement must be matched up with, and perhaps converted to, the types of the target columns.

- UNION, CASE, and Related Constructs

  Since all query results from a unionized **SELECT** statement must appear in a single set of columns, the types of the results of each **SELECT** clause must be matched up and converted to a uniform set. Similarly, the result expressions of a **CASE** construct must be converted to a common type so that the **CASE** expression as a whole has a known output type. The same holds for **ARRAY** constructs, and for the **GREATEST** and **LEAST** functions.

The system catalog pg_cast stores information about which conversions, or casts, exist between which data types, and how to perform those conversions. For details, see **15.2.45 PG_CAST**.

The return type and conversion behavior of an expression are determined during semantic analysis. Data types are divided into several basic type categories, including **Boolean**, **numeric**, **string**, **bitstring**, **datetime**, **timespan**, **geometric**, and **network**. Within each category there can be one or more preferred types, which are preferred when there is a choice of possible types. With careful selection of preferred types and available implicit casts, it is possible to ensure that ambiguous expressions (those with multiple candidate parsing solutions) can be resolved in a useful way.

All type conversion rules are designed based on the following principles:

- Implicit conversions should never have surprising or unpredictable outcomes.
- There should be no extra overhead in the parser or executor if a query does not need implicit type conversion. That is, if a query is well-formed and the types already match, then the query should execute without spending extra time in the parser and without introducing unnecessary implicit conversion calls in the query.

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- Additionally, if a query usually requires an implicit conversion for a function, and if then the user defines a new function with the correct argument types, the parser should use this new function.

# 12.7.2 Operators

## Operator Type Resolution

1. Select the operators to be considered from the **pg_operator** system catalog. Considered operators are those with the matching name and argument count. If the search path finds multiple available operators, only the most suitable one is considered.
2. Look for the best match.
   a. Discard candidate operators for which the input types do not match and cannot be converted (using an implicit conversion) to match. **unknown** literals are assumed to be convertible to anything for this purpose. If only one candidate remains, use it; else continue to the next step.
   b. Run through all candidates and keep those with the most exact matches on input types. Domains are considered the same as their base type for this purpose. Keep all candidates if none survives these tests. If only one candidate remains, use it; else continue to the next step.
   c. Run through all candidates and keep those that accept preferred types (of the input data type's type category) at the most positions where type conversion will be required. Keep all candidates if none accepts preferred types. If only one candidate remains, use it; else continue to the next step.
   d. If any input arguments are of **unknown** types, check the type categories accepted at those argument positions by the remaining candidates. At each position, select the string category if any candidate accepts that category. (This bias towards string is appropriate since an unknown-type literal looks like a string.) Otherwise, if all the remaining candidates accept the same type category, select that category; otherwise fail because the correct choice cannot be deduced without more clues. Now discard candidates that do not accept the selected type category. Furthermore, if any candidate accepts a preferred type in that category, discard candidates that accept non-preferred types for that argument. Keep all candidates if none survives these tests. If only one candidate remains, use it; else continue to the next step.
   e. If there are both **unknown** and known-type arguments, and all the known-type arguments have the same type, assume that the **unknown** arguments are also of that type, and check which candidates can accept that type at the unknown-argument positions. If exactly one candidate passes this test, use it. Otherwise, fail.

## Examples

Example 1: Use factorial operator type resolution. There is only one factorial operator (postfix !) defined in the system catalog, and it takes an argument of type **bigint**. The scanner assigns an initial type of **bigint** to the argument in this query expression:

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```
openGauss=# SELECT 40 ! AS "40 factorial";

                  40 factorial
-----------------------------------------------
 815915283247897734345611269596115894272000000000
(1 row)
```

So the parser does a type conversion on the operand and the query is equivalent to:

```
openGauss=# SELECT CAST(40 AS bigint) ! AS "40 factorial";
```

Example 2: String concatenation operator type resolution. A string-like syntax is used for working with string types and for working with complex extension types. Strings with unspecified type are matched with likely operator candidates. An example with one unspecified argument:

```
openGauss=# SELECT text 'abc' || 'def' AS "text and unknown";
 text and unknown
------------------
 abcdef
(1 row)
```

In this example, the parser looks for an operator whose parameters are of the text type. Such an operator is found.

Here is a concatenation of two values of unspecified types:

```
openGauss=# SELECT 'abc' || 'def' AS "unspecified";
 unspecified
-------------
 abcdef
(1 row)
```

**NOTE**

In this case there is no initial hint for which type to use, since no types are specified in the query. So, the parser looks for all candidate operators and finds that there are candidates accepting both string-category and bit-string-category inputs. Since string category is preferred when available, that category is selected, and then the preferred type for strings, **text**, is used as the specific type to resolve the unknown-type literals as.

Example 3: Absolute-value and negation operator type resolution. The GaussDB operator catalog has several entries for the prefix operator @. All the entries implement absolute-value operations for various numeric data types. One of these entries is for type **float8**, which is the preferred type in the numeric category. Therefore, GaussDB will use that entry when faced with an unknown input:

```
openGauss=# SELECT @ '-4.5' AS "abs";
 abs
-----
 4.5
(1 row)
```

Here the system has implicitly resolved the unknown-type literal as type **float8** before applying the chosen operator.

Example 4: Use the array inclusion operator type resolution as an example. Here is another example of resolving an operator with one known and one unknown input:

```
openGauss=# SELECT array[1,2] <@ '{1,2,3}' as "is subset";
 is subset
-----------
 t
(1 row)
```

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NOTE

The GaussDB operator catalog has several entries for the infix operator <@, but the only two that could possibly accept an integer array on the left side are array inclusion (anyarray <@ anyarray) and range inclusion (anyelement <@ anyrange). Since none of these polymorphic pseudo-types (see section **12.3.16 Pseudo-Types**) is considered preferred, the parser cannot resolve the ambiguity on that basis. However, the last resolution rule tells it to assume that the unknown-type literal is of the same type as the other input, that is, integer array. Now only one of the two operators can match, so array inclusion is selected. (Had range inclusion been selected, we would have gotten an error, because the string does not have the right format to be a range literal.)

# 12.7.3 Functions

## Function Type Resolution

1. Select the functions to be considered from the **pg_proc** system catalog. If a non-schema-qualified function name was used, the functions in the current search path are considered. If a qualified function name was given, only functions in the specified schema are considered.

   If the search path finds multiple functions of different argument types, a proper function in the path is considered.
2. Check for a function accepting exactly the input argument types. If the function exists, use it. Cases involving **unknown** will never find a match at this step.
3. If no exact match is found, see if the function call appears to be a special type conversion request.
4. Look for the best match.
   a. Discard candidate functions for which the input types do not match and cannot be converted (using an implicit conversion) to match. **unknown** literals are assumed to be convertible to anything for this purpose. If only one candidate remains, use it; else continue to the next step.
   b. Run through all candidates and keep those with the most exact matches on input types. Domains are considered the same as their base type for this purpose. Keep all candidates if none has exact matches. If only one candidate remains, use it; else continue to the next step.
   c. Run through all candidates and keep those that accept preferred types at the most positions where type conversion will be required. Keep all candidates if none accepts preferred types. If only one candidate remains, use it; else continue to the next step.
   d. If any input arguments are of **unknown** types, check the type categories accepted at those argument positions by the remaining candidates. At each position, select the string category if any candidate accepts that category. (This bias towards string is appropriate since an unknown-type literal looks like a string.) Otherwise, if all the remaining candidates accept the same type category, select that category; otherwise fail because the correct choice cannot be deduced without more clues. Now discard candidates that do not accept the selected type category. Furthermore, if any candidate accepts a preferred type in that category, discard candidates that accept non-preferred types for that argument. Keep all candidates if none survives these tests. If only one candidate remains, use it; else continue to the next step.

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e. If there are both **unknown** and known-type arguments, and all the known-type arguments have the same type, assume that the **unknown** arguments are also of that type, and check which candidates can accept that type at the **unknown**-argument positions. If exactly one candidate passes this test, use it. Otherwise, fail.

## Examples

Example 1: Use the rounding function argument type resolution as the first example. There is only one **round** function that takes two arguments; it takes a first argument of type **numeric** and a second argument of type **integer**. So the following query automatically converts the first argument of type **integer** to **numeric**:

```
openGauss=# SELECT round(4, 4);
 round
--------
 4.0000
(1 row)
```

That query is actually transformed by the parser to:

```
openGauss=# SELECT round(CAST (4 AS numeric), 4);
```

Since numeric constants with decimal points are initially assigned the type **numeric**, the following query will require no type conversion and therefore might be slightly more efficient:

```
openGauss=# SELECT round(4.0, 4);
```

Example 2: Use the substring function type resolution as the second example. There are several **substr** functions, one of which takes types **text** and **integer**. If called with a string constant of unspecified type, the system chooses the candidate function that accepts an argument of the preferred category **string** (namely of type **text**).

```
openGauss=# SELECT substr('1234', 3);
 substr
--------
    34
(1 row)
```

If the string is declared to be of type **varchar**, as might be the case if it comes from a table, then the parser will try to convert it to become **text**:

```
openGauss=# SELECT substr(varchar '1234', 3);
 substr
--------
    34
(1 row)
```

This is transformed by the parser to effectively become:

```
openGauss=# SELECT substr(CAST (varchar '1234' AS text), 3);
```

**NOTE**

The parser learns from the **pg_cast** catalog that **text** and **varchar** are binary-compatible, meaning that one can be passed to a function that accepts the other without doing any physical conversion. Therefore, no type conversion is really inserted in this case.

And, if the function is called with an argument of type **integer**, the parser will try to convert that to **text**:

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```
openGauss=# SELECT substr(1234, 3);
substr
--------
 34
(1 row)
```

This is transformed by the parser to effectively become:

```
openGauss=# SELECT substr(CAST (1234 AS text), 3);
 substr
--------
    34
(1 row)
```

# 12.7.4 Value Storage

## Value Storage Type Resolution

1. Search for an exact match with the target column.
2. Try to convert the expression to the target type. This will succeed if there is a registered cast between the two types. If the expression is an unknown-type literal, the content of the literal string will be fed to the input conversion routine for the target type.
3. Check to see if there is a sizing cast for the target type. A sizing cast is a cast from that type to itself. If one is found in the **pg_cast** catalog, apply it to the expression before storing into the destination column. The implementation function for such a cast always takes an extra parameter of type **integer**. The parameter receives the destination column's **atttypmod** value (typically its declared length, although the interpretation of **atttypmod** varies for different data types), and may take a third Boolean parameter that says whether the cast is explicit or implicit. The cast function is responsible for applying any length-dependent semantics such as size checking or truncation.

## Examples

Use the **character** storage type conversion as an example. For a target column declared as **character(20)** the following statement shows that the stored value is sized correctly:

```
openGauss=# CREATE TABLE tpcds.value_storage_t1 (
    VS_COL1 CHARACTER(20)
)DISTRIBUTE BY HASH (VS_COL1);
openGauss=# INSERT INTO tpcds.value_storage_t1 VALUES('abcdef');
openGauss=# SELECT VS_COL1, octet_length(VS_COL1) FROM tpcds.value_storage_t1;
       vs_col1        | octet_length
----------------------+--------------
 abcdef               |           20
(1 row)
)

openGauss=# DROP TABLE tpcds.value_storage_t1;
```

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NOTE

What has happened here is that the two unknown literals are resolved to **text** by default, allowing the || operator to be resolved as **text** concatenation. Then the **text** result of the operator is converted to **bpchar** ("blank-padded char", the internal name of the **character** data type) to match the target column type. Since the conversion from **text** to **bpchar** is binary-coercible, this conversion does not insert any real function call. Finally, the sizing function **bpchar(bpchar, integer, Boolean)** is found in the system catalog and used for the operator's result and the stored column length. This type-specific function performs the required length check and addition of padding spaces.

# 12.7.5 UNION, CASE, and Related Constructs

SQL **UNION** constructs must match up possibly dissimilar types to become a single result set. The resolution algorithm is applied separately to each output column of a union query. The **INTERSECT** and **EXCEPT** construct resolve dissimilar types in the same way as **UNION**. The **CASE**, **ARRAY**, **VALUES**, **GREATEST** and **LEAST** constructs use the identical algorithm to match up their component expressions and select a result data type.

## Type Resolution for UNION, CASE, and Related Constructs

- If all inputs are of the same type, and it is not **unknown**, resolve as that type.
- If all inputs are of type **unknown**, resolve as type **text** (the preferred type of the string category). Otherwise, **unknown** inputs are ignored.
- If the inputs are not all of the same type category, a failure will be resulted. (Type **unknown** is not included in this case.)
- If the inputs are all of the same type category, choose the top preferred type in that category. (Exception: The UNION operation regards the type of the first branch as the selected type.)

  NOTE

  **typcategory** in the **pg_type** system catalog indicates the data type category. **typispreferred** indicates whether a type is preferred in **typcategory**.
- Convert all inputs to the selected type. (Retain the original lengths of strings). Fail if there is not an implicit conversion from a given input to the selected type.
- If the input contains the json, txid_snapshot, sys_refcursor, or geometry type, **UNION** cannot be performed.

## Type Resolution for CASE and COALESCE in TD Compatibility Type

- If all inputs are of the same type, and it is not **unknown**, resolve as that type.
- If all inputs are of type **unknown**, resolve as type **text**.
- If inputs are of the string type (including **unknown** which is resolved as type **text**) and digit type, resolve as the string type. If the inputs are not of the two types, an error will be reported.
- If the inputs are all of the same type category, choose the top preferred type in that category.
- Convert all inputs to the selected type. Fail if there is not an implicit conversion from a given input to the selected type.

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## Type Resolution for CASE in ORA Compatibility Mode

**decode(expr, search1, result1, search2, result2, ..., defresult)**: When the **sql_beta_feature** is set to **a_style_coerce**, the final return value type of the expression is set to the data type of result1 or a higher-precision data type in the same type as result1. (For example, numeric and int are both numeric data types, but numeric has higher precision and priority than int.) For CASE WHEN, the behavior is the same as the default behavior in ORA-compatible mode.

- If all inputs are of the same type, and it is not **unknown**, resolve as that type. Otherwise, proceed to the next step.
- Set the data type of result1 to the final return value type preferType, which belongs to preferCategory.
- Consider the data types of result2, result3, and defresult in sequence. If the type category is also preferCategory, which is the same as that of result1, check whether the precision (priority) is higher than that of preferType. If it is, update preferType to a data type with higher precision. If the type category is not preferCategory, check whether the category can be implicitly converted to preferType. If it cannot, an error is reported.
- Uses the data type recorded by preferType as the return value type of the expression. The expression result is implicitly converted to this data type.

Note 1:

There is a special case where the character type of a super-large number is converted to the numeric type, for example, **select decode(1, 2, 2, '53465465676465454657567678676')**, in which the large number exceeds the range of the bigint and double types. If result1 is of the numeric type and does not meet the condition that all inputs are of the same type, the type of the return value is set to numeric to be compatible with this special case.

Note 2:

Priority of the numeric types: numeric > float8 > float4 > int8 > int4 > int2 > int1

Priority of the character types: text > varchar (nvarchar2) > bpchar > char

Priority of date types: timestamptz > timestamp > smalldatetime > date > abstime > timetz > time

Priority of date span types: interval > tinterval > reltime

Note 3:

The following figure shows the supported implicit type conversion when **set sql_beta_feature** is set to **'a_style_coerce'** in ORA compatibility mode. **** indicates that conversion is not required, **yes** indicates that conversion is supported, and the blank value indicates that conversion is not supported.

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| | bool | int1 | int2 | int4 | int8 | float4 | float8 | numeric | money | char | bpchar | varchar2 | nvarchar2 | text/clob | raw | blob | date | time | timetz | timestamp | timestamptz | smalldatetime | interval | reltime | abstime |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| bool | \ | | | | | | | | | | | | | | | | | | | | | | | | |
| int1 | | \ | yes | yes | yes | yes | yes | yes | | yes | yes | yes | yes | yes | | | | | | | | | | | |
| int2 | | yes | \ | yes | yes | yes | yes | yes | | yes | yes | yes | yes | yes | | | | | | | | | | | |
| int4 | | yes | yes | \ | yes | yes | yes | yes | | yes | yes | yes | yes | yes | | | | | | | | | | | |
| int8 | | yes | yes | yes | \ | yes | yes | yes | | yes | yes | yes | yes | yes | | | | | | | | | | | |
| float4 | | yes | yes | yes | yes | \ | yes | yes | | yes | yes | yes | yes | yes | | | | | | | | | | | |
| float8 | | yes | yes | yes | yes | yes | \ | yes | | yes | yes | yes | yes | yes | | | | | | | | | | | |
| numeric | | yes | yes | yes | yes | yes | yes | \ | | yes | yes | yes | yes | yes | | | | | | | | | | | |
| money | | | | | | | | | \ | | | | | | | | | | | | | | | | |
| char | | yes | yes | yes | yes | yes | yes | yes | | \ | yes | yes | yes | yes | | | | | | | | | | | |
| bpchar | | yes | yes | yes | yes | yes | yes | yes | | yes | \ | yes | yes | yes | | | | | | | | | | | |
| varchar2 | | yes | yes | yes | yes | yes | yes | yes | | yes | yes | \ | yes | yes | yes | | | | | | | | | | |
| nvarchar2 | | yes | yes | yes | yes | yes | yes | yes | | yes | yes | yes | \ | yes | | | | | | | | | | | |
| text/clob | | yes | yes | yes | yes | yes | yes | yes | | yes | yes | yes | yes | \ | | | | | | | | | | | |
| raw | | | | | | | | | | | | yes | | yes | \ | yes | | | | | | | | | |
| blob | | | | | | | | | | | | | | | yes | \ | | | | | | | | | |
| date | | | | | | | | | | | | yes | yes | yes | | | \ | | | yes | yes | yes | | | yes |
| time | | | | | | | | | | | | | | yes | | | | \ | yes | | | | | | |
| timetz | | | | | | | | | | | | | | yes | | | | yes | \ | | | | | | |
| timestamp | | | | | | | | | | | | yes | yes | yes | | | yes | | | \ | yes | yes | | | yes |
| timestamptz | | | | | | | | | | | | | | yes | | | yes | | | yes | \ | yes | | | yes |
| smalldatetime | | | | | | | | | | | | yes | | yes | | | yes | | | yes | yes | \ | | | yes |
| interval | | | | | | | | | | | | yes | yes | yes | | | | | | | | | \ | yes | |
| reltime | | | | | | | | | | | | | | yes | | | | | | | | | yes | \ | |
| abstime | | | | | | | | | | | | | | yes | | | yes | | | yes | yes | yes | | | \ |

## Examples

Example 1: Use type resolution with underspecified types in a union as the first example. Here, the unknown-type literal **'b'** will be resolved to type **text**.

```
openGauss=# SELECT text 'a' AS "text" UNION SELECT 'b';
 text
------
 a
 b
(2 rows)
```

Example 2: Use type resolution in a simple union as the second example. The literal **1.2** is of type **numeric**, and the **integer** value **1** can be cast implicitly to **numeric**, so that type is used.

```
openGauss=# SELECT 1.2 AS "numeric" UNION SELECT 1;
 numeric
---------
       1
     1.2
(2 rows)
```

Example 3: Use type resolution in a transposed union as the third example. Since type **real** cannot be implicitly cast to **integer**, but **integer** can be implicitly cast to **real**, the union result type is resolved as **real**.

```
openGauss=# SELECT 1 AS "real" UNION SELECT CAST('2.2' AS REAL);
 real
------
    1
  2.2
(2 rows)
```

Example 4: In the **TD** type, if input parameters for **COALESCE** are of **int** and **varchar** types, resolve as type **varchar**. In **ORA** mode, an error is reported.

```
-- In Oracle mode, create the oracle_1 database compatible with Oracle.
openGauss=# CREATE DATABASE oracle_1 dbcompatibility = 'ORA';
```

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```
-- Switch to the oracle_1 database.
openGauss=# \c oracle_1

-- Create the t1 table.
oracle_1=# CREATE TABLE t1(a int, b varchar(10));
```

```
--查看coalesce参数输入int和varchar类型的查询语句的执行计划。
oracle_1=# EXPLAIN SELECT coalesce(a, b) FROM t1;
ERROR:  COALESCE types integer and character varying cannot be matched
LINE 1: EXPLAIN SELECT coalesce(a, b) FROM t1;
                                           ^
CONTEXT:  referenced column: coalesce
```

```
-- Delete the table.
oracle_1=# DROP TABLE t1;

-- Switch to the postgres database.
oracle_1=# \c postgres

-- In TD mode, create the td_1 database compatible with Teradata.
openGauss=# CREATE DATABASE td_1 dbcompatibility = 'TD';

-- Switch to the td_1 database.
openGauss=# \c td_1

-- Create the t2 table.
td_1=# CREATE TABLE t2(a int, b varchar(10));

-- Show the execution plan of a statement for querying the types int and varchar of input parameters for
COALESCE.
td_1=# EXPLAIN VERBOSE select coalesce(a, b) from t2;
                                QUERY PLAN
-------------------------------------------------------------------------------------
 Data Node Scan  (cost=0.00..0.00 rows=0 width=0)
   Output: (COALESCE((t2.a)::character varying, t2.b))
   Node/s: All DNs
   Remote query: SELECT COALESCE(a::character varying, b) AS "coalesce" FROM public.t2
(4 rows)

-- Delete the table.
td_1=# DROP TABLE t2;

-- Switch to the postgres database.
td_1=# \c postgres

-- Delete databases in Oracle and TD mode.
openGauss=# DROP DATABASE oracle_1;
openGauss=# DROP DATABASE td_1;
```

Example 5: In ORA mode, set the final return value type of the expression to the data type of result1 or a higher-precision data type whose category is the same as that of the data type of result1.

```
-- In ORA mode, create the ora_1 database compatible with ORA.
openGauss=# CREATE DATABASE ora_1 dbcompatibility = 'A';

-- Switch to the ora_1 database.
openGauss=# \c ora_1

-- Enable the decode compatibility parameters.
set sql_beta_feature='a_style_coerce';

-- Create the t1 table.
ora_1=# CREATE TABLE t1(c_int int, c_float8 float8, c_char char(10), c_text text, c_date date);

-- Insert data.
ora_1=# INSERT INTO t1 VALUES(1, 2, '3', '4', date '12-10-2010');
```

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```
-- The data type of result1 is char and that of defresult is text. The precision of text is higher, and the type
of the return value is changed to text from char.
ora_1=# SELECT decode(1, 2, c_char, c_text) AS result, pg_typeof(result) FROM t1;
 result | pg_typeof
--------+-----------
 4      | text
(1 row)

-- The data type of result1 is int, which is a numeric type. The type of the return value is set to numeric.
ora_1=# SELECT decode(1, 2, c_int, c_float8) AS result, pg_typeof(result) FROM t1;
 result | pg_typeof
--------+-----------
      2 | numeric
(1 row)

-- The implicit conversion from the data type of defresult to that of result1 does not exist. If it is performed,
an error is reported.
ora_1=# SELECT decode(1, 2, c_int, c_date) FROM t1;
ERROR:  CASE types integer and timestamp without time zone cannot be matched
LINE 1: SELECT decode(1, 2, c_int, c_date) FROM t1;
                                   ^
CONTEXT:  referenced column: c_date

-- Disable the decode compatibility parameters.
set sql_beta_feature='none';

-- Delete the table.
ora_1=# DROP TABLE t1;
DROP TABLE

-- Switch to the postgres database.
ora_1=# \c postgres

-- Delete the database in ORA mode.
openGauss=# DROP DATABASE ora_1;
DROP DATABASE
```

# 12.8 Full Text Search

Full text search (or just text search) provides the capability to identify natural-language documents that satisfy a query, and optionally to sort them by relevance to the query. The most common type of search is to find all documents containing given query terms and return them in order of their similarity to the query.

## 12.8.1 Introduction

### 12.8.1.1 Full-Text Retrieval

Textual search operators have been used in databases for years. GaussDB has **~**, **~***, **LIKE**, and **ILIKE** operators for textual data types, but they lack many essential properties required by modern information systems. They can be supplemented by indexes and dictionaries.

Text search lacks the following essential properties required by information systems:

- There is no linguistic support, even for English.

  Regular expressions are not sufficient because they cannot easily handle derived words, For example, you might miss documents that contain **satisfies**, although you probably would like to find them when searching for **satisfy**. It

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is possible to use **OR** to search for multiple derived forms, but this is tedious and error-prone, because some words can have several thousand derivatives.

- They provide no ordering (ranking) of search results, which makes them ineffective when thousands of matching documents are found.
- They tend to be slow because there is no index support, so they must process all documents for every search.

Full text indexing allows documents to be preprocessed and an index is saved for later rapid searching. Preprocessing includes:

- Parsing documents into tokens

  It is useful to identify various classes of tokens, for example, numbers, words, complex words, and email addresses, so that they can be processed differently. In principle, token classes depend on the specific application, but for most purposes it is adequate to use a predefined set of classes.

- Converting tokens into lexemes

  A lexeme is a string, just like a token, but it has been normalized so that different forms of the same word are made alike. For example, normalization almost always includes folding upper-case letters to lower-case, and often involves removal of suffixes (such as **s** or **es** in English) This allows searches to find variant forms of the same word, without tediously entering all the possible variants. Also, this step typically eliminates stop words, which are words that are so common that they are useless for searching. (In short, tokens are raw fragments of the document text, while lexemes are words that are believed useful for indexing and searching.) GaussDB uses dictionaries to perform this step and provides various standard dictionaries.

- Storing preprocessed documents optimized for searching

  For example, each document can be represented as a sorted array of normalized lexemes. Along with the lexemes, it is often desirable to store positional information for proximity ranking. Therefore, a document that contains a more "dense" region of query words is assigned with a higher rank than the one with scattered query words.

Dictionaries allow fine-grained control over how tokens are normalized. With appropriate dictionaries, you can define stop words that should not be indexed.

A data type **tsvector** is provided for storing preprocessed documents, along with a type **tsquery** for storing query conditions. For details, see **12.3.10 Text Search Types**. For details about the functions and operators available for these data types, see **12.5.12 Text Search Functions and Operators**. The match operator **@@**, which is the most important among those functions and operators, is introduced in **12.8.1.3 Basic Text Matching**.

## 12.8.1.2 What Is a Document?

A document is the unit of searching in a full text search system; for example, a magazine article or email message. The text search engine must be able to parse documents and store associations of lexemes (keywords) with their parent document. Later, these associations are used to search for documents that contain query words.

For searches within GaussDB, a document is normally a textual column within a row of a database table, or possibly a combination (concatenation) of such

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columns, perhaps stored in several tables or obtained dynamically. In other words, a document can be constructed from different parts for indexing and it might not be stored anywhere as a whole. For example:

```
openGauss=# SELECT d_dow || '-' || d_dom || '-' || d_fy_week_seq  AS identify_serials FROM tpcds.date_dim
WHERE d_fy_week_seq = 1;
identify_serials
------------------
 5-6-1
 0-8-1
 2-3-1
 3-4-1
 4-5-1
 1-2-1
 6-7-1
(7 rows)
```

**NOTICE**

Actually, in these example queries, **coalesce** should be used to prevent a single **NULL** attribute from causing a **NULL** result for the whole document.

Another possibility is to store the documents as simple text files in the file system. In this case, the database can be used to store the full text index and to execute searches, and some unique identifier can be used to retrieve the document from the file system. However, retrieving files from outside the database requires system administrator permissions or special function support, so this is usually less convenient than keeping all the data inside the database. Also, keeping everything inside the database allows easy access to document metadata to assist in indexing and display.

For text search purposes, each document must be reduced to the preprocessed **tsvector** format. Searching and relevance-based ranking are performed entirely on the **tsvector** representation of a document. The original text is retrieved only when the document has been selected for display to a user. We therefore often speak of the **tsvector** as being the document, but it is only a compact representation of the full document.

### 12.8.1.3 Basic Text Matching

Full text search in GaussDB is based on the match operator **@@**, which returns **true** if a **tsvector** (document) matches a **tsquery** (query). It does not matter which data type is written first:

```
openGauss=# SELECT 'a fat cat sat on a mat and ate a fat rat'::tsvector @@ 'cat & rat'::tsquery AS RESULT;
 result
----------
 t
(1 row)
openGauss=# SELECT 'fat & cow'::tsquery @@ 'a fat cat sat on a mat and ate a fat rat'::tsvector AS RESULT;
 result
----------
 f
(1 row)
```

As the above example suggests, a **tsquery** is not raw text, any more than a **tsvector** is. A tsquery contains search terms, which must be already-normalized lexemes, and may combine multiple terms using **AND**, **OR**, and **NOT** operators. For details, see **12.3.10 Text Search Types**. There are functions **to_tsquery** and

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**plainto_tsquery** that are helpful in converting user-written text into a proper tsquery, for example by normalizing words appearing in the text. Similarly, **to_tsvector** is used to parse and normalize a document string. So in practice a text search match would look more like this:

```
openGauss=# SELECT to_tsvector('fat cats ate fat rats') @@ to_tsquery('fat & rat') AS RESULT;
result
----------
 t
(1 row)
```

Observe that this match would not succeed if written as follows:

```
openGauss=# SELECT 'fat cats ate fat rats'::tsvector @@ to_tsquery('fat & rat')AS RESULT;
result
----------
 f
(1 row)
```

In the preceding match, no normalization of the word **rats** will occur. Therefore, **rats** does not match **rat**.

The **@@** operator also supports text input, allowing explicit conversion of a text string to **tsvector** or **tsquery** to be skipped in simple cases. The variants available are:

```
tsvector @@ tsquery
tsquery  @@ tsvector
text @@ tsquery
text @@ text
```

We already saw the first two of these. The form **text @@ tsquery** is equivalent to **to_tsvector(text) @@ tsquery**. The form **text @@ text** is equivalent to **to_tsvector(text) @@ plainto_tsquery(text)**.

## 12.8.1.4 Configurations

Full text search functionality includes the ability to do many more things: skip indexing certain words (stop words), process synonyms, and use sophisticated parsing, for example, parse based on more than just white space. This functionality is controlled by text search configurations. GaussDB comes with predefined configurations for many languages, and you can easily create your own configurations. (The **\dF** command of **gsql** shows all available configurations.)

During installation an appropriate configuration is selected and **default_text_search_config** is set accordingly in **postgresql.conf**. If you are using the same text search configuration for the entire cluster you can use the value in **postgresql.conf**. To use different configurations throughout the cluster but the same configuration within any one database, use **ALTER DATABASE ... SET.** Otherwise, you can set **default_text_search_config** in each session.

Each text search function that depends on a configuration has an optional argument, so that the configuration to use can be specified explicitly. **default_text_search_config** is used only when this argument is omitted.

To make it easier to build custom text search configurations, a configuration is built up from simpler database objects. GaussDB's text search facility provides the following types of configuration-related database objects:

- Text search parsers break documents into tokens and classify each token (for example, as words or numbers).

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- Text search dictionaries convert tokens to normalized form and reject stop words.
- Text search templates provide the functions underlying dictionaries. (A dictionary simply specifies a template and a set of parameters for the template.)
- Text search configurations select a parser and a set of dictionaries to use to normalize the tokens produced by the parser.

## 12.8.2 Tables and Indexes

### 12.8.2.1 Searching a Table

It is possible to do a full text search without an index.

- A simple query to print each row that contains the word **america** in its **body** column is as follows:

```
openGauss=# DROP SCHEMA IF EXISTS tsearch CASCADE;

openGauss=# CREATE SCHEMA tsearch;

openGauss=# CREATE TABLE tsearch.pgweb(id int, body text, title text, last_mod_date date);

openGauss=# INSERT INTO tsearch.pgweb VALUES(1, 'China, officially the People''s Republic of China (PRC), located in Asia, is the world''s most populous state.', 'China', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(2, 'America is a rock band, formed in England in 1970 by multi-instrumentalists Dewey Bunnell, Dan Peek, and Gerry Beckley.', 'America', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(3, 'England is a country that is part of the United Kingdom. It shares land borders with Scotland to the north and Wales to the west.', 'England', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(4, 'Australia, officially the Commonwealth of Australia, is a country comprising the mainland of the Australian continent, the island of Tasmania, and numerous smaller islands.', 'Australia', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(6, 'Japan is an island country in East Asia.', 'Japan', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(7, 'Germany, officially the Federal Republic of Germany, is a sovereign state and federal parliamentary republic in central-western Europe.', 'Germany', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(8, 'France, is a sovereign state comprising territory in western Europe and several overseas regions and territories.', 'France', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(9, 'Italy officially the Italian Republic, is a unitary parliamentary republic in Europe.', 'Italy', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(10, 'India, officially the Republic of India, is a country in South Asia.', 'India', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(11, 'Brazil, officially the Federative Republic of Brazil, is the largest country in both South America and Latin America.', 'Brazil', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(12, 'Canada is a country in the northern half of North America.', 'Canada', '2010-1-1');

openGauss=# INSERT INTO tsearch.pgweb VALUES(13, 'Mexico, officially the United Mexican States, is a federal republic in the southern part of North America.', 'Mexico', '2010-1-1');

openGauss=# SELECT id, body, title FROM tsearch.pgweb WHERE to_tsvector('english', body) @@ to_tsquery('english', 'america');
```

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```
 id |                                                
```

The **to_tsvector** function comes in to two versions: the 1-argument version and the 2-argument version. When the 1-argument version is used, the system uses the configuration specified by **default_text_search_config** by default.

Notice that the 2-argument version of **to_tsvector** is used for index creation. Only text search functions that specify a configuration name can be used in expression indexes. This is because the index contents must be unaffected by **default_text_search_config**, whose value can be changed at any time. If they were affected, the index contents might be inconsistent, because different entries could contain **tsvectors** that were created with different text search configurations, and there would be no way to guess which was which. It would be impossible to dump and restore such an index correctly.

Because the two-argument version of **to_tsvector** was used in the index above, only a query reference that uses the 2-argument version of **to_tsvector** with the same configuration name will use that index. That is, **WHERE to_tsvector('english', body) @@ 'a & b'** can use the index, but **WHERE to_tsvector(body) @@ 'a & b'** cannot. This ensures that an index will be used only with the same configuration used to create the index entries.

It is possible to set up more complex expression indexes wherein the configuration name is specified by another column. For example:

```
openGauss=# CREATE INDEX pgweb_idx_2 ON tsearch.pgweb USING gin(to_tsvector('ngram', body));
```

where **body** is a column in the **pgweb** table. This allows mixed configurations in the same index while recording which configuration was used for each index entry. This would be useful, for example, if the document collection contained documents in different languages. Again, queries that are meant to use the index must be phrased to match, for example, **WHERE to_tsvector(config_name, body) @@ 'a & b'** must match **to_tsvector** in the index.

Indexes can even concatenate columns:

```
openGauss=# CREATE INDEX pgweb_idx_3 ON tsearch.pgweb USING gin(to_tsvector('english', title || ' ' ||
body));
```

Another approach is to create a separate **tsvector** column to hold the output of **to_tsvector**. This example is a concatenation of **title** and **body**, using **coalesce** to ensure that one column will still be indexed when the other is **NULL**:

```
openGauss=# ALTER TABLE tsearch.pgweb ADD COLUMN textsearchable_index_col tsvector;
openGauss=# UPDATE tsearch.pgweb SET textsearchable_index_col = to_tsvector('english', coalesce(title,'')
|| ' ' || coalesce(body,''));
```

Then, create a GIN index to speed up the search:

```
openGauss=# CREATE INDEX textsearch_idx_4 ON tsearch.pgweb USING gin(textsearchable_index_col);
```

Now you are ready to perform a fast full text search:

```
openGauss=# SELECT title
FROM tsearch.pgweb
WHERE textsearchable_index_col @@ to_tsquery('north & america')
ORDER BY last_mod_date DESC
LIMIT 10;

 title
--------
 Canada
 Mexico
(2 rows)
```

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One advantage of the separate-column approach over an expression index is that it is unnecessary to explicitly specify the text search configuration in queries in order to use the index. As shown in the preceding example, the query can depend on **default_text_search_config**. Another advantage is that searches will be faster, since it will not be necessary to redo the **to_tsvector** calls to verify index matches. The expression-index approach is simpler to set up, however, and it requires less disk space since the **tsvector** representation is not stored explicitly.

### 12.8.2.3 Constraints on Index Use

The following is an example of index use:

```
openGauss=# create table table1 (c_int int,c_bigint bigint,c_varchar varchar,c_text text)
with(orientation=row);

openGauss=# create text search configuration ts_conf_1(parser=POUND);
openGauss=# create text search configuration ts_conf_2(parser=POUND) with(split_flag='%');

openGauss=# set default_text_search_config='ts_conf_1';
openGauss=# create index idx1 on table1 using gin(to_tsvector(c_text));

openGauss=# set default_text_search_config='ts_conf_2';
openGauss=# create index idx2 on tscp_u_m_005_tbl using gin(to_tsvector(c_text));

openGauss=# select c_varchar,to_tsvector(c_varchar) from table1 where to_tsvector(c_text) @@
plainto_tsquery('¥#@……&**')  and to_tsvector(c_text) @@ openGauss=# plainto_tsquery('Company ')
and c_varchar is not null order by 1 desc limit 3;
```

In this example, **table1** has two GIN indexes created on the same column **c_text**, **idx1** and **idx2**, but these two indexes are created under different settings of **default_text_search_config**. Differences between this example and the scenario where one table has common indexes created on the same column are as follows:

- GIN indexes use different parsers (that is, different delimiters). In this case, the index data of **idx1** is different from that of **idx2**.
- In the specified scenario, the index data of multiple common indexes created on the same column is the same.

As a result, using **idx1** and **idx2** for the same query returns different results.

### Constraints

Still use the above example. When:

- Multiple GIN indexes are created on the same column of the same table.
- The GIN indexes use different parsers (that is, different delimiters).
- The column is used in a query, and an index scan is used in the execution plan.

  To avoid different query results caused by different GIN indexes, ensure that only one GIN index is available on a column of the physical table.

## 12.8.3 Controlling Text Search

To implement full text searching there must be a function to create a **tsvector** from a document and a **tsquery** from a user query. Also, we need to return results in a useful order, so we need a function that compares documents with respect to their relevance to the query. It is also important to be able to display the results nicely. GaussDB supports all these functions.

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### 12.8.3.1 Parsing Documents

GaussDB provides function **to_tsvector** for converting a document to the **tsvector** data type.

```
to_tsvector([ config regconfig, ] document text) returns tsvector
```

**to_tsvector** parses a textual document into tokens, reduces the tokens to lexemes, and returns a **tsvector**, which lists the lexemes together with their positions in the document. The document is processed according to the specified or default text search configuration. Here is a simple example:

```
openGauss=# SELECT to_tsvector('english', 'a fat  cat sat on a mat - it ate a fat rats');
                  to_tsvector
-----------------------------------------------------
 'ate':9 'cat':3 'fat':2,11 'mat':7 'rat':12 'sat':4
```

In the preceding example we see that the resulting **tsvector** does not contain the words **a**, **on**, or **it**, the word **rats** became **rat**, and the punctuation sign (-) was ignored.

The **to_tsvector** function internally calls a parser which breaks the document text into tokens and assigns a type to each token. For each token, a list of dictionaries is consulted. where the list can vary depending on the token type. The first dictionary that recognizes the token emits one or more normalized lexemes to represent the token. For example:

- **rats** became **rat** because one of the dictionaries recognized that the word **rats** is a plural form of **rat**.
- Some words are recognized as stop words (see **12.8.6.2 Stop Words**), which causes them to be ignored since they occur too frequently to be useful in searching. In our example these are **a**, **on**, and **it**.
- If no dictionary in the list recognizes the token then it is also ignored. In this example that happened to the punctuation sign (-) because there are no dictionaries assigned for its token type (**Space symbols**), meaning space tokens will never be indexed.

The choices of parser, dictionaries and which types of tokens to index are determined by the selected text search configuration. It is possible to have many different configurations in the same database, and predefined configurations are available for various languages. In our example we used the default configuration **english** for the English language.

The function **setweight** can be used to label the entries of a **tsvector** with a given weight, where a weight is one of the letters **A**, **B**, **C**, or **D**. This is typically used to mark entries coming from different parts of a document, such as title versus body. Later, this information can be used for ranking of search results.

Because **to_tsvector(NULL)** will return **NULL**, you are advised to use **coalesce** whenever a column might be null. Here is the recommended method for creating a **tsvector** from a structured document:

```
openGauss=# CREATE TABLE tsearch.tt (id int, title text, keyword text, abstract text, body text, ti tsvector);

openGauss=# INSERT INTO tsearch.tt(id, title, keyword, abstract, body) VALUES (1, 'China', 'Beijing',
'China','China, officially the People''s Republic of China (PRC), located in Asia, is the world''s most populous
state.');

openGauss=# UPDATE tsearch.tt SET ti =
```

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```
    setweight(to_tsvector(coalesce(title,'')), 'A')    ||
    setweight(to_tsvector(coalesce(keyword,'')), 'B')  ||
    setweight(to_tsvector(coalesce(abstract,'')), 'C') ||
    setweight(to_tsvector(coalesce(body,'')), 'D');
openGauss=# DROP TABLE tsearch.tt;
```

In this example, **setweight** is used to label the source of each lexeme in the finished **tsvector**, and then the labeled **tsvector** values are merged using the tsvector concatenation operator **||**. For details about these operations, see **12.8.4.1 Manipulating tsvector**.

## 12.8.3.2 Parsing Queries

GaussDB provides functions **to_tsquery** and **plainto_tsquery** for converting a query to the **tsquery** data type. **to_tsquery** offers access to more features than **plainto_tsquery**, but is less forgiving about its input.

```
to_tsquery([ config regconfig, ] querytext text) returns tsquery
```

**to_tsquery** creates a **tsquery** value from **querytext**, which must consist of single tokens separated by the Boolean operators **&** (AND), **|** (OR), and **!** (NOT). These operators can be grouped using parentheses. In other words, the input to **to_tsquery** must follow the general rules for **tsquery** input, as described in **12.3.10 Text Search Types**. The difference is that while basic **tsquery** input takes the tokens at face value, **to_tsquery** normalizes each token to a lexeme using the specified or default configuration, and discards any tokens that are stop words according to the configuration. For example:

```
openGauss=# SELECT to_tsquery('english', 'The & Fat & Rats');
  to_tsquery
---------------
 'fat' & 'rat'
(1 row)
```

As in basic **tsquery** input, **weight(s)** can be attached to each lexeme to restrict it to match only **tsvector** lexemes of those **weight(s)**. For example:

```
openGauss=# SELECT to_tsquery('english', 'Fat | Rats:AB');
   to_tsquery
------------------
 'fat' | 'rat':AB
(1 row)
```

Also, the asterisk (*) can be attached to a lexeme to specify prefix matching:

```
openGauss=# SELECT to_tsquery('supern:*A & star:A*B');
       to_tsquery
--------------------------
 'supern':*A & 'star':*AB
(1 row)
```

Such a lexeme will match any word having the specified string and weight in a **tsquery**.

```
plainto_tsquery([ config regconfig, ] querytext text) returns tsquery
```

**plainto_tsquery** transforms unformatted text **querytext** to **tsquery**. The text is parsed and normalized much as for **to_tsvector**, then the **&** (AND) Boolean operator is inserted between surviving words.

For example:

```
openGauss=# SELECT plainto_tsquery('english', 'The Fat Rats');
 plainto_tsquery
```

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```
-----------------
 'fat' & 'rat'
(1 row)
```

Note that **plainto_tsquery** cannot recognize Boolean operators, weight labels, or prefix-match labels in its input:

```
openGauss=# SELECT plainto_tsquery('english', 'The Fat & Rats:C');
   plainto_tsquery
---------------------
 'fat' & 'rat' & 'c'
(1 row)
```

Here, all the input punctuation was discarded as being space symbols.

## 12.8.3.3 Ranking Search Results

Ranking attempts to measure how relevant documents are to a particular query, so that when there are many matches the most relevant ones can be shown first. GaussDB provides two predefined ranking functions, which take into account lexical, proximity, and structural information; that is, they consider how often the query terms appear in the document, how close together the terms are in the document, and how important is the part of the document where they occur. However, the concept of relevancy is vague and application-specific. Different applications might require additional information for ranking, for example, document modification time. The built-in ranking functions are only examples. You can write your own ranking functions and/or combine their results with additional factors to fit your specific needs.

The two ranking functions currently available are:

```
ts_rank([ weights float4[], ] vector tsvector, query tsquery [, normalization integer ]) returns float4
```

Ranks vectors based on the frequency of their matching lexemes.

```
ts_rank_cd([ weights float4[], ] vector tsvector, query tsquery [, normalization integer ]) returns
float4
```

This function requires positional information in its input. Therefore, it will not work on "stripped" **tsvector** values. It will always return zero.

For both these functions, the optional **weights** argument offers the ability to weigh word instances more or less heavily depending on how they are labeled. The weight arrays specify how heavily to weigh each category of words, in the order:

```
{D-weight, C-weight, B-weight, A-weight}
```

If no **weights** are provided, then these defaults are used: {0.1, 0.2, 0.4, 1.0}

Typically weights are used to mark words from special areas of the document, like the title or an initial abstract, so they can be treated with more or less importance than words in the document body.

Since a longer document has a greater chance of containing a query term, it is reasonable to take into account document size. For example, a hundred-word document with five instances of a search word is probably more relevant than a thousand-word document with five instances. Both ranking functions take an integer **normalization** option that specifies whether and how a document's length should impact its rank. The integer option controls several behaviors, so it is a bit

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mask: you can specify one or more behaviors using a vertical bar (|) (for example, **2|4**).

- **0** (default) ignores the document length.
- **1** divides the rank by (1 + logarithm of the document length).
- **2** divides the rank by the document length.
- **4** divides the rank by the mean harmonic distance between extents. This is implemented only by **ts_rank_cd**.
- **8** divides the rank by the number of unique words in document.
- **16** divides the rank by (1 + Logarithm of the number of unique words in document).
- **32** divides the rank by (itself + 1).

If more than one flag bit is specified, the transformations are applied in the order listed.

It is important to note that the ranking functions do not use any global information, so it is impossible to produce a fair normalization to 1% or 100% as sometimes desired. Normalization option 32 (**rank/(rank+1)**) can be applied to scale all ranks into the range zero to one, but of course this is just a cosmetic change; it will not affect the ordering of the search results.

Here is an example that selects only the ten highest-ranked matches:

```
openGauss=# SELECT id, title, ts_rank_cd(to_tsvector(body), query) AS rank
FROM tsearch.pgweb, to_tsquery('america') query
WHERE query @@ to_tsvector(body)
ORDER BY rank DESC
LIMIT 10;
 id |  title  | rank
----+---------+------
 11 | Brazil  |   .2
  2 | America |   .1
 12 | Canada  |   .1
 13 | Mexico  |   .1
(4 rows)
```

This is the same example using normalized ranking:

```
openGauss=# SELECT id, title, ts_rank_cd(to_tsvector(body), query, 32 /* rank/(rank+1) */ ) AS rank
FROM tsearch.pgweb, to_tsquery('america') query
WHERE  query @@ to_tsvector(body)
ORDER BY rank DESC
LIMIT 10;
 id |  title  |   rank
----+---------+----------
 11 | Brazil  |  .166667
  2 | America | .0909091
 12 | Canada  | .0909091
 13 | Mexico  | .0909091
(4 rows)
```

The following example sorts queries by Chinese word segmentation:

```
openGauss=# CREATE TABLE tsearch.ts_ngram(id int, body text);
openGauss=# INSERT INTO tsearch.ts_ngram VALUES (1, 'Chinese');
openGauss=# INSERT INTO tsearch.ts_ngram VALUES (2, 'Chinese search');
openGauss=# INSERT INTO tsearch.ts_ngram VALUES (3 'Search Chinese');
-- Exact match
openGauss=# SELECT id, body, ts_rank_cd(to_tsvector('ngram',body), query) AS rank FROM
tsearch.ts_ngram, to_tsquery ('Chinese') query WHERE query @@ to_tsvector(body);
 id | body | rank
```

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```
----+------+------
  1 | Chinese |   .1
(1 row)

-- Fuzzy match
openGauss=# SELECT id, body, ts_rank_cd(to_tsvector('ngram',body), query) AS rank FROM
tsearch.ts_ngram, to_tsquery('Chinese') query WHERE query @@ to_tsvector('ngram',body);
 id |   body   | rank
----+----------+------
  3 | Search Chinese |   .1
  1 | Chinese     |   .1
  2 | Chinese search |   .1
(3 rows)
```

Ranking can be expensive since it requires consulting the **tsvector** of each matching document, which can be I/O bound and therefore slow. Unfortunately, it is almost impossible to avoid since practical queries often result in large numbers of matches.

## 12.8.3.4 Highlighting Results

To present search results it is ideal to show a part of each document and how it is related to the query. Usually, search engines show fragments of the document with marked search terms. GaussDB provides a function **ts_headline** that implements this functionality.

```
ts_headline([ config regconfig, ] document text, query tsquery [, options text ]) returns text
```

**ts_headline** accepts a document along with a query, and returns an excerpt from the document in which terms from the query are highlighted. The configuration to be used to parse the document can be specified by **config**. If **config** is omitted, the **default_text_search_config** configuration is used.

If an options string is specified it must consist of a comma-separated list of one or more **option=value** pairs. The available options are:

- **StartSel**, **StopSel**: The strings with which to delimit query words appearing in the document, to distinguish them from other excerpted words. You must double-quote these strings if they contain spaces or commas.
- **MaxWords**, **MinWords**: These numbers determine the longest and shortest headlines to output.
- **ShortWord**: Words of this length or less will be dropped at the start and end of a headline. The default value of three eliminates common English articles.
- **HighlightAll**: Boolean flag. If **true** the whole document will be used as the headline, ignoring the preceding three parameters.
- **MaxFragments**: Maximum number of text excerpts or fragments to display. The default value of zero selects a non-fragment-oriented headline generation method. A value greater than zero selects fragment-based headline generation. This method finds text fragments with as many query words as possible and stretches those fragments around the query words. As a result query words are close to the middle of each fragment and have words on each side. Each fragment will be of at most **MaxWords** and words of length **ShortWord** or less are dropped at the start and end of each fragment. If not all query words are found in the document, then a single fragment of the first **MinWords** in the document will be displayed.
- **FragmentDelimiter**: When more than one fragment is displayed, the fragments will be separated by this string.

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Any unspecified options receive these defaults:

```
StartSel=<b>, StopSel=</b>,
MaxWords=35, MinWords=15, ShortWord=3, HighlightAll=FALSE,
MaxFragments=0, FragmentDelimiter=" ... "
```

For example:

```
openGauss=# SELECT ts_headline('english',
'The most common type of search
is to find all documents containing given query terms
and return them in order of their similarity to the
query.',
to_tsquery('english', 'query & similarity'));
                        ts_headline
------------------------------------------------------------
 containing given <b>query</b> terms
 and return them in order of their <b>similarity</b> to the
 <b>query</b>.
(1 row)

openGauss=# SELECT ts_headline('english',
'The most common type of search
is to find all documents containing given query terms
and return them in order of their similarity to the
query.',
to_tsquery('english', 'query & similarity'),
'StartSel = <, StopSel = >');
                       ts_headline
-------------------------------------------------------
 containing given <query> terms
 and return them in order of their <similarity> to the
 <query>.
(1 row)
```

**ts_headline** uses the original document, not a **tsvector** summary, so it can be slow and should be used with care.

# 12.8.4 Additional Features

## 12.8.4.1 Manipulating tsvector

GaussDB provides functions and operators that can be used to manipulate documents that are already in tsvector type.

- tsvector || tsvector

  The tsvector concatenation operator returns a new tsvector which combines the lexemes and positional information of the two tsvectors given as arguments. Positions and weight labels are retained during the concatenation. Positions appearing in the right-hand tsvector are offset by the largest position mentioned in the left-hand tsvector, so that the result is nearly equivalent to the result of performing **to_tsvector** on the concatenation of the two original document strings. (The equivalence is not exact, because any stop-words removed from the end of the left-hand argument will not affect the result, whereas they would have affected the positions of the lexemes in the right-hand argument if textual concatenation were used.)

  One advantage of using concatenation in the tsvector form, rather than concatenating text before applying **to_tsvector**, is that you can use different configurations to parse different sections of the document. Also, because the **setweight** function marks all lexemes of the given tsvector the same way, it is

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necessary to parse the text and do **setweight** before concatenating if you want to label different parts of the document with different weights.

- setweight(vector tsvector, weight "char") returns tsvector

  **setweight** returns a copy of the input tsvector in which every position has been labeled with the given weight, either **A**, **B**, **C**, or **D**. (**D** is the default for new tsvectors and as such is not displayed on output.) These labels are retained when tsvectors are concatenated, allowing words from different parts of a document to be weighted differently by ranking functions.

  **NOTICE**

  Note that weight labels apply to positions, not lexemes. If the input tsvector has been stripped of positions then **setweight** does nothing.

- length(vector tsvector) returns integer

  Returns the number of lexemes stored in the tsvector.

- strip(vector tsvector) returns tsvector

  Returns a tsvector which lists the same lexemes as the given tsvector, but which lacks any position or weight information. While the returned tsvector is much less useful than an unstripped tsvector for relevance ranking, it will usually be much smaller.

## 12.8.4.2 Manipulating Queries

GaussDB provides functions and operators that can be used to manipulate queries that are already in **tsquery** type.

- tsquery && tsquery

  Returns the AND-combination of the two given queries.

- tsquery || tsquery

  Returns the OR-combination of the two given queries.

- !! tsquery

  Returns the negation (NOT) of the given query.

- numnode(query tsquery) returns integer

  Returns the number of nodes (lexemes plus operators) in a **tsquery**. This function is useful to determine if the query is meaningful (returns > 0), or contains only stop words (returns 0). For example:

```
openGauss=# SELECT numnode(plainto_tsquery('the any'));
NOTICE:  text-search query contains only stop words or doesn't contain lexemes, ignored
CONTEXT:  referenced column: numnode
 numnode
---------
       0

openGauss=# SELECT numnode('foo & bar'::tsquery);
 numnode
---------
       3
```

- querytree(query tsquery) returns text

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Returns the portion of a **tsquery** that can be used for searching an index. This function is useful for detecting unindexable queries, for example those containing only stop words or only negated terms. For example:

```
openGauss=# SELECT querytree(to_tsquery('!defined'));
 querytree
-----------
 T
(1 row)
```

## 12.8.4.3 Rewriting Queries

The **ts_rewrite** family of functions searches a given **tsquery** for occurrences of a target subquery, and replace each occurrence with a substitute subquery. In essence this operation is a **tsquery** specific version of substring replacement. A target and substitute combination can be thought of as a query rewrite rule. A collection of such rewrite rules can be a powerful search aid. For example, you can expand the search using synonyms (that is, new york, big apple, nyc, gotham) or narrow the search to direct the user to some hot topic.

- ts_rewrite (query tsquery, target tsquery, substitute tsquery) returns tsquery

  This form of **ts_rewrite** simply applies a single rewrite rule: **target** is replaced by **substitute** wherever it appears in query. For example:

  ```
  openGauss=# SELECT ts_rewrite('a & b'::tsquery, 'a'::tsquery, 'c'::tsquery);
   ts_rewrite
  ------------
   'b' & 'c'
  ```

- ts_rewrite (query tsquery, select text) returns tsquery

  This form of **ts_rewrite** accepts a starting query and a SQL select command, which is given as a text string. The **select** must yield two columns of **tsquery** type. For each row of the select result, occurrences of the first column value (the target) are replaced by the second column value (the substitute) within the current **query** value.

  NOTE

  Note that when multiple rewrite rules are applied in this way, the order of application can be important; so in practice you will want the source query to **ORDER BY** some ordering key.

  Consider a real-life astronomical example. We will expand query supernovae using table-driven rewriting rules:

  ```
  openGauss=# CREATE TABLE tsearch.aliases (id int, t tsquery, s tsquery);

  openGauss=# INSERT INTO tsearch.aliases VALUES(1, to_tsquery('supernovae'),
  to_tsquery('supernovae|sn'));

  openGauss=# SELECT ts_rewrite(to_tsquery('supernovae & crab'), 'SELECT t, s FROM tsearch.aliases');

            ts_rewrite
  ---------------------------------
   'crab' & ( 'supernova' | 'sn' )
  ```

  We can change the rewriting rules just by updating the table:

  ```
  openGauss=# UPDATE tsearch.aliases
  SET s = to_tsquery('supernovae|sn & !nebulae')
  WHERE t = to_tsquery('supernovae');

  openGauss=# SELECT ts_rewrite(to_tsquery('supernovae & crab'), 'SELECT t, s FROM tsearch.aliases');

                  ts_rewrite
  ```

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```
---------------------------------------------
 'crab' & ( 'supernova' | 'sn' & !'nebula' )
```

Rewriting can be slow when there are many rewriting rules, since it checks every rule for a possible match. To filter out obvious non-candidate rules we can use the containment operators for the **tsquery** type. In the example below, we select only those rules which might match the original query:

```
openGauss=# SELECT ts_rewrite('a & b'::tsquery, 'SELECT t,s FROM tsearch.aliases WHERE ''a &
b''::tsquery @> t');

 ts_rewrite
------------
 'b' & 'a'
(1 row)
openGauss=# DROP TABLE tsearch.aliases;
```

### 12.8.4.4 Gathering Document Statistics

The function **ts_stat** is useful for checking your configuration and for finding stop-word candidates.

```
ts_stat(sqlquery text, [ weights text, ]
        OUT word text, OUT ndoc integer,
        OUT nentry integer) returns setof record
```

**sqlquery** is a text value containing an SQL query which must return a single **tsvector** column. **ts_stat** executes the query and returns statistics about each distinct lexeme (word) contained in the **tsvector** data. The columns returned are:

- **word text**: the value of a lexeme
- **ndoc integer**: number of documents (**tsvector**s) the word occurred in
- **nentry integer**: total number of occurrences of the word

If **weights** are supplied, only occurrences having one of those weights are counted. For example, to find the ten most frequent words in a document collection:

```
openGauss=# SELECT * FROM ts_stat('SELECT to_tsvector(''english'', sr_reason_sk) FROM
tpcds.store_returns WHERE sr_customer_sk < 10') ORDER BY nentry DESC, ndoc DESC, word LIMIT 10;
  word | ndoc | nentry
------+------+--------
 32   |    2 |      2
 33   |    2 |      2
 1    |    1 |      1
 10   |    1 |      1
 13   |    1 |      1
 14   |    1 |      1
 15   |    1 |      1
 17   |    1 |      1
 20   |    1 |      1
 22   |    1 |      1
(10 rows)
```

The same, but counting only word occurrences with weight **A** or **B**:

```
openGauss=# SELECT * FROM ts_stat('SELECT to_tsvector(''english'', sr_reason_sk) FROM
tpcds.store_returns WHERE sr_customer_sk < 10', 'a') ORDER BY nentry DESC, ndoc DESC, word LIMIT 10;
 word | ndoc | nentry
------+------+--------
(0 rows)
```

## 12.8.5 Parser

Text search parsers are responsible for splitting raw document text into tokens and identifying each token's type, where the set of types is defined by the parser itself.

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Note that a parser does not modify the text at all — it simply identifies plausible word boundaries. Because of this limited scope, there is less need for application-specific custom parsers than there is for custom dictionaries.

Currently, GaussDB provides the following built-in parsers: pg_catalog.default for English configuration, and pg_catalog.ngram and pg_catalog.pound for full text search in texts containing Chinese, or both Chinese and English.

The built-in parser is named **pg_catalog.default**. It recognizes 23 token types, shown in **Table 12-97**.

**Table 12-97** Default parser's token types

| Alias | Description | Example |
| --- | --- | --- |
| asciiword | Word, all ASCII letters | elephant |
| word | Word, all letters | mañana |
| numword | Word, letters and digits | beta1 |
| asciihword | Hyphenated word, all ASCII | up-to-date |
| hword | Hyphenated word, all letters | lógico-matemática |
| numhword | Hyphenated word, letters and digits | postgresql-beta1 |
| hword_asciipart | Hyphenated word part, all ASCII | postgresql in the context postgresql-beta1 |
| hword_part | Hyphenated word part, all letters | lógico or matemática in the context lógico-matemática |
| hword_numpart | Hyphenated word part, letters and digits | beta1 in the context postgresql-beta1 |
| email | Email address | foo@example.com |
| protocol | Protocol head | http:// |
| url | URL | example.com/stuff/index.html |
| host | Host | example.com |
| url_path | URL path | /stuff/index.html, in the context of a URL |
| file | File or path name | /usr/local/foo.txt, if not within a URL |
| sfloat | Scientific notation | -1.23E+56 |
| float | Decimal notation | -1.234 |
| int | Signed integer | -1234 |
| uint | Unsigned integer | 1234 |

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| Alias | Description | Example |
| --- | --- | --- |
| version | Version number | 8.3.0 |
| tag | XML tag | <a href="dictionaries.html"> |
| entity | XML entity | & |
| blank | Space symbols | (any whitespace or punctuation not otherwise recognized) |

Note: The parser's notion of a "letter" is determined by the database's locale setting, specifically **lc_ctype**. Words containing only the basic ASCII letters are reported as a separate token type, since it is sometimes useful to distinguish them. In most European languages, token types word and asciiword should be treated alike.

**email** does not support all valid email characters as defined by RFC 5322. Specifically, the only non-alphanumeric characters supported for email user names are period, dash, and underscore.

It is possible for the parser to identify overlapping tokens in the same piece of text. As an example, a hyphenated word will be reported both as the entire word and as each component:

```
openGauss=# SELECT alias, description, token FROM ts_debug('english','foo-bar-beta1');
      alias      |              description               |     token
-----------------+----------------------------------------+---------------
 numhword        | Hyphenated word, letters and digits    | foo-bar-beta1
 hword_asciipart | Hyphenated word part, all ASCII        | foo
 blank           | Space symbols                          | -
 hword_asciipart | Hyphenated word part, all ASCII        | bar
 blank           | Space symbols                          | -
 hword_numpart   | Hyphenated word part, letters and digits | beta1
```

This behavior is desirable since it allows searches to work for both the whole compound word and for components. Here is another instructive example:

```
openGauss=# SELECT alias, description, token FROM ts_debug('english','http://example.com/stuff/
index.html');
  alias   |  description  |            token
----------+---------------+------------------------------
 protocol | Protocol head | http://
 url      | URL           | example.com/stuff/index.html
 host     | Host          | example.com
 url_path | URL path      | /stuff/index.html
```

N-gram is a mechanical word segmentation method, and applies to no semantic Chinese segmentation scenarios. The N-gram segmentation method ensures the completeness of the segmentation. However, to cover all the possibilities, it but adds unnecessary words to the index, resulting in a large number of index items. N-gram supports Chinese coding, including GBK and UTF-8. Six built-in token types are shown in **Table 12-98**.

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**Table 12-98** Token types

| Alias | Description |
| --- | --- |
| zh_words | chinese words |
| en_word | english word |
| numeric | numeric data |
| alnum | alnum string |
| grapsymbol | graphic symbol |
| multisymbol | multiple symbol |

Pound segments words in a fixed format. It is used to segment to-be-parsed nonsense Chinese and English words that are separated by fixed separators. It supports Chinese encoding (including GBK and UTF8) and English encoding (including ASCII). Pound has six pre-configured token types (as listed in **Table 12-99**) and supports five separators (as listed in **Table 12-100**). The default, the separator is **#**. Pound The maximum length of a token is 256 characters.

**Table 12-99** Token types

| Alias | Description |
| --- | --- |
| zh_words | chinese words |
| en_word | english word |
| numeric | numeric data |
| alnum | alnum string |
| grapsymbol | graphic symbol |
| multisymbol | multiple symbol |

**Table 12-100** Separator types

| Separator | Description |
| --- | --- |
| @ | Special character |
| # | Special character |
| $ | Special character |
| % | Special character |
| / | Special character |

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# 12.8.6 Dictionaries

## 12.8.6.1 Overview

A dictionary is used to define stop words, that is, words to be ignored in full-text retrieval.

A dictionary can also be used to normalize words so that different derived forms of the same word will match. A normalized word is called a lexeme.

In addition to improving retrieval quality, normalization and removal of stop words can reduce the size of the **tsvector** representation of a document, thereby improving performance. Normalization and removal of stop words do not always have linguistic meaning. Users can define normalization and removal rules in dictionary definition files based on application environments.

A dictionary is a program that receives a token as input and returns:

- An array of lexemes if the input token is known to the dictionary (note that one token can produce more than one lexeme).
- A single lexeme with the **TSL_FILTER** flag set (which is automatically set in a filtering dictionary and is not perceived by users), to replace the original token with a new token to be passed to subsequent dictionaries (a dictionary that does this is called a filtering dictionary).
- An empty array if the input token is known to the dictionary but is a stop word.
- **NULL** if the dictionary does not recognize the token.

GaussDB provides predefined dictionaries for many languages and also provides five predefined dictionary templates, **Simple**, **Synonym**, **Thesaurus**, **Ispell**, and **Snowball**. These templates can be used to create new dictionaries with custom parameters.

When using full-text retrieval, you are advised to:

- In the text search configuration, configure a parser together with a set of dictionaries to process the parser's output tokens. For each token type that the parser can return, a separate list of dictionaries is specified by the configuration. When a token of that type is found by the parser, each dictionary in the list is consulted in turn, until a dictionary recognizes it as a known word. If it is identified as a stop word, or no dictionary recognizes the token, it will be discarded and not indexed or searched for. Generally, the first dictionary that returns a non-**NULL** output determines the result, and any remaining dictionaries are not consulted. However, a filtering dictionary can replace the input token with a modified one, which is then passed to subsequent dictionaries.
- The general rule for configuring a list of dictionaries is to place first the most narrow, most specific dictionary, then the more general dictionaries, finishing with a very general dictionary, like a **Snowball** stemmer dictionary or a **Simple** dictionary, which recognizes everything. In the following example, for an astronomy-specific search (**astro_en** configuration), you can configure the token type **asciiword** (ASCII word) with a **Synonym** dictionary of astronomical terms, a general English **Ispell** dictionary, and a **Snowball** English stemmer dictionary:

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```
openGauss=# ALTER TEXT SEARCH CONFIGURATION astro_en
  ADD MAPPING FOR asciiword WITH astro_syn, english_ispell, english_stem;
```

A filtering dictionary can be placed anywhere in the list, except at the end where it would be useless. Filtering dictionaries are useful to partially normalize words to simplify the task of later dictionaries.

### 12.8.6.2 Stop Words

Stop words are words that are very common, appear in almost every document, and have no discrimination value. Therefore, they can be ignored in the context of full text searching. Each type of dictionaries treats stop words in different ways. For example, **Ispell** dictionaries first normalize words and then check the list of stop words, while **Snowball** dictionaries first check the list of stop words.

For example, every English text contains words like **a** and **the**, so it is useless to store them in an index. However, stop words affect the positions in **tsvector**, which in turn affect ranking.

```
openGauss=# SELECT to_tsvector('english','in the list of stop words');
        to_tsvector
----------------------------
 'list':3 'stop':5 'word':6
```

The missing positions 1, 2, and 4 are because of stop words. Ranks calculated for documents with and without stop words are quite different:

```
openGauss=# SELECT ts_rank_cd (to_tsvector('english','in the list of stop words'), to_tsquery('list & stop'));
 ts_rank_cd
------------
        .05

openGauss=# SELECT ts_rank_cd (to_tsvector('english','list stop words'), to_tsquery('list & stop'));
 ts_rank_cd
------------
         .1
```

### 12.8.6.3 Simple Dictionary

A **Simple** dictionary operates by converting the input token to lower case and checking it against a list of stop words. If the token is found in the list, an empty array will be returned, causing the token to be discarded. If it is not found, the lower-cased form of the word is returned as the normalized lexeme. In addition, you can set **Accept** to **false** for **Simple** dictionaries (default: **true**) to report non-stop-words as unrecognized, allowing them to be passed on to the next dictionary in the list.

## Precautions

- Most types of dictionaries rely on dictionary configuration files. The name of a configuration file can only be lowercase letters, digits, and underscores (_).
- A dictionary cannot be created in **pg_temp** mode.
- Dictionary configuration files must be stored in UTF-8 encoding. They will be translated to the actual database encoding, if that is different, when they are read into the server.
- Generally, a session will read a dictionary configuration file only once, when it is first used within the session. To modify a configuration file, run the **ALTER TEXT SEARCH DICTIONARY** statement to update and reload the file.

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## Procedure

**Step 1** Create a **Simple** dictionary.

```
openGauss=# CREATE TEXT SEARCH DICTIONARY public.simple_dict (
    TEMPLATE = pg_catalog.simple,
    STOPWORDS = english
);
```

**english.stop** is the full name of a file of stop words. For details about the syntax and parameters for creating a **Simple** dictionary, see **12.14.85 CREATE TEXT SEARCH DICTIONARY**.

**Step 2** Use the **Simple** dictionary.

```
openGauss=# SELECT ts_lexize('public.simple_dict','YeS');
 ts_lexize
-----------
 {yes}
(1 row)

openGauss=# SELECT ts_lexize('public.simple_dict','The');
 ts_lexize
-----------
 {}
(1 row)
```

**Step 3** Set **Accept=false** so that the **Simple** dictionary returns **NULL** instead of a lower-cased non-stop word.

```
openGauss=# ALTER TEXT SEARCH DICTIONARY public.simple_dict ( Accept = false );
ALTER TEXT SEARCH DICTIONARY
openGauss=# SELECT ts_lexize('public.simple_dict','YeS');
 ts_lexize
-----------

(1 row)

openGauss=# SELECT ts_lexize('public.simple_dict','The');
 ts_lexize
-----------
 {}
(1 row)
```

**----End**

## 12.8.6.4 Synonym Dictionary

A **Synonym** dictionary is used to define, identify, and convert synonyms of a token. Phrases are not supported. Synonyms of phrases can be defined in a **Thesaurus** dictionary. For details, see **12.8.6.5 Thesaurus Dictionary**.

## Examples

- A **Synonym** dictionary can be used to overcome linguistic problems. For example, to prevent an English stemmer dictionary from reducing the word 'Paris' to 'pari', define a **Paris paris** line in the **Synonym** dictionary and put it before the **english_stem** dictionary.

```
openGauss=# SELECT * FROM ts_debug('english', 'Paris');
   alias   |   description   | token |  dictionaries  |  dictionary  | lexemes
-----------+-----------------+-------+----------------+--------------+---------
 asciiword | Word, all ASCII | Paris | {english_stem} | english_stem | {pari}
(1 row)

openGauss=# CREATE TEXT SEARCH DICTIONARY my_synonym (
    TEMPLATE = synonym,
```

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```
    SYNONYMS = my_synonyms,
    FILEPATH = 'file:///home/dicts/'
);

openGauss=# ALTER TEXT SEARCH CONFIGURATION english
    ALTER MAPPING FOR asciiword
    WITH my_synonym, english_stem;

openGauss=# SELECT * FROM ts_debug('english', 'Paris');
   alias   |   description   | token |       dictionaries        | dictionary | lexemes
-----------+-----------------+-------+---------------------------+------------+---------
 asciiword | Word, all ASCII | Paris | {my_synonym,english_stem} | my_synonym | {paris}
(1 row)

openGauss=# SELECT * FROM ts_debug('english', 'paris');
   alias   |   description   | token |       dictionaries        | dictionary | lexemes
-----------+-----------------+-------+---------------------------+------------+---------
 asciiword | Word, all ASCII | Paris | {my_synonym,english_stem} | my_synonym | {paris}
(1 row)

openGauss=# ALTER TEXT SEARCH DICTIONARY my_synonym ( CASESENSITIVE=true);

openGauss=# SELECT * FROM ts_debug('english', 'Paris');
   alias   |   description   | token |       dictionaries        | dictionary | lexemes
-----------+-----------------+-------+---------------------------+------------+---------
 asciiword | Word, all ASCII | Paris | {my_synonym,english_stem} | my_synonym | {paris}
(1 row)

openGauss=# SELECT * FROM ts_debug('english', 'paris');
   alias   |   description   | token |       dictionaries        | dictionary | lexemes
-----------+-----------------+-------+---------------------------+------------+---------
 asciiword | Word, all ASCII | Paris | {my_synonym,english_stem} | my_synonym | {pari}
(1 row)
```

The full name of the **Synonym** dictionary file is **my_synonyms.syn**, and the dictionary is stored in the *Connected CN*/**home/dicts/** directory. For details about the syntax and parameters for creating a **Synonym** dictionary, see **12.14.85 CREATE TEXT SEARCH DICTIONARY**.

- An asterisk (*) can be placed at the end of a synonym in the configuration file. This indicates that the synonym is a prefix. The asterisk is ignored when the entry is used in to_tsvector(), but when it is used in to_tsquery(), the result will be a query item with the prefix match marker (see **12.8.4.2 Manipulating Queries**).

  Assume that the content in the dictionary file **synonym_sample.syn** is as follows:

  ```
  postgres        pgsql
  postgresql      pgsql
  postgre pgsql
  gogle   googl
  indices index*
  ```

  Create and use a dictionary.

  ```
  openGauss=# CREATE TEXT SEARCH DICTIONARY syn (
      TEMPLATE = synonym,
      SYNONYMS = synonym_sample
  );

  openGauss=# SELECT ts_lexize('syn','indices');
   ts_lexize
  -----------
   {index}
  (1 row)

  openGauss=# CREATE TEXT SEARCH CONFIGURATION tst (copy=simple);

  openGauss=# ALTER TEXT SEARCH CONFIGURATION tst ALTER MAPPING FOR asciiword WITH syn;
  ```

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```
openGauss=# SELECT to_tsvector('tst','indices');
 to_tsvector
-------------
 'index':1
(1 row)

openGauss=# SELECT to_tsquery('tst','indices');
 to_tsquery
------------
 'index':*
(1 row)

openGauss=# SELECT 'indexes are very useful'::tsvector;
            tsvector
---------------------------------
 'are' 'indexes' 'useful' 'very'
(1 row)

openGauss=# SELECT 'indexes are very useful'::tsvector @@ to_tsquery('tst','indices');
 ?column?
----------
 t
(1 row)
```

### 12.8.6.5 Thesaurus Dictionary

A **Thesaurus** dictionary (sometimes abbreviated as TZ) is a collection of relationships between words and phrases, such as broader terms (BT), narrower terms (NT), preferred terms, non-preferred terms, and related terms. Based on definitions in the dictionary file, a TZ replaces all non-preferred terms by one preferred term and, optionally, preserves the original terms for indexing as well. A TZ is an extension of a **Synonym** dictionary with added phrase support.

## Precautions

- A TZ has the capability to recognize phrases and therefore it must remember its state and interact with the parser to determine whether to handle the next token or stop accumulation. A TZ must be configured carefully. For example, if an AZ is configured to handle only **asciiword** tokens, a TZ definition like **one 7** will not work because the token type **uint** is not assigned to the TZ.
- TZs are used during indexing, so any change in the TZ's parameters requires reindexing. For most other dictionary types, small changes such as adding or removing stop words does not force reindexing.

## Procedure

**Step 1** Create a TZ named **thesaurus_astro**.

**thesaurus_astro** is a simple astronomical TZ that defines two astronomical word combinations (word+synonym).

```
supernovae stars : sn
crab nebulae : crab
```

Run the following statement to create the TZ:

```
openGauss=# CREATE TEXT SEARCH DICTIONARY thesaurus_astro (
    TEMPLATE = thesaurus,
    DictFile = thesaurus_astro,
    Dictionary = pg_catalog.english_stem,
    FILEPATH = 'file:///home/dicts/'
);
```

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The full name of the TZ file is **thesaurus_astro.ths**, and the TZ is stored in the *Connected CN*/**home/dicts/** directory. **pg_catalog.english_stem** is the subdictionary (a **Snowball** English stemmer) used for input normalization. The subdictionary has its own configuration (for example, stop words), which is not shown here. For details about the syntax and parameters for creating a **Thesaurus** dictionary, see **12.14.85 CREATE TEXT SEARCH DICTIONARY**.

**Step 2** Bind the TZ to the desired token types in the text search configuration.

```
openGauss=# ALTER TEXT SEARCH CONFIGURATION russian
   ALTER MAPPING FOR asciiword, asciihword, hword_asciipart
   WITH thesaurus_astro, english_stem;
```

**Step 3** Use the TZ.

- Test the TZ.

  The **ts_lexize** function is not very useful for testing the TZ because the function processes its input as a single token. Instead, you can use the **plainto_tsquery**, **to_tsvector**, or **to_tsquery** function which will break their input strings into multiple tokens.

  ```
  openGauss=# SELECT plainto_tsquery('russian','supernova star');
   plainto_tsquery
  -----------------
   'sn'
  (1 row)

  openGauss=# SELECT to_tsvector('russian','supernova star');
   to_tsvector
  -------------
   'sn':1
  (1 row)

  openGauss=# SELECT to_tsquery('russian','"supernova star"');
   to_tsquery
  ------------
   'sn'
  (1 row)
  ```

  **supernova star** matches **supernovae stars** in **thesaurus_astro** because the **english_stem** stemmer is specified in the **thesaurus_astro** definition. The stemmer removed **e** and **s**.

- To index the original phrase, include it in the right-hand part of the definition.

  ```
  supernovae stars : sn supernovae stars

  openGauss=# ALTER TEXT SEARCH DICTIONARY thesaurus_astro (
      DictFile = thesaurus_astro,
      FILEPATH = 'file:///home/dicts/');

  openGauss=# SELECT plainto_tsquery('russian','supernova star');
         plainto_tsquery
  -----------------------------
   'sn' & 'supernova' & 'star'
  (1 row)
  ```

**----End**

## 12.8.6.6 Ispell Dictionary

An **Ispell** dictionary is a morphological dictionary, which can normalize different linguistic forms of a word into the same lexeme. For example, an English **Ispell** dictionary can match all declensions and conjugations of the search term **bank**, such as, **banking**, **banked**, **banks**, **banks'**, and **bank's**.

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GaussDB does not provide any predefined **Ispell** dictionaries or dictionary files. The .dict files and .affix files support multiple open-source dictionary formats, including **Ispell**, **MySpell**, and **Hunspell**.

## Procedure

**Step 1** Obtain the dictionary definition file (.dict) and affix file (.affix).

You can use an open-source dictionary (available on OpenOffice). The name extensions of the open-source dictionary may be .aff and .dic. In this case, you need to change them to .affix and .dict. In addition, for some dictionary files (for example, Norwegian dictionary files), you need to run the following commands to convert the character encoding to UTF-8:

```
iconv -f ISO_8859-1 -t UTF-8 -o nn_no.affix nn_NO.aff
iconv -f ISO_8859-1 -t UTF-8 -o nn_no.dict nn_NO.dic
```

**Step 2** Create an **Ispell** dictionary.

```
openGauss=# CREATE TEXT SEARCH DICTIONARY norwegian_ispell (
    TEMPLATE = ispell,
    DictFile = nn_no,
    AffFile = nn_no,
    FilePath = 'file:///home/dicts'
);
```

The full names of the **Ispell** dictionary files are **nn_no.dict** and **nn_no.affix**, and the dictionary is stored in the *Connected CN*/**home/dicts/** directory. For details about the syntax and parameters for creating an **Ispell** dictionary, see **12.14.85 CREATE TEXT SEARCH DICTIONARY**.

**Step 3** Use the **Ispell** dictionary to split compound words.

```
openGauss=# SELECT ts_lexize('norwegian_ispell', 'sjokoladefabrikk');
      ts_lexize
---------------------
 {sjokolade,fabrikk}
(1 row)
```

**MySpell** does not support compound words. **Hunspell** supports compound words. GaussDB supports only the basic compound word operations of **Hunspell**. Generally, **Ispell** dictionaries recognize a limited set of words, so they should be followed by another broader dictionary, for example, a **Snowball** dictionary, which recognizes everything.

**----End**

## 12.8.6.7 Snowball Dictionary

A **Snowball** dictionary is based on a project by Martin Porter and is used for stem analysis, providing stemming algorithms for many languages. GaussDB provides predefined **Snowball** dictionaries of many languages. You can query the **15.2.98 PG_TS_DICT** system catalog to view the predefined **Snowball** dictionaries and supported stemming algorithms.

A **Snowball** dictionary recognizes everything, no matter whether it is able to simplify the word. Therefore, it should be placed at the end of the dictionary list. It is useless to place it before any other dictionary because a token will never pass it through to the next dictionary.

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For details about the syntax of **Snowball** dictionaries, see **12.14.85 CREATE TEXT SEARCH DICTIONARY**.

# 12.8.7 Configuration Examples

Text search configuration specifies the following components required for converting a document into a **tsvector**:

- A parser, decomposes a text into tokens.
- Dictionary list, converts each token into a lexeme.

Each time when the **to_tsvector** or **to_tsquery** function is invoked, a text search configuration is required to specify a processing procedure. The GUC parameter **default_text_search_config** specifies the default text search configuration, which will be used if the text search function does not explicitly specify a text search configuration.

GaussDB provides some predefined text search configurations. You can also create user-defined text search configurations. In addition, to facilitate the management of text search objects, multiple **gsql** meta-commands are provided to display information about text search objects. For details, see "Client Tool > Meta-Command Reference" in *Tool Reference*.

## Procedure

**Step 1** Create a text search configuration **ts_conf** by copying the predefined text search configuration **english**.

```
openGauss=# CREATE TEXT SEARCH CONFIGURATION ts_conf ( COPY = pg_catalog.english );
CREATE TEXT SEARCH CONFIGURATION
```

**Step 2** Create a **Synonym** dictionary.

Assume that the definition file **pg_dict.syn** of the **Synonym** dictionary contains the following contents:

```
postgres    pg
pgsql       pg
postgresql  pg
```

Run the following statement to create the **Synonym** dictionary:

```
openGauss=# CREATE TEXT SEARCH DICTIONARY pg_dict (
    TEMPLATE = synonym,
    SYNONYMS = pg_dict,
    FILEPATH = 'file:///home/dicts'
);
```

**Step 3** Create an **Ispell** dictionary **english_ispell** (the dictionary definition file is from the open source dictionary).

```
openGauss=# CREATE TEXT SEARCH DICTIONARY english_ispell (
   TEMPLATE = ispell,
   DictFile = english,
   AffFile = english,
   StopWords = english,
   FILEPATH = 'file:///home/dicts'
);
```

**Step 4** Modify the text search configuration **ts_conf** and change the dictionary list for tokens of certain types. For details about token types, see **12.8.5 Parser**.

```
openGauss=# ALTER TEXT SEARCH CONFIGURATION ts_conf
   ALTER MAPPING FOR asciiword, asciihword, hword_asciipart,
```

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```
                word, hword, hword_part
  WITH pg_dict, english_ispell, english_stem;
```

**Step 5** In the text search configuration, set non-index or set the search for tokens of certain types.

```
openGauss=# ALTER TEXT SEARCH CONFIGURATION ts_conf
   DROP MAPPING FOR email, url, url_path, sfloat, float;
```

**Step 6** Use the text retrieval commissioning function ts_debug() to test the text search configuration **ts_conf**.

```
openGauss=# SELECT * FROM ts_debug('ts_conf', '
PostgreSQL, the highly scalable, SQL compliant, open source object-relational
database management system, is now undergoing beta testing of the next
version of our software.
');
```

**Step 7** You can set the default text search configuration of the current session to **ts_conf**. This setting is valid only for the current session.

```
openGauss=# \dF+ ts_conf
    Text search configuration "public.ts_conf"
Parser: "pg_catalog.default"
     Token      |            Dictionaries
----------------+------------------------------------
 asciihword     | pg_dict,english_ispell,english_stem
 asciiword      | pg_dict,english_ispell,english_stem
 file           | simple
 host           | simple
 hword          | pg_dict,english_ispell,english_stem
 hword_asciipart | pg_dict,english_ispell,english_stem
 hword_numpart  | simple
 hword_part     | pg_dict,english_ispell,english_stem
 int            | simple
 numhword       | simple
 numword        | simple
 uint           | simple
 version        | simple
 word           | pg_dict,english_ispell,english_stem

openGauss=# SET default_text_search_config = 'public.ts_conf';
SET
openGauss=# SHOW default_text_search_config;
 default_text_search_config
----------------------------
 public.ts_conf
(1 row)
```

**----End**

# 12.8.8 Testing and Debugging Text Search

The behavior of a custom text search configuration can easily become confusing. The functions described in this section are useful for testing text search objects. You can test a complete configuration, or test parsers and dictionaries separately.

## 12.8.8.1 Testing a Configuration

The function ts_debug allows easy testing of a text search configuration.

```
ts_debug([ config regconfig, ] document text,
        OUT alias text,
        OUT description text,
        OUT token text,
        OUT dictionaries regdictionary[],
        OUT dictionary regdictionary,
```

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```
    OUT lexemes text[])
    returns setof record
```

**ts_debug** displays information about every token of document as produced by the parser and processed by the configured dictionaries. It uses the configuration specified by **config**, or **default_text_search_config** if that argument is omitted.

**ts_debug** returns one row for each token identified in the text by the parser. The columns returned are:

- **alias text**: short name of the token type
- **description text**: description of the token type
- **token text**: text of the token
- **dictionaries regdictionary[]**: dictionaries selected by the configuration for this token type
- **dictionary regdictionary**: dictionary that recognized the token, or NULL if none did
- **lexemes text[]**: lexeme produced by the dictionary that recognized the token, or NULL if none did; an empty array ({}) means the token was recognized as a stop word

Here is a simple example:

```
openGauss=# SELECT * FROM ts_debug('english','a fat  cat sat on a mat - it ate a fat rats');
  alias   |   description   | token |  dictionaries  |  dictionary  | lexemes
-----------+-----------------+-------+----------------+--------------+---------
 asciiword | Word, all ASCII | a     | {english_stem} | english_stem | {}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | fat   | {english_stem} | english_stem | {fat}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | cat   | {english_stem} | english_stem | {cat}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | sat   | {english_stem} | english_stem | {sat}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | on    | {english_stem} | english_stem | {}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | a     | {english_stem} | english_stem | {}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | mat   | {english_stem} | english_stem | {mat}
 blank     | Space symbols   |       | {}             |              |
 blank     | Space symbols   | -     | {}             |              |
 asciiword | Word, all ASCII | it    | {english_stem} | english_stem | {}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | ate   | {english_stem} | english_stem | {ate}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | a     | {english_stem} | english_stem | {}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | fat   | {english_stem} | english_stem | {fat}
 blank     | Space symbols   |       | {}             |              |
 asciiword | Word, all ASCII | rats  | {english_stem} | english_stem | {rat}
(24 rows)
```

## 12.8.8.2 Testing an Age Parser

The **ts_parse** function allows direct testing of a text search parser.

```
ts_parse(parser_name text, document text,
    OUT tokid integer, OUT token text) returns setof record
```

**ts_parse** parses the given **document** and returns a series of records, one for each token produced by parsing. Each record includes a **tokid** showing the assigned token type and a **token** which is the text of the token. For example:

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```
openGauss=# SELECT * FROM ts_parse('default', '123 - a number');
 tokid | token
-------+--------
    22 | 123
    12 |
    12 | -
     1 | a
    12 |
     1 | number
(6 rows)
```

The **ts_token_type** function returns the token type and description of the specified parser.

```
ts_token_type(parser_name text, OUT tokid integer,
              OUT alias text, OUT description text) returns setof record
```

**ts_token_type** returns a table which describes each type of token the specified parser can recognize. For each token type, the table gives the integer **tokid** that the parser uses to label a token of that type, the **alias** that names the token type in configuration commands, and a short description. For example:

```
openGauss=# SELECT * FROM ts_token_type('default');
 tokid |      alias      |                description
-------+-----------------+-------------------------------------------
     1 | asciiword       | Word, all ASCII
     2 | word            | Word, all letters
     3 | numword         | Word, letters and digits
     4 | email           | Email address
     5 | url             | URL
     6 | host            | Host
     7 | sfloat          | Scientific notation
     8 | version         | Version number
     9 | hword_numpart   | Hyphenated word part, letters and digits
    10 | hword_part      | Hyphenated word part, all letters
    11 | hword_asciipart | Hyphenated word part, all ASCII
    12 | blank           | Space symbols
    13 | tag             | XML tag
    14 | protocol        | Protocol head
    15 | numhword        | Hyphenated word, letters and digits
    16 | asciihword      | Hyphenated word, all ASCII
    17 | hword           | Hyphenated word, all letters
    18 | url_path        | URL path
    19 | file            | File or path name
    20 | float           | Decimal notation
    21 | int             | Signed integer
    22 | uint            | Unsigned integer
    23 | entity          | XML entity
(23 rows)
```

## 12.8.8.3 Testing a Dictionary

The **ts_lexize** function facilitates dictionary testing.

**ts_lexize(dict regdictionary, token text) returns text[] ts_lexize** returns an array of lexemes if the input **token** is known to the dictionary, or an empty array if the token is known to the dictionary but it is a stop word, or **NULL** if it is an unknown word.

For example:

```
openGauss=# SELECT ts_lexize('english_stem', 'stars');
 ts_lexize
-----------
 {star}
```

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```
openGauss=# SELECT ts_lexize('english_stem', 'a');
 ts_lexize
-----------
 {}
```

NOTICE

The **ts_lexize** function expects a single **token**, not text.

## 12.8.9 Limitations

The current limitations of GaussDB's text search features are:

- The length of each lexeme must be less than 2K bytes.
- The length of a **tsvector** (lexemes + positions) must be less than 1 megabyte.
- Position values in **tsvector** must be greater than 0 and no more than 16383.
- No more than 256 positions per lexeme. Excessive positions, if any, will be discarded.
- The number of nodes (lexemes + operators) in a tsquery must be less than 32768.

# 12.9 System Operation

GaussDB text runs SQL statements to perform different system operations, such as setting variables, displaying the execution plan, and collecting garbage data.

### Setting Variables

For details about how to set various parameters for a session or transaction, see **12.14.161 SET**.

### Displaying the Execution Plan

For details about how to display the execution plan that GaussDB makes for SQL statements, see **12.14.137 EXPLAIN**.

### Specifying a Checkpoint in Transaction Logs

By default, WALs periodically specify checkpoints in a transaction log. **CHECKPOINT** forces an immediate checkpoint when the related command is issued, without waiting for a regular checkpoint scheduled by the system. For details, see **12.14.43 CHECKPOINT**.

### Collecting Unnecessary Data

For details about how to collect garbage data and analyze a database as required, For details, see **12.14.171 VACUUM**.

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### Collecting Statistics

For details about how to collect statistics on tables in databases, see **12.14.40 ANALYZE | ANALYSE**.

### Setting the Constraint Check Mode for the Current Transaction

For details about how to set the constraint check mode for the current transaction, see **12.14.162 SET CONSTRAINTS**.

## 12.10 Controlling Transactions

A transaction is a user-defined sequence of database operations, which form an integral unit of work.

### Starting a Transaction

GaussDB starts a transaction using **START TRANSACTION** and **BEGIN**. For details, see **12.14.168 START TRANSACTION** and **12.14.41 BEGIN**.

### Setting a Transaction

GaussDB sets a transaction using **SET TRANSACTION** or **SET LOCAL TRANSACTION**. For details, see **12.14.165 SET TRANSACTION**.

### Committing a Transaction

GaussDB commits all operations of a transaction using **COMMIT** or **END**. For details, see **12.14.48 COMMIT | END**.

### Rolling Back a Transaction

If a fault occurs during a transaction and the transaction cannot proceed, the system performs rollback to cancel all the completed database operations related to the transaction. For details, see **12.14.155 ROLLBACK**.

NOTE

If an execution request (not in a transaction block) received in the database contains multiple statements, the request is packed into a transaction. If one of the statements fails, the entire request will be rolled back.

## 12.11 DDL Syntax Overview

Data definition language (DDL) is used to define or modify an object in a database, such as a table, an index, or a view.

NOTE

GaussDB does not support DDL if its CN is unavailable. For example, if a CN in the cluster is faulty, creating a database or a table will fail.

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## Defining a client master key (CMK).

CMKs are used to encrypt column encryption keys (CEKs) for the encrypted database feature. CMK definition includes creating and deleting a CMK. For details about related SQL statements, see **Table 12-101**.

**Table 12-101** SQL statements for defining a CMK

| Function | SQL Statement |
| --- | --- |
| Creating a CMK | **12.14.54 CREATE CLIENT MASTER KEY** |
| Deleting a CMK | **12.14.99 DROP CLIENT MASTER KEY** |

## Defining a Column Encryption Key (CEK)

CEKs are used to encrypt data for the encrypted database feature. CEK definition includes creating and deleting a CEK. For details about related SQL statements, see **Table 12-101**.

**Table 12-102** SQL statements for defining a CEK

| Function | SQL Statement |
| --- | --- |
| Creating a CEK | **12.14.55 CREATE COLUMN ENCRYPTION KEY** |
| Deleting a CEK | **12.14.100 DROP COLUMN ENCRYPTION KEY** |

## Defining a Database

A database is the warehouse for organizing, storing, and managing data. Defining a database includes: creating a database, altering the database attributes, and dropping the database. For details about related SQL statements, see **Table 12-103**.

**Table 12-103** SQL statements for defining a database

| Function | SQL Statement |
| --- | --- |
| Creating a database | **12.14.57 CREATE DATABASE** |
| Altering database attributes | **12.14.5 ALTER DATABASE** |
| Dropping a Database | **12.14.101 DROP DATABASE** |

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## Defining a Schema

A schema is the set of a group of database objects and is used to control the access to the database objects. For details about related SQL statements, see **Table 12-104**.

**Table 12-104** SQL statements for defining a schema

| Function | SQL Statement |
| --- | --- |
| Creating a schema | **12.14.76 CREATE SCHEMA** |
| Altering schema attributes | **12.14.24 ALTER SCHEMA** |
| Dropping a schema | **12.14.121 DROP SCHEMA** |

## Defining a Tablespace

A tablespace is used to manage data objects and corresponds to a catalog on a disk. For details about related SQL statements, see **Table 12-105**.

**Table 12-105** SQL statements for defining a tablespace

| Function | SQL Statement |
| --- | --- |
| Creating a tablespace | **12.14.81 CREATE TABLESPACE** |
| Altering tablespace attributes | **12.14.32 ALTER TABLESPACE** |
| Dropping a tablespace | **12.14.126 DROP TABLESPACE** |

## Defining a Table

A table is a special data structure in a database and is used to store data objects and relationship between data objects. For details about related SQL statements, see **Table 12-106**.

**Table 12-106** SQL statements for defining a table

| Function | SQL Statement |
| --- | --- |
| Creating a table | **12.14.80 CREATE TABLE** |
| Altering table attributes | **12.14.30 ALTER TABLE** |
| Dropping a table | **12.14.125 DROP TABLE** |

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## Defining a Partitioned Table

A partitioned table is a logical table used to improve query performance and does not store data (data is stored in common tables). For details about related SQL statements, see **Table 12-107**.

**Table 12-107** SQL statements for defining a partitioned table

| Function | SQL Statement |
| --- | --- |
| Creating a partitioned table | **12.14.83 CREATE TABLE PARTITION** |
| Create a partition | **12.14.31 ALTER TABLE PARTITION** |
| Altering partitioned table attributes | **12.14.31 ALTER TABLE PARTITION** |
| Deleting a partition | **12.14.31 ALTER TABLE PARTITION** |
| Dropping a partitioned table | **12.14.125 DROP TABLE** |

## Defining an Index

An index indicates the sequence of values in one or more columns in a database table. It is a data structure that improves the speed of data access to specific information in a database table. For details about related SQL statements, see **Table 12-108**.

**Table 12-108** SQL statements for defining an index

| Function | SQL Statement |
| --- | --- |
| Creating an index | **12.14.64 CREATE INDEX** |
| Altering index attributes | **12.14.13 ALTER INDEX** |
| Dropping an index | **12.14.108 DROP INDEX** |
| Rebuilding an index | **12.14.149 REINDEX** |

## Defining a Stored Procedure

A stored procedure is a set of SQL statements for achieving specific functions and is stored in the database after compiling. Users can specify a name and provide parameters (if necessary) to execute the stored procedure. For details about related SQL statements, see **Table 12-109**.

**Table 12-109** SQL statements for defining a stored procedure

| Function | SQL Statement |
| --- | --- |
| Creating a stored procedure | **12.14.71 CREATE PROCEDURE** |

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| Function | SQL Statement |
| --- | --- |
| Dropping a stored procedure | 12.14.116 DROP PROCEDURE |

## Defining a Function

In GaussDB, a function is similar to a stored procedure, which is a set of SQL statements. The function and stored procedure are used the same. For details about related SQL statements, see Table 12-110.

**Table 12-110** SQL statements for defining a function

| Function | SQL Statement |
| --- | --- |
| Creating a function | 12.14.61 CREATE FUNCTION |
| Altering function attributes | 12.14.10 ALTER FUNCTION |
| Dropping a function | 12.14.105 DROP FUNCTION |

## Defining a View

A view is a virtual table exported from one or more basic tables. It is used to control data accesses of users. Table 12-111 lists the related SQL statements.

**Table 12-111** SQL statements for defining a view

| Function | SQL Statement |
| --- | --- |
| Creating a view | 12.14.89 CREATE VIEW |
| Dropping a view | 12.14.132 DROP VIEW |

## Defining a Cursor

To process SQL statements, the stored procedure process assigns a memory segment to store context association. Cursors are handles or pointers to context regions. With a cursor, the stored procedure can control alterations in context areas. For details, see Table 12-112.

**Table 12-112** SQL statements for defining a cursor

| Function | SQL Statement |
| --- | --- |
| Creating a cursor | 12.14.92 CURSOR |
| Moving a cursor | 12.14.143 MOVE |
| Fetching data from a cursor | 12.14.139 FETCH |

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| Function | SQL Statement |
| --- | --- |
| Closing a cursor | 12.14.45 CLOSE |

## Defining a Resource Pool

A resource pool is a system catalog used by the resource load management module to specify attributes related to resource management, such as Cgroups. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) For details about related SQL statements, see **Table 12-113**.

**Table 12-113** SQL statements for defining a resource pool

| Function | SQL Statement |
| --- | --- |
| Creating a resource pool | 12.14.73 CREATE RESOURCE POOL |
| Altering resource attributes | 12.14.21 ALTER RESOURCE POOL |
| Dropping a resource pool | 12.14.118 DROP RESOURCE POOL |

## Defining a Workload Group

A workload group is a system catalog used by the resource load management module to specify the number of concurrent SQL statements in the associated resource pool. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) For details about related SQL statements, see **Table 12-114**.

**Table 12-114** SQL statements for defining a workload group

| Function | SQL Statement |
| --- | --- |
| Creating a workload group | 12.14.90 CREATE WORKLOAD GROUP |
| Altering the attributes of a workload group | 12.14.39 ALTER WORKLOAD GROUP |
| Dropping a workload group | 12.14.133 DROP WORKLOAD GROUP |

## Defining Application Mapping

Application mapping is a system catalog used by the resource load management module to associate with a workload group. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) After a user connects to a database, the user can specify a workload group to associate SQL

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statements to certain resources. For details about related SQL statements, see **Table 12-115**.

**Table 12-115** SQL statements for defining application mapping

| Function | SQL Statement |
| --- | --- |
| Creating application mapping | **12.14.51 CREATE APP WORKLOAD GROUP MAPPING** |
| Altering application mapping attributes | **12.14.2 ALTER APP WORKLOAD GROUP MAPPING** |
| Dropping application mapping | **12.14.97 DROP APP WORKLOAD GROUP MAPPING** |

# 12.12 DML Syntax Overview

Data manipulation language (DML) is used to perform operations on data in database tables, such as inserting, updating, querying, or deleting data.

## Inserting Data

Inserting data refers to adding one or multiple records to a database table. For details, see **12.14.141 INSERT**.

## Updating Data

Updating data refers to modifying one or multiple records in a database table. For details, see **12.14.170 UPDATE**.

## Querying Data

The database query statement **SELECT** is used to search required information in a database. For details, see **12.14.159 SELECT**.

## Deleting Data

GaussDB provides two statements for deleting data from database tables. To delete data meeting specified conditions from a database table, see **12.14.95 DELETE**. To delete all data from a database table, see **12.14.169 TRUNCATE**.

**TRUNCATE** can quickly delete all data from a database table, which achieves the effect same as that running **DELETE** to delete data without specifying conditions from each table. Deletion efficiency using **TRUNCATE** is faster because **TRUNCATE** does not scan tables. Therefore, **TRUNCATE** is useful in large tables.

## Copying Data

GaussDB provides a statement for copying data between tables and files. For details, see **12.14.50 COPY**.

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### Locking a Table

GaussDB provides multiple lock modes to control concurrent accesses to table data. For details, see **12.14.142 LOCK**.

### Calling a Function

GaussDB provides three statements for calling functions. These statements are the same in the syntax structure. For details, see **12.14.42 CALL**.

### Session Management

A session is a connection established between the user and the database. **Table 12-116** lists the related SQL statements.

**Table 12-116** SQL statements related to sessions

| Function | SQL Statement |
| --- | --- |
| Altering a session | **12.14.27 ALTER SESSION** |
| Killing a session | **12.14.29 ALTER SYSTEM KILL SESSION** |

## 12.13 DCL Syntax Overview

Data control language (DCL) is used to create users and roles and set or modify database users or role rights.

### Defining a Role

A role is used to manage permissions. For database security, management and operation permissions can be granted to different roles. For details about related SQL statements, see **Table 12-117**.

**Table 12-117** SQL statements for defining a role

| Function | SQL Statement |
| --- | --- |
| Creating a role | **12.14.74 CREATE ROLE** |
| Altering role attributes | **12.14.22 ALTER ROLE** |
| Dropping a role | **12.14.119 DROP ROLE** |

### Defining a User

A user is used to log in to a database. Different permissions can be granted to users for managing data accesses and operations of the users. For details about related SQL statements, see **Table 12-118**.

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**Table 12-118** SQL statements for defining a user

| Function | SQL Statement |
| --- | --- |
| Creating a user | **12.14.88 CREATE USER** |
| Altering user attributes | **12.14.37 ALTER USER** |
| Dropping a user | **12.14.131 DROP USER** |

### Granting Rights

GaussDB provides a statement for granting rights to data objects and roles. For details, see **12.14.140 GRANT**.

### Revoking Rights

GaussDB provides a statement for revoking rights. For details, see **12.14.154 REVOKE**.

### Setting Default Rights

GaussDB allows users to set rights for objects that will be created in the future. For details, see **12.14.7 ALTER DEFAULT PRIVILEGES**.

# 12.14 SQL Syntax

## 12.14.1 ABORT

### Function

**ABORT** rolls back the current transaction and cancels the changes in the transaction.

This command is equivalent to **12.14.155 ROLLBACK**, and is present only for historical reasons. Now **ROLLBACK** is recommended.

### Precautions

**ABORT** has no impact outside a transaction, but will provoke a warning.

### Syntax

```
ABORT [ WORK | TRANSACTION ] ;
```

### Parameter Description

**WORK | TRANSACTION**

Optional keyword has no effect except increasing readability.

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## Examples

```
-- Create the customer_demographics_t1 table.
openGauss=# CREATE TABLE customer_demographics_t1
(
    CD_DEMO_SK              INTEGER              NOT NULL,
    CD_GENDER               CHAR(1)                      ,
    CD_MARITAL_STATUS       CHAR(1)                      ,
    CD_EDUCATION_STATUS     CHAR(20)                     ,
    CD_PURCHASE_ESTIMATE    INTEGER                      ,
    CD_CREDIT_RATING        CHAR(10)                     ,
    CD_DEP_COUNT            INTEGER                      ,
    CD_DEP_EMPLOYED_COUNT   INTEGER                      ,
    CD_DEP_COLLEGE_COUNT    INTEGER
)
WITH (ORIENTATION = COLUMN,COMPRESSION=MIDDLE)
DISTRIBUTE BY HASH (CD_DEMO_SK);

-- Insert data.
openGauss=# INSERT INTO customer_demographics_t1 VALUES(1920801,'M', 'U', 'DOCTOR DEGREE', 200,
'GOOD', 1, 0,0);

-- Start a transaction.
openGauss=# START TRANSACTION;

-- Update the column.
openGauss=# UPDATE customer_demographics_t1 SET cd_education_status= 'Unknown';

-- Abort the transaction. All updates are rolled back.
openGauss=# ABORT;

-- Query data.
openGauss=# SELECT * FROM customer_demographics_t1 WHERE cd_demo_sk = 1920801;
cd_demo_sk | cd_gender | cd_marital_status | cd_education_status  | cd_purchase_estimate | cd_credit_rating
| cd_dep_count | cd_dep_employed_count | cd_dep_college_count
------------+-----------+-------------------+----------------------+----------------------+------------------
+--------------+-----------------------+----------------------
   1920801 | M         | U                 | DOCTOR DEGREE        |                  200 | GOOD             |            1
|                0 |                     0
(1 row)

-- Delete the table.
openGauss=# DROP TABLE customer_demographics_t1;
```

## Helpful Links

**12.14.165 SET TRANSACTION**, **12.14.48 COMMIT | END**, and **12.14.155 ROLLBACK**

# 12.14.2 ALTER APP WORKLOAD GROUP MAPPING

## Function

**ALTER APP WORKLOAD GROUP MAPPING** modifies the workload group associated with an application mapping group. Only users who have the **ALTER** permission on the current database can modify application mapping group.

## Precautions

None

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## Syntax

```
ALTER APP WORKLOAD GROUP MAPPING app_name
    WITH ( WORKLOAD_GPNAME = wg_name );
```

## Parameter Description

- **app_name**

  Specifies the name of an application mapping group. The name of an application mapping group must be unique in the current database.

  Value range: a string. It must comply with the naming convention.

- **wg_name**

  Specifies a Workload Cgroup name.

  Value range: a string, which indicates the created workload group.

## Examples

```
-- Create a resource pool and specify the High Timeshare Workload Cgroup under the DefaultClass Cgroup.
openGauss=# CREATE RESOURCE POOL pool1 WITH (CONTROL_GROUP="High");

-- Create a workload group and associate it with the created resource pool.
openGauss=# CREATE WORKLOAD GROUP wg_hr1 USING RESOURCE POOL pool1;

-- Create a default application mapping group and associate it with the default workload group.
openGauss=# CREATE APP WORKLOAD GROUP MAPPING app_wg_map1;

-- Change the name of the workload group associated with an application mapping group.
openGauss=# ALTER APP WORKLOAD GROUP MAPPING app_wg_map1
WITH(WORKLOAD_GPNAME=wg_hr1);

-- Delete the application mapping group.
openGauss=# DROP APP WORKLOAD GROUP MAPPING app_wg_map1;

-- Delete the workload group.
openGauss=# DROP WORKLOAD GROUP wg_hr1;

-- Delete the resource pool.
openGauss=# DROP RESOURCE POOL pool1;
```

## Helpful Links

**12.14.51 CREATE APP WORKLOAD GROUP MAPPING** and **12.14.97 DROP APP WORKLOAD GROUP MAPPING**

# 12.14.3 ALTER AUDIT POLICY

## Function

**ALTER AUDIT POLICY** modifies the unified audit policy.

## Precautions

- Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.
- The unified audit policy takes effect only after **enable_security_policy** is set to **on**. For details, see "Database Configuration > Database Security Management Policies > Unified Auditing" in the *Security Hardening Guide*.

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## Syntax

```
ALTER AUDIT POLICY [ IF EXISTS ] policy_name { ADD | REMOVE } { [ privilege_audit_clause ]
[ access_audit_clause ] };
ALTER AUDIT POLICY [ IF EXISTS ] policy_name MODIFY ( filter_group_clause );
ALTER AUDIT POLICY [ IF EXISTS ] policy_name DROP FILTER;
ALTER AUDIT POLICY [ IF EXISTS ] policy_name COMMENTS policy_comments;
ALTER AUDIT POLICY [ IF EXISTS ] policy_name { ENABLE | DISABLE };
```

- privilege_audit_clause
  ```
  PRIVILEGES { DDL | ALL }
  ```
- access_audit_clause
  ```
  ACCESS { DML | ALL }
  ```
- filter_group_clause
  ```
  FILTER ON { ( FILTER_TYPE ( filter_value [, ... ] ) ) [, ... ] }
  ```

## Parameter Description

- **policy_name**

  Specifies the audit policy name, which must be unique.

  Value range: a string. It must comply with the naming convention rule.
- **DDL**

  Specifies the operations that will be audited within the database: ALTER, ANALYZE, COMMENT, CREATE, DROP, GRANT, REVOKE, SET, SHOW, LOGIN_ACCESS, LOGIN_FAILURE, LOGOUT, and LOGIN.
- **ALL**

  Indicates all operations supported by the specified DDL statements in the database.
- **DML**

  Specifies the operations that are audited within the database: COPY, DEALLOCATE, DELETE_P, EXECUTE, REINDEX, INSERT, PREPARE, SELECT, TRUNCATE, and UPDATE.
- **FILTER_TYPE**

  Specifies the types of information to be filtered by the audit: **IP**, **ROLES**, and **APP**.
- **filter_value**

  Indicates the detailed information to be filtered.
- **policy_comments**

  Records description information of audit policies.
- **ENABLE|DISABLE**

  Enables or disables the unified audit policy. If **ENABLE|DISABLE** is not specified, **ENABLE** is used by default.

## Examples

See **Examples** in **CREATE AUDIT POLICY**.

## Helpful Links

**12.14.52 CREATE AUDIT POLICY** and **12.14.98 DROP AUDIT POLICY**

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# 12.14.4 ALTER COORDINATOR

## Function

**ALTER COORDINATOR** changes the value of **nodeis_active** on a specified node in the **pgxc_node** system catalog. This operation can be performed on any normal CN in the cluster and also specifies the node on which the system catalog is to be modified.

## Precautions

- *ALTER COORDINATOR* is a statement used to modify the system catalog. Only the administrator and internal maintenance mode (for example, CM) can execute this statement. This statement is dedicated for the CN removal feature and must be used together with other operations. You are not advised to run it by yourself.
- After this statement is executed, **select reload_active_coordinator()** needs to be called to update the connection pool information of the node on which the system catalog is modified.

## Syntax

```
ALTER COORDINATOR nodename SET status
    WITH (nodename1[, nodename2, nodename3 ...]);
```

## Parameter Description

- **nodename**

  Specifies the node name corresponding to a row of records in the **pgxc_node** system catalog. After the node name is specified, the value of **nodeis_active** in the record is changed.

  Value range: a string. Only CNs are supported. Ensure that the node name has a corresponding record in the **pgxc_node** system catalog.

- **status**

  Specifies the updated value of **nodeis_acitve** in the **pgxc_node** system catalog.

  Value range:

  - FALSE

  - TRUE

- **nodename1[, nodename2, nodename3 ...]**

  Specifies the range of nodes on which the SQL statement is executed. When **ALTER COORDINATOR** is executed, the SQL statement is automatically delivered to all nodes in the range. The current execution node must be included.

  Value range: a string. Only CNs are supported. Ensure that the node name has a corresponding record in the **pgxc_node** system catalog and the node state is normal. Otherwise, the SQL statement fails to be executed.

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## Examples

The cluster has three CNs, namely, cn_5001, cn_5002, and cn_5003, which are running properly.

If cn_5001 is faulty and needs to be removed from the cluster within the specified time, run the following SQL statement on cn_5002 and cn_5003 to change the value of **nodeis_active** corresponding to cn_5001 in the **pgxc_node** system catalog to **false**:

```
ALTER COORDINATOR cn_5001 SET False WITH (cn_5002,cn_5003).
```

After cn_5001 is recovered, run the following SQL statement on cn_5002 and cn_5003 to change the value of **nodeis_active** corresponding to cn_5001 in the **pgxc_node** system catalog to **true**:

```
ALTER COORDINATOR cn_5001 SET True WITH (cn_5002,cn_5003).
```

# 12.14.5 ALTER DATABASE

## Function

**ALTER DATABASE** modifies a database, including its name, owner, connection limitation, and object isolation.

## Precautions

- Only the database owner or a user granted with the ALTER permission can run the **ALTER DATABASE** command. The system administrator has this permission by default. The following is permission constraints depending on attributes to be modified:
  - To modify the database name, you must have the **CREATEDB** permission.
  - To modify a database owner, you must be a database owner or system administrator and a member of the new owner role, with the **CREATEDB** permission.
  - To modify the default tablespace of the database, you must have the **CREATE** permission on the new tablespace. This statement physically migrates tables and indexes in a default tablespace to a new tablespace. Note that tables and indexes outside the default tablespace are not affected.
- You are not allowed to rename a database in use. To rename it, connect to another database.

## Syntax

- Modify the maximum number of connections to the database.
  ```
  ALTER DATABASE database_name
    [ [ WITH ] CONNECTION LIMIT connlimit ];
  ```
- Rename the database.
  ```
  ALTER DATABASE database_name
    RENAME TO new_name;
  ```
- Change the database owner.
  ```
  ALTER DATABASE database_name
    OWNER TO new_owner;
  ```

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- Change the default tablespace of the database.

```
ALTER DATABASE database_name
  SET TABLESPACE new_tablespace;
```

  NOTE

  If some tables or objects in the database have been created in **new_tablespace**, the default tablespace of the database cannot be changed to **new_tablespace**. An error will be reported during the execution.

- Modify the object isolation attribute of the database.

```
ALTER DATABASE database_name [ WITH ] { ENABLE | DISABLE } PRIVATE OBJECT;
```

  NOTE

  - To modify the object isolation attribute of a database, the database must be connected. Otherwise, the modification will fail.
  - For a new database, the object isolation attribute is disabled by default. After the database object isolation attribute is enabled, the database automatically adds row-level access control policies to the system catalogs **PG_CLASS**, **PG_ATTRIBUTE**, **PG_PROC**, **PG_NAMESPACE**, **PGXC_SLICE** and **PG_PARTITION**. Common users can only view the objects (tables, functions, views, and columns) that they have the permission to access. This attribute does not take effect for administrators. After this attribute is enabled, administrators can still view all database objects.

## Description

- **database_name**

  Specifies the name of the database whose attributes are to be modified.

  Value range: a string. It must comply with the naming convention.

- **connlimit**

  Specifies the maximum number of concurrent connections that can be made to this database (excluding administrators' connections).

  Value range: The value must be an integer, preferably from 1 to 50. The default value **-1** indicates that there is no restriction on the number of concurrent connections.

- **new_name**

  Specifies the new name of a database.

  Value range: a string. It must comply with the naming convention.

- **new_owner**

  Specifies the new owner of a database.

  Value range: a string. It must be a valid username.

- **new_tablespace**

  Specifies the new default tablespace of a database. The tablespace exists in the database. The default tablespace is **pg_default**.

  Value range: a string. It must be a valid tablespace name.

- **configuration_parameter**

  **value**

  Sets a specified database session parameter to a specified value. If the value is **DEFAULT** or **RESET**, the default setting is used in the new session. **OFF** closes the setting.

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**NOTICE**

The current version does not support setting database-level parameters.

Value range: a string

- DEFAULT
- OFF
- RESET

- **FROM CURRENT**

  Sets the value of the database based on the current connected session.

- **RESET configuration_parameter**

  Resets the specified database session parameter.

**NOTICE**

The current version does not support resetting database-level parameters.

- **RESET ALL**

  Resets all database session parameters.

**NOTICE**

The current version does not support resetting database-level parameters.

**NOTE**

- Modify the default tablespace of a database by moving the table or index in the old tablespace into the new tablespace. This operation does not affect the tables or indexes in other non-default tablespaces.
- The modified database session parameter values will take effect in the next session.
- After setting the parameters, you need to manually run the **CLEAN CONNECTION** command to clear the old connections. Otherwise, the parameter values between cluster nodes may be inconsistent.

## Example

See **Examples** in **CREATE DATABASE**.

## Helpful Links

**12.14.57 CREATE DATABASE** and **12.14.101 DROP DATABASE**.

# 12.14.6 ALTER DATA SOURCE

## Function

**ALTER DATA SOURCE** modifies the attributes and content of the data source object.

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The attributes include the name and owner. The content includes the type, version, and connection options.

## Precautions

- Only the initial user, system administrator, and owner have the permission to modify data sources.
- To change the owner, the new owner must be the initial user or a system administrator.
- If the **password** option is displayed, ensure that the **datasource.key.cipher** and **datasource.key.rand** files exist in the *$GAUSSHOME*/**bin** directory of each node in the cluster. If the two files do not exist, use the **gs_guc** tool to generate them and use the **gs_ssh** tool to release them to the *$GAUSSHOME*/**bin** directory on each node in the cluster.

## Syntax

```
ALTER DATA SOURCE src_name
   [TYPE  'type_str']
   [VERSION  {'version_str' | NULL}]
   [OPTIONS ( { [ ADD | SET | DROP ] optname ['optvalue'] } [, ...] )];
ALTER DATA SOURCE src_name RENAME TO src_new_name;
ALTER DATA SOURCE src_name OWNER TO new_owner;
```

## Parameter Description

- **src_name**

  Specifies the data source name to be modified.

  Value range: a string. It must comply with the naming convention.

- **TYPE**

  Changes the original **TYPE** value of the data source to the specified value.

  Value range: an empty string or a non-empty string

- **VERSION**

  Changes the original **VERSION** value of the data source to the specified value.

  Value range: an empty string, a non-empty string, or null

- **OPTIONS**

  Specifies the column to be added, modified, or deleted. The value of optname should be unique. Comply with the following rules to set this parameter:

  To add a column, you can omit **ADD** and simply specify the column name, which cannot be an existing column name.

  To modify a column, specify **SET** and an existing column name.

  To delete a column, specify **DROP** and an existing column name. Do not set **optvalue**.

- **src_new_name**

  Specifies the new data source name.

  Value range: a string. It must comply with the naming convention.

- **new_user**

  Specifies the new owner of an object.

  Value range: a string. It must be a valid username.

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## Examples

```
-- Create an empty data source object.
openGauss=# CREATE DATA SOURCE ds_test1;

-- Rename the data source.
openGauss=# ALTER DATA SOURCE ds_test1 RENAME TO ds_test;

-- Change the owner.
openGauss=# CREATE USER user_test1 IDENTIFIED BY 'Gs@123456';
openGauss=# ALTER USER user_test1 WITH SYSADMIN;
openGauss=# ALTER DATA SOURCE ds_test OWNER TO user_test1;

-- Modify TYPE and VERSION.
openGauss=# ALTER DATA SOURCE ds_test TYPE 'MPPDB_TYPE' VERSION 'XXX';

-- Add a column.
openGauss=# ALTER DATA SOURCE ds_test OPTIONS (add dsn 'mppdb', username 'test_user');

-- Modify a column.
openGauss=# ALTER DATA SOURCE ds_test OPTIONS (set dsn 'unknown');

-- Delete a column.
openGauss=# ALTER DATA SOURCE ds_test OPTIONS (drop username);

-- Delete the data source and user objects.
openGauss=# DROP DATA SOURCE ds_test;
openGauss=# DROP USER user_test1;
```

## Helpful Links

12.14.58 CREATE DATA SOURCE and 12.14.102 DROP DATA SOURCE

# 12.14.7 ALTER DEFAULT PRIVILEGES

## Function

**ALTER DEFAULT PRIVILEGES** allows you to set the permissions that will be applied to objects created in the future. (It does not affect permissions granted to existing objects.)

## Precautions

Currently, you can change only the permissions for tables (including views), sequences, functions, types, client master keys of encrypted databases, and column encryption keys.

## Syntax

```
ALTER DEFAULT PRIVILEGES
    [ FOR { ROLE | USER } target_role [, ...] ]
    [ IN SCHEMA schema_name [, ...] ]
    abbreviated_grant_or_revoke;
```

- **abbreviated_grant_or_revoke** grants or revokes permissions on some objects.

  ```
  grant_on_tables_clause
    | grant_on_sequences_clause
    | grant_on_functions_clause
    | grant_on_types_clause
    | grant_on_client_master_keys_clause
    | grant_on_column_encryption_keys_clause
    | revoke_on_tables_clause
    | revoke_on_sequences_clause
  ```

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```
| revoke_on_functions_clause
| revoke_on_types_clause
| revoke_on_client_master_keys_clause
| revoke_on_column_encryption_keys_clause
```

- **grant_on_tables_clause** grants permissions on tables.

```
GRANT { { SELECT | INSERT | UPDATE | DELETE | TRUNCATE | REFERENCES | ALTER | DROP |
COMMENT | INDEX | VACUUM }
   [, ...] | ALL [ PRIVILEGES ] }
   ON TABLES
   TO { [ GROUP ] role_name | PUBLIC } [, ...]
   [ WITH GRANT OPTION ]
```

- **grant_on_sequences_clause** grants permissions on sequences.

```
GRANT { { SELECT | UPDATE | USAGE | ALTER | DROP | COMMENT }
   [, ...] | ALL [ PRIVILEGES ] }
   ON SEQUENCES
   TO { [ GROUP ] role_name | PUBLIC } [, ...]
   [ WITH GRANT OPTION ]
```

- **grant_on_functions_clause** grants permissions on functions.

```
GRANT { { EXECUTE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
   ON FUNCTIONS
   TO { [ GROUP ] role_name | PUBLIC } [, ...]
   [ WITH GRANT OPTION ]
```

- **grant_on_types_clause** grants permissions on types.

```
GRANT { { USAGE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
   ON TYPES
   TO { [ GROUP ] role_name | PUBLIC } [, ...]
   [ WITH GRANT OPTION ]
```

- **grant_on_client_master_keys_clause** grants permissions on CMKs.

```
GRANT { { USAGE  | DROP } [, ...] | ALL [ PRIVILEGES ] }
   ON CLIENT_MASTER_KEYS
   TO { [ GROUP ] role_name | PUBLIC } [, ...]
   [ WITH GRANT OPTION ]
```

- **grant_on_column_encryption_keys_clause** grants permissions on column encryption keys.

```
GRANT { { USAGE | DROP } [, ...] | ALL [ PRIVILEGES ] }
   ON COLUMN_ENCRYPTION_KEYS
   TO { [ GROUP ] role_name | PUBLIC } [, ...]
   [ WITH GRANT OPTION ]
```

- **revoke_on_tables_clause** revokes permissions on tables.

```
REVOKE [ GRANT OPTION FOR ]
   { { SELECT | INSERT | UPDATE | DELETE | TRUNCATE | REFERENCES | ALTER | DROP | COMMENT |
INDEX | VACUUM }
   [, ...] | ALL [ PRIVILEGES ] }
   ON TABLES
   FROM { [ GROUP ] role_name | PUBLIC } [, ...]
   [ CASCADE | RESTRICT | CASCADE CONSTRAINTS ]
```

- **revoke_on_sequences_clause** revokes permissions on sequences.

```
REVOKE [ GRANT OPTION FOR ]
   { { SELECT | UPDATE | USAGE | ALTER | DROP | COMMENT }
   [, ...] | ALL [ PRIVILEGES ] }
   ON SEQUENCES
   FROM { [ GROUP ] role_name | PUBLIC } [, ...]
   [ CASCADE | RESTRICT | CASCADE CONSTRAINTS ]
```

- **revoke_on_functions_clause** revokes permissions on functions.

```
REVOKE [ GRANT OPTION FOR ]
   { { EXECUTE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
   ON FUNCTIONS
   FROM { [ GROUP ] role_name | PUBLIC } [, ...]
   [ CASCADE | RESTRICT | CASCADE CONSTRAINTS ]
```

- **revoke_on_types_clause** revokes permissions on types.

```
REVOKE [ GRANT OPTION FOR ]
   { { USAGE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
```

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```
  ON TYPES
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT | CASCADE CONSTRAINTS ]
```

- **revoke_on_client_master_keys_clause** revokes permissions on CMKs.

```
REVOKE [ GRANT OPTION FOR ]
  { { USAGE | DROP } [, ...] | ALL [ PRIVILEGES ] }
  ON CLIENT_MASTER_KEYS
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT | CASCADE CONSTRAINTS ]
```

- **revoke_on_column_encryption_keys_clause** revokes permissions on CEKs.

```
REVOKE [ GRANT OPTION FOR ]
  { { USAGE | DROP } [, ...] | ALL [ PRIVILEGES ] }
  ON COLUMN_ENCRYPTION_KEYS
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT | CASCADE CONSTRAINTS ]
```

## Parameter Description

- **target_role**

  Specifies the name of an existing role. If **FOR ROLE/USER** is omitted, the current role is assumed.

  Value range: an existing role name

- **schema_name**

  Specifies the name of an existing schema.

  **target_role** must have the **CREATE** permission for **schema_name**.

  Value range: an existing schema name

- **role_name**

  Specifies the name of an existing role to grant or revoke permissions for.

  Value range: an existing role name

**NOTICE**

To drop a role for which the default permissions have been granted, reverse the changes in its default permissions or use **DROP OWNED BY** to get rid of the default permission entry for the role.

## Examples

```
-- Grant the SELECT permission on all the tables (and views) in tpcds to every user.
openGauss=# ALTER DEFAULT PRIVILEGES IN SCHEMA tpcds GRANT SELECT ON TABLES TO PUBLIC;

-- Create a common user jack.
openGauss=# CREATE USER jack PASSWORD 'xxxxxxxxxx';

-- Grant the INSERT permission on all the tables in tpcds to the user jack.
openGauss=# ALTER DEFAULT PRIVILEGES IN SCHEMA tpcds GRANT INSERT ON TABLES TO jack;

-- Revoke the preceding permissions.
openGauss=# ALTER DEFAULT PRIVILEGES IN SCHEMA tpcds REVOKE SELECT ON TABLES FROM PUBLIC;
openGauss=# ALTER DEFAULT PRIVILEGES IN SCHEMA tpcds REVOKE INSERT ON TABLES FROM jack;

-- Delete user jack.
openGauss=# DROP USER jack;
```

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### Helpful Links

12.14.140 GRANT and 12.14.154 REVOKE

## 12.14.8 ALTER DIRECTORY

### Function

**ALTER DIRECTORY** modifies a directory.

### Precautions

- Currently, only the directory owner can be changed.
- When **enable_access_server_directory** is set to **off**, only the initial user is allowed to change the directory owner. When **enable_access_server_directory** is set to **on**, users with the **SYSADMIN** permission and the directory object owner can change the directory object owner, and the user who changes the owner is required to be a member of the new owner.

### Syntax

```
ALTER DIRECTORY directory_name
    OWNER TO new_owner;
```

### Parameter Description

**directory_name**

Specifies the name of a directory to be modified. The value must be an existing directory name.

### Examples

```
-- Create a directory.
openGauss=# CREATE OR REPLACE DIRECTORY  dir  as '/tmp/';

-- Change the owner of the directory.
openGauss=# ALTER DIRECTORY dir OWNER TO system;

-- Delete the foreign table.
openGauss=# DROP DIRECTORY dir;
```

### Helpful Links

12.14.59 CREATE DIRECTORY and 12.14.103 DROP DIRECTORY

## 12.14.9 ALTER FOREIGN TABLE (for Import and Export)

### Function

**ALTER FOREIGN TABLE** modifies a foreign table.

### Precautions

When multi-layer quotation marks are used for sensitive columns (such as **password** and **secret_access_key**) in OPTIONS, the semantics is different from

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that in the scenario where quotation marks are not used. Therefore, sensitive columns are not identified for anonymization.

## Syntax

- Set the attributes of a foreign table.

```
ALTER FOREIGN TABLE [ IF EXISTS ]  table_name
    OPTIONS ( {[ ADD | SET | DROP ] option ['value']}[, ... ]);
```

- Set a new owner.

```
ALTER FOREIGN TABLE [ IF EXISTS ] tablename
    OWNER TO new_owner;
```

- Set foreign table column options.

```
ALTER FOREIGN TABLE [ IF EXISTS ] table_name
    ALTER column_name OPTIONS;
```

## Parameter Description

- **table_name**

  Specifies the name of an existing foreign table to be modified.

  Value range: an existing table name

- **option**

  Specifies the name of the option to be modified.

  Value range: See **Parameter Description** in **CREATE FOREIGN TABLE**.

- **value**

  Specifies the new value of **option**.

## Examples

```
-- Create a foreign table.
openGauss=# CREATE FOREIGN TABLE tpcds.customer_ft
(
    c_customer_sk             integer               ,
    c_customer_id             char(16)              ,
    c_current_cdemo_sk        integer               ,
    c_current_hdemo_sk        integer               ,
    c_current_addr_sk         integer               ,
    c_first_shipto_date_sk    integer               ,
    c_first_sales_date_sk     integer               ,
    c_salutation              char(10)              ,
    c_first_name              char(20)              ,
    c_last_name               char(30)              ,
    c_preferred_cust_flag     char(1)               ,
    c_birth_day               integer               ,
    c_birth_month             integer               ,
    c_birth_year              integer               ,
    c_birth_country           varchar(20)           ,
    c_login                   char(13)              ,
    c_email_address           char(50)              ,
    c_last_review_date        char(10)
)
    SERVER gsmpp_server
    OPTIONS
(
    location 'gsfs://10.185.179.143:5000/customer1*.dat',
    FORMAT 'TEXT' ,
    DELIMITER '|',
    encoding 'utf8',
    mode 'Normal')
READ ONLY;
```

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```
-- Modify foreign table attributes and delete the mode option.
openGauss=# ALTER FOREIGN TABLE tpcds.customer_ft options(drop mode);

-- Delete the foreign table.
openGauss=# DROP FOREIGN TABLE tpcds.customer_ft;
```

## Helpful Links

**12.14.60 CREATE FOREIGN TABLE (for Import and Export)** and **12.14.104 DROP FOREIGN TABLE**

# 12.14.10 ALTER FUNCTION

## Function

**ALTER FUNCTION** modifies the attributes of a customized function.

## Precautions

Only the function owner or a user granted with the **ALTER** permission can run the **ALTER FUNCTION** command. The system administrator has this permission by default. The following is permission constraints depending on attributes to be modified:

- If a function involves operations on temporary tables, **ALTER FUNCTION** cannot be used.
- To modify the owner or schema of a function, you must be a function owner or system administrator and a member of the new owner role.
- Only the system administrator and initial user can change the schema of a function to public.

## Syntax

- Modify the additional parameters of the customized function.

  ```
  ALTER FUNCTION function_name ( [ { [ argname ] [ argmode ] argtype} [, ...] ] )
      action [ ... ] [ RESTRICT ];
  ```

  The syntax of the **action** clause is as follows:

  ```
  {CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT | STRICT}
   | {IMMUTABLE | STABLE | VOLATILE}
   | {SHIPPABLE | NOT SHIPPABLE}
   | {NOT FENCED | FENCED}
   | [ NOT ] LEAKPROOF
   | { [ EXTERNAL ] SECURITY INVOKER | [ EXTERNAL ] SECURITY DEFINER }
   | AUTHID { DEFINER | CURRENT_USER }
   | COST execution_cost
   | ROWS result_rows
   | SET configuration_parameter { { TO | = } { value | DEFAULT }| FROM CURRENT}
   | RESET {configuration_parameter | ALL}
  ```

- Rename the customized function.

  ```
  ALTER FUNCTION funname ( [ { [ argname ] [ argmode ] argtype} [, ...] ] )
      RENAME TO new_name;
  ```

- Change the owner of the customized function.

  ```
  ALTER FUNCTION funname ( [ { [ argname ] [ argmode ] argtype} [, ...] ] )
      OWNER TO new_owner;
  ```

- Modify the schema of the customized function.

  ```
  ALTER FUNCTION funname ( [ { [ argname ] [ argmode ] argtype} [, ...] ] )
      SET SCHEMA new_schema;
  ```

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## Parameter Description

- **function_name**

  Specifies the name of the function to be modified.

  Value range: an existing function name

- **argmode**

  Specifies whether a parameter is an input or output parameter.

  Value range: **IN**, **OUT**, and **IN OUT**

- **argname**

  Parameter name.

  Value range: a string. It must comply with the naming convention.

- **argtype**

  Specifies the parameter type.

  Value range: a valid type. For details, see **12.3 Data Type**.

- **CALLED ON NULL INPUT**

  Declares that some parameters of the function can be invoked in normal mode if the parameter values are null. Omitting this parameter is the same as specifying it.

- **RETURNS NULL ON NULL INPUT**

  **STRICT**

  Specifies that the function always returns **NULL** whenever any of its parameters is **NULL**. If **STRICT** is specified, the function will not be executed when there are null parameters; instead a null result is assumed automatically.

  **RETURNS NULL ON NULL INPUT** and **STRICT** have the same functions.

- **IMMUTABLE**

  Specifies that the function always returns the same result if the parameter values are the same.

- **STABLE**

  Specifies that the function cannot modify the database, and that within a single table scan it will consistently return the same result for the same parameter value, but its result varies by SQL statements.

- **VOLATILE**

  Specifies that the function value can change in a single table scan and no optimization is performed.

- **SHIPPABLE**
- **NOT SHIPPABLE**

  Specifies whether the function can be pushed down to DN for execution.

  Functions of the **IMMUTABLE** type can always be pushed down to DN.

  Functions of the **STABLE** or **VOLATILE** type can be pushed down to DN only if their attribute is **SHIPPABLE**.

- **LEAKPROOF**

  Specifies that the function has no side effect and the parameter contains only the return value. **LEAKROOF** can be set only by the system administrator.

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- **EXTERNAL**

  (Optional) The purpose is to be compatible with SQL. This feature applies to all functions, not only external functions.

- **SECURITY INVOKER**

  **AUTHID CURREN_USER**

  Specifies that the function will be executed with the permissions of the user who invokes it. Omitting this parameter is the same as specifying it.

  **SECURITY INVOKER** and **AUTHID CURREN_USER** have the same functions.

- **SECURITY DEFINER**

  **AUTHID DEFINER**

  Specifies that the function will be executed with the permissions of the user who created it.

  **AUTHID DEFINER** and **SECURITY DEFINER** have the same functions.

- **COST execution_cost**

  Estimates the execution cost of a function.

  The unit of **execution_cost** is **cpu_operator_cost**.

  Value range: a positive integer

- **ROWS result_rows**

  Estimates the number of rows returned by the function. This is only allowed when the function is declared to return a set.

  Value range: a positive number. The default value is **1000**.

- **configuration_parameter**
  - **value**

    Sets a specified database session parameter to a specified value. If the value is **DEFAULT** or **RESET**, the default setting is used in the new session. **OFF** closes the setting.

    Value range: a string

    - DEFAULT
    - OFF
    - RESET

    Specifies the default value.
  - **from current**

    Uses the value of **configuration_parameter** of the current session.

- **new_name**

  Specifies the new name of a function. To change the schema of a function, you must have the **CREATE** permission on the new schema.

  Value range: a string. It must comply with the naming convention.

- **new_owner**

  Specifies the new owner of a function. To change the owner of a function, the new owner must have the **CREATE** permission on the schema to which the function belongs.

  Value range: an existing user role

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- **new_schema**

  Specifies the new schema of a function.

  Value range: an existing schema

## Examples

See **Examples** in **CREATE FUNCTION**.

## Helpful Links

**12.14.61 CREATE FUNCTION** and **12.14.105 DROP FUNCTION**

# 12.14.11 ALTER GLOBAL CONFIGURATION

## Function

**ALTER GLOBAL CONFIGURATION** adds and modifies the **gs_global_config** system catalog and adds the value of **key-value**.

## Precautions

Only the initial database user can run this command.

The keyword cannot be changed to **weak_password**.

## Syntax

```
ALTER GLOBAL CONFIGURATION with(paraname=value, paraname=value...);
```

## Parameter Description

The parameter name and value are of the text type.

# 12.14.12 ALTER GROUP

## Function

**ALTER GROUP** modifies the attributes of a user group.

## Precautions

**ALTER GROUP** is an alias for **ALTER ROLE**, and it is not a standard SQL syntax and not recommended. Users can use **ALTER ROLE** directly.

## Syntax

- Add users to a group.

  ```
  ALTER GROUP group_name
    ADD USER user_name [, ... ];
  ```

- Remove users from a group.

  ```
  ALTER GROUP group_name
    DROP USER user_name [, ... ];
  ```

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- Change the name of the group.

```
ALTER GROUP group_name
    RENAME TO new_name;
```

## Parameter Description

See **Parameter Description** in **ALTER ROLE**.

## Examples

```
-- Add users to a user group.
openGauss=# ALTER GROUP super_users ADD USER lche, jim;

-- Remove users from a user group.
openGauss=# ALTER GROUP super_users DROP USER jim;

-- Change the name of a user group.
openGauss=# ALTER GROUP super_users RENAME TO normal_users;
```

## Helpful Links

**12.14.62 CREATE GROUP**, **12.14.107 DROP GROUP**, and **12.14.22 ALTER ROLE**

# 12.14.13 ALTER INDEX

## Function

**ALTER INDEX** modifies the definition of an existing index.

It has the following forms:

- IF EXISTS

  Sends a notice instead of an error if the specified index does not exist.
- RENAME TO

  Changes only the name of the index. The stored data is not affected.
- SET TABLESPACE

  This option changes the index tablespace to the specified tablespace and moves index-related data files to the new tablespace.
- SET ( { STORAGE_PARAMETER = value } [, ...] )

  Changes one or more index-method-specific storage parameters of an index. Note that the index content will not be modified immediately by this statement. You may need to use **REINDEX** to recreate the index based on different parameters to achieve the expected effect.
- RESET ( { storage_parameter } [, ...] )

  Resets one or more index-method-specific storage parameters of an index to the default value. Similar to the **SET** statement, **REINDEX** may be used to completely update the index.
- [ MODIFY PARTITION index_partition_name ] UNUSABLE

  Sets the indexes on a table or index partition to be unavailable.
- REBUILD [ PARTITION index_partition_name ]

  Rebuilds indexes on a table or an index partition.

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- RENAME PARTITION

  Renames an index partition.
- MOVE PARTITION

  Modifies the tablespace to which an index partition belongs.

## Precautions

Only the index owner or a user who has the INDEX permission on the table where the index resides can run the **ALTER INDEX** command. The system administrator has this permission by default.

## Syntax

- Rename a table index.
```
ALTER INDEX [ IF EXISTS ] index_name
    RENAME TO new_name;
```
- Change the tablespace to which a table index belongs.
```
ALTER INDEX [ IF EXISTS ] index_name
    SET TABLESPACE tablespace_name;
```
- Modify the storage parameter of a table index.
```
ALTER INDEX [ IF EXISTS ] index_name
    SET ( {storage_parameter = value} [, ... ] );
```
- Reset the storage parameter of a table index.
```
ALTER INDEX [ IF EXISTS ] index_name
    RESET ( storage_parameter [, ... ] ) ;
```
- Set a table index or an index partition to be unavailable.
```
ALTER INDEX [ IF EXISTS ] index_name
    [ MODIFY PARTITION index_partition_name ] UNUSABLE;
```

  NOTE

  The syntax cannot be used for column-store tables.
- Rebuild a table index or index partition.
```
ALTER INDEX index_name
    REBUILD [ PARTITION index_partition_name ];
```
- Rename an index partition.
```
ALTER INDEX [ IF EXISTS ] index_name
    RENAME PARTITION index_partition_name TO new_index_partition_name;
```
- Modify the tablespace to which an index partition belongs.
```
ALTER INDEX [ IF EXISTS ] index_name
    MOVE PARTITION index_partition_name TABLESPACE new_tablespace;
```

## Parameter Description

- **index_name**

  Specifies the index name to be modified.
- **new_name**

  Specifies the new name of the index.

  Value range: a string. It must comply with the naming convention rule.
- **tablespace_name**

  Specifies the tablespace name.

  Value range: an existing tablespace name

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- **storage_parameter**

  Specifies the name of an index-method-specific parameter.
- **value**

  Specifies the new value for an index-method-specific storage parameter. This might be a number or a word depending on the parameter.
- **new_index_partition_name**

  Specifies the new name of the index partition.
- **index_partition_name**

  Specifies the name of an index partition.
- **new_tablespace**

  Specifies a new tablespace.

### Examples

See **Examples** in **CREATE INDEX**.

### Helpful Links

**12.14.64 CREATE INDEX**, **12.14.108 DROP INDEX**, and **12.14.149 REINDEX**

## 12.14.14 ALTER LANGUAGE

This version does not support this syntax.

## 12.14.15 ALTER LARGE OBJECT

### Function

**ALTER LARGE OBJECT** changes the owner of a large object.

### Precautions

Only a system administrator or the owner of the to-be-modified large object can run **ALTER LARGE OBJECT**.

### Syntax

```
ALTER LARGE OBJECT large_object_oid
    OWNER TO new_owner;
```

### Parameter Description

- **large_object_oid**

  Specifies the OID of the large object to be modified.

  Value range: an existing large object name
- **OWNER TO new_owner**

  Specifies the new owner of the object.

  Value range: an existing username/role name

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## Examples

None

# 12.14.16 ALTER MASKING POLICY

## Function

**ALTER MASKING POLICY** modifies anonymization policies.

## Precautions

- Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.
- The masking policy takes effect only after **enable_security_policy** is set to **on**. For details about how to enable the masking policy, see "Database Configuration > Database Security Management Policies > Dynamic Data Masking" in the *Security Hardening Guide*.
- For details about the execution effect and supported data types of preset masking functions, see "Database Security > Dynamic Data Masking" in *Feature Description*.

## Syntax

- Modify the policy description.
```
ALTER MASKING POLICY policy_name COMMENTS policy_comments;
```
- Modify the anonymization method.
```
ALTER MASKING POLICY policy_name [ADD | REMOVE | MODIFY] masking_actions[, ...]*;
```
The syntax of **masking_action**.
```
    masking_function ON LABEL(label_name[, ...]*)
```
- Modify the scenarios where the anonymization policies take effect.
```
ALTER MASKING POLICY policy_name MODIFY(FILTER ON FILTER_TYPE(filter_value[, ...]*)[, ...]*);
```
- Removes the filters of the anonymization policies.
```
ALTER MASKING POLICY policy_name DROP FILTER;
```
- Enable or disable the anonymization policies.
```
ALTER MASKING POLICY policy_name [ENABLE | DISABLE];
```

## Parameter Description

- **policy_name**

  Specifies the anonymization policy name, which must be unique.

  Value range: a string. It must comply with the naming convention.

- **policy_comments**

  Adds or modifies description of anonymization policies.

- **masking_function**

  Specifies eight preset anonymization methods or user-defined functions. Schema is supported.

  **maskall** is not a preset function. It is hard-coded and cannot be displayed by running **\df**.

  The preset anonymization methods are as follows:

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```
maskall | randommasking | creditcardmasking | basicemailmasking | fullemailmasking |
shufflemasking | alldigitsmasking | regepmasking
```

- **label_name**

  Specifies the resource label name.

- **FILTER_TYPE**

  Specifies the types of information to be filtered by the policies: **IP**, **ROLES**, and **APP**.

- **filter_value**

  Indicates the detailed information to be filtered, such as the IP address, app name, and username.

- **ENABLE|DISABLE**

  Enables or disables the masking policy. If **ENABLE|DISABLE** is not specified, **ENABLE** is used by default.

## Examples

```
-- Create users dev_mask and bob_mask.
openGauss=# CREATE USER dev_mask PASSWORD 'dev@1234';
openGauss=# CREATE USER bob_mask PASSWORD 'bob@1234';

-- Create table tb_for_masking.
openGauss=# CREATE TABLE tb_for_masking(col1 text, col2 text, col3 text);

-- Create a resource label for label sensitive column col1.
openGauss=# CREATE RESOURCE LABEL mask_lb1 ADD COLUMN(tb_for_masking.col1);

-- Create a resource label for label sensitive column col2.
openGauss=# CREATE RESOURCE LABEL mask_lb2 ADD COLUMN(tb_for_masking.col2);

-- Create an anonymization policy for the operation of accessing sensitive column col1.
openGauss=# CREATE MASKING POLICY maskpol1 maskall ON LABEL(mask_lb1);

-- Add description for anonymization policy maskpol1.
openGauss=# ALTER MASKING POLICY maskpol1 COMMENTS 'masking policy for tb_for_masking.col1';

-- Modify anonymization policy maskpol1 to add an anonymization method.
openGauss=# ALTER MASKING POLICY maskpol1 ADD randommasking ON LABEL(mask_lb2);

-- Modify anonymization policy maskpol1 to remove an anonymization method.
openGauss=# ALTER MASKING POLICY maskpol1 REMOVE randommasking ON LABEL(mask_lb2);

-- Modify anonymization policy maskpol1 to modify an anonymization method.
openGauss=# ALTER MASKING POLICY maskpol1 MODIFY randommasking ON LABEL(mask_lb1);

-- Modify anonymization policy maskpol1 so that it takes effect only for scenarios where users are
dev_mask and bob_mask, client tools are psql and gsql, and the IP addresses are 10.20.30.40 and
127.0.0.0/24.
openGauss=# ALTER MASKING POLICY maskpol1 MODIFY (FILTER ON ROLES(dev_mask, bob_mask),
APP(psql, gsql), IP('10.20.30.40', '127.0.0.0/24'));

-- Modify anonymization policy maskpol1 so that it takes effect for all user scenarios.
openGauss=# ALTER MASKING POLICY maskpol1 DROP FILTER;

-- Disable anonymization policy maskpol1.
openGauss=# ALTER MASKING POLICY maskpol1 DISABLE;
```

## Helpful Links

5.1.13.14.59-CREATE MASKING POLICY and 5.1.13.14.96-DROP MASKING POLICY

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# 12.14.17 ALTER MATERIALIZED VIEW

## Function

**ALTER MATERIALIZED VIEW** changes multiple auxiliary attributes of an existing materialized view.

Statements and actions that can be used for **ALTER MATERIALIZED VIEW** are a subset of **ALTER TABLE** and have the same meaning when used for materialized views. For details, see **12.14.30 ALTER TABLE**.

## Precautions

- Only the owner of a materialized view or a system administrator has the **ALTER TMATERIALIZED VIEW** permission.
- The materialized view structure cannot be modified.

## Syntax

- Change the owner of a materialized view.
```
ALTER MATERIALIZED VIEW [ IF EXISTS ] mv_name
    OWNER TO new_owner;
```
- Modify the column of a materialized view.
```
ALTER MATERIALIZED VIEW [ IF EXISTS ] mv_name
    RENAME [ COLUMN ] column_name TO new_column_name;
```
- Rename a materialized view.
```
ALTER MATERIALIZED VIEW [ IF EXISTS ] mv_name
    RENAME TO new_name;
```

## Parameter Description

- **mv_name**

  Specifies the name of an existing materialized view, which can be schema-qualified.

  Value range: a string. It must comply with the naming convention.
- **column_name**

  Specifies the name of a new or existing column.

  Value range: a string. It must comply with the naming convention.
- **new_column_name**

  Specifies the new name of an existing column.
- **new_owner**

  Specifies the user name of the new owner of a materialized view.
- **new_name**

  Specifies the new name of a materialized view.

## Examples

```
-- Rename the materialized view foo to bar.
openGauss=# ALTER MATERIALIZED VIEW foo RENAME TO bar;
```

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### Helpful Links

12.14.63 CREATE INCREMENTAL MATERIALIZED VIEW, 12.14.67 CREATE MATERIALIZED VIEW, 12.14.111 DROP MATERIALIZED VIEW, 12.14.150 REFRESH INCREMENTAL MATERIALIZED VIEW, and 12.14.151 REFRESH MATERIALIZED VIEW

## 12.14.18 ALTER NODE

### Function

**ALTER NODE** modifies the definition of an existing node.

### Precautions

**ALTER NODE** is an interface of the cluster management tool and is used to manage clusters. Only administrators have the permission to use this interface. You are not advised to use this interface, because doing so affects the cluster.

### Syntax

```
ALTER NODE nodename WITH
  (
    [ TYPE = nodetype,]
    [ HOST = hostname,]
    [ PORT = portnum,]
    [ HOST1 = 'hostname',]
    [ PORT1 = portnum,]
    [ HOSTPRIMARY [ = boolean ],]
    [ PRIMARY [ = boolean ],]
    [ PREFERRED [ = boolean ],]
    [ SCTP_PORT = portnum,]
    [ CONTROL_PORT = portnum,]
    [ SCTP_PORT1 = portnum,]
    [ CONTROL_PORT1 = portnum, ]
    [ NODEIS_CENTRAL [ = boolean ]]
  );
```

NOTE

The port whose number is specified by **PORT** is used for internal communications between nodes. Unlike the port connecting to an external client, it can be queried in the **pgxc_node** table.

### Parameter Description

See **Parameter Description** in **CREATE NODE**.

### Helpful Links

12.14.69 CREATE NODE and 12.14.113 DROP NODE

## 12.14.19 ALTER NODE GROUP

### Function

**ALTER NODE GROUP** modifies the information about a node group.

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## Precautions

- Only the system administrator or a user who has the **ALTER** permission of a node group can modify the information about the node group.
- Node group modification is an internal operation of the system. Except **SET DEFAULT**, other operations must be performed in maintenance mode (by invoking **set xc_maintenance_mode=on;**).
- **ALTER NODE GROUP** can be used only within a database. To avoid data inconsistency in DBMS, do not manually run this SQL statement.

## Syntax

```
ALTER NODE GROUP groupname
   | SET DEFAULT
   | RENAME TO new_group_name
   | SET VCGROUP RENAME TO new_group_name
   | SET NOT VCGROUP
   | SET TABLE GROUP new_group_name
   | COPY BUCKETS FROM src_group_name
   | ADD NODE ( nodename [, ... ] )
   | DELETE NODE ( nodename [, ... ] )
   | RESIZE TO dest_group_name
   | SET VCGROUP WITH GROUP new_group_name
```

## Parameter Description

- **groupname**

  Specifies the name of the node group to be modified.

  Value range: a string. It must comply with the naming convention.

- **SET DEFAULT**

  Sets **in_redistribution** to **'y'** for all node groups excluding the one specified by **groupname**. To be compatible with earlier versions, this syntax is retained and does not need to be executed in maintenance mode.

- **RENAME TO new_group_name**

  Renames the node group specified by **groupname** to **new_group_name**.

- **SET VCGROUP RENAME TO new_group_name**

  Converts a physical cluster into a logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) After the conversion, **groupname** is the logical cluster name, and the original physical cluster name is changed to **new_group_name**.

- **SET NOT VCGROUP**

  Converts all logical clusters to common node groups and changes **group_kind** from **'v'** to **'n'** for all of them. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

- **SET TABLE GROUP new_group_name**

  Changes all the **group_names** in the **pgroup** columns of the **pgxc_class** tables on all CNs to **new_group_name**.

- **COPY BUCKETS FROM src_group_name**

  Copies values in the **group_members** and **group_buckets** columns from the node group specified by **src_group_name** to the node group specified by **groupname**.

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- **ADD NODE ( nodename [, ... ] )**

  Adds nodes from the node group specified by **groupname**. After the statement execution, the new nodes are registered with the **15.2.107 PGXC_NODE** system catalog. This statement only modifies the system catalog and does not add nodes or redistribute data. Do not invoke this statement.

- **DELETE NODE ( nodename [, ... ] )**

  Deletes nodes from the node group specified by **groupname**. The deleted nodes still exist in the **15.2.107 PGXC_NODE** system catalog. This statement only modifies the system catalog and does not delete nodes or redistribute data. Do not invoke this statement.

- **RESIZE TO dest_group_name**

  Specifies a resize flag for the cluster. Set **groupname** to the source node group before data redistribution and **is_installation** of the node group to **FALSE**. Set **desst_group_name** to the destination node group and **is_installation** of the node group to **TRUE**.

- **SET VCGROUP WITH GROUP new_group_name**

  Converts a physical cluster into a logical cluster. After the conversion, **groupname** is still the physical cluster, and **new_group_name** is the name of the logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

# 12.14.20 ALTER RESOURCE LABEL

## Function

**ALTER RESOURCE LABEL** modifies resource labels.

## Precautions

Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.

## Syntax

```
ALTER RESOURCE LABEL label_name (ADD|REMOVE)
  label_item_list[, ...]*;
```

- label_item_list
  ```
  resource_type(resource_path[, ...]*)
  ```
- resource_type
  ```
  TABLE | COLUMN | SCHEMA | VIEW | FUNCTION
  ```

## Parameter Description

- **label_name**

  Specifies the resource label name.

  Value range: a string. It must comply with the naming convention.

- **resource_type**

  Specifies the type of database resources to be labeled.

- **resource_path**

  Specifies the path of database resources.

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## Examples

```
-- Create basic table table_for_label.
openGauss=# CREATE TABLE table_for_label(col1 int, col2 text);

-- Create resource label table_label.
openGauss=# CREATE RESOURCE LABEL table_label ADD COLUMN(table_for_label.col1);

-- Attach resource label table_label to col2.
openGauss=# ALTER RESOURCE LABEL table_label ADD COLUMN(table_for_label.col2)

-- Remove table_label from an item.
openGauss=# ALTER RESOURCE LABEL table_label REMOVE COLUMN(table_for_label.col1);
```

## Helpful Links

5.1.13.14.61-CREATE RESOURCE LABEL and 5.1.13.14.102-DROP RESOURCE LABEL

# 12.14.21 ALTER RESOURCE POOL

The current feature is a lab feature. Contact Huawei technical support before using it.

## Function

**ALTER RESOURCE POOL** changes the Cgroup of a resource pool.

## Precautions

Only a user with the **ALTER** permission on the current database can perform this operation.

## Syntax

```
ALTER RESOURCE POOL pool_name
    WITH ({MEM_PERCENT= pct | CONTROL_GROUP="group_name" | ACTIVE_STATEMENTS=stmt |
MAX_DOP = dop | MEMORY_LIMIT='memory_size' | io_limits=io_limits | io_priority='io_priority'}[, ... ]);
```

## Parameter Description

- **pool_name**

  Specifies the name of a resource pool.

  The resource pool must already exist.

  Value range: a string. It must comply with the naming convention.

- **group_name**

  Specifies the name of a Cgroup.

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NOTE

- You can use either double quotation marks ("") or single quotation marks (') in the syntax when setting the name of a Cgroup.
- The value of **group_name** is case-sensitive.
- If **group_name** is not specified, the string "Medium" will be used by default in the syntax, indicating the **Medium** Timeshare Cgroup under **DefaultClass**.
- If an administrator specifies a Workload Cgroup under Class, for example, **control_group** set to **class1:workload1**, the resource pool will be associated with the **workload1** Cgroup under **class1**. The level of **Workload** can also be specified. For example, **control_group** is set to **class1:workload1:1**.
- If a database user specifies the Timeshare string (**Rush**, **High**, **Medium**, or **Low**) in the syntax, for example, **control_group** is set to **High**, the resource pool will be associated with the **High** Timeshare Cgroup under **DefaultClass**.
- In multi-tenant scenarios, the Cgroup associated with a group resource pool is a Class Cgroup, and that associated with a service resource pool is a Workload Cgroup. Additionally, switching Cgroups between different resource pools is not allowed.

Value range: an existing Cgroup.

- **stmt**

  Specifies the maximum number of statements that can be concurrently executed in a resource pool.

  Value range: numeric data ranging from –1 to 2147483647

- **dop**

  Specifies the maximum statement concurrency degree for a resource pool, equivalent to the number of threads that can be created for executing a statement.

  Value range: numeric data ranging from 1 to 2147483647

- **memory_size**

  Specifies the maximum memory size of a resource pool.

  Value range: a string from 1 KB to 2047 GB

- **mem_percent**

  Specifies the proportion of available resource pool memory to the total memory or group user memory.

  In multi-tenant scenarios, **mem_percent** of group users or service users ranges from 1 to 100. The default value is **20**.

  In common scenarios, **mem_percent** of common users is an integer ranging from 0 to 100. The default value is **0**.

  NOTE

  When both of **mem_percent** and **memory_limit** are specified, only **mem_percent** takes effect.

- **io_limits**

  Specifies the upper limit of IOPS in a resource pool.

  Row-store is measured by 10,000 IOPS, while column-store is measured by IOPS.

- **io_priority**

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Specifies the I/O priority for jobs that consume many I/O resources. It takes effect when the I/O usage reaches 90%.

There are three priorities: **Low**, **Medium**, and **High**. If you do not want to control I/O resources, set this parameter to **None**, which is the default value.

NOTE

The settings of **io_limits** and **io_priority** are valid only for complex jobs, such as batch import (using **INSERT INTO SELECT**, **COPY FROM**, or **CREATE TABLE AS**), complex queries involving over 500 MB data on each DN, and **VACUUM FULL**.

## Examples

The following example assumes that the user has created the **class1** Cgroup and three Workload Cgroups under **class1**: **Low**, **wg1**, and **wg2**.

```
-- Create a resource pool.
openGauss=# CREATE RESOURCE POOL pool1;

-- Specify the High Timeshare Workload Cgroup under the DefaultClass Cgroup.
openGauss=# ALTER RESOURCE POOL pool1 WITH (CONTROL_GROUP="High");

-- Specify the Low Timeshare Workload Cgroup under the class1 Cgroup.
openGauss=# ALTER RESOURCE POOL pool1 WITH (CONTROL_GROUP="class1:Low");

-- Specify the wg1 Workload Cgroup under the class1 Cgroup.
openGauss=# ALTER RESOURCE POOL pool1 WITH (CONTROL_GROUP="class1:wg1");

-- Specify the wg2 Workload Cgroup under the class1 Cgroup.
openGauss=# ALTER RESOURCE POOL pool1 WITH (CONTROL_GROUP="class1:wg2:3");
-- Delete the resource pool pool1.
openGauss=# DROP RESOURCE POOL pool1;
```

## Helpful Links

12.14.73 CREATE RESOURCE POOL and 12.14.118 DROP RESOURCE POOL

# 12.14.22 ALTER ROLE

## Function

**ALTER ROLE** modifies role attributes.

## Precautions

None

## Syntax

- Modify the permissions of a role.

  ```
  ALTER ROLE role_name [ [ WITH ] option [ ... ] ];
  ```

  The **option** clause for granting permissions is as follows:

  ```
  {CREATEDB | NOCREATEDB}
    | {CREATEROLE | NOCREATEROLE}
    | {INHERIT | NOINHERIT}
    | {AUDITADMIN | NOAUDITADMIN}
    | {SYSADMIN | NOSYSADMIN}
    | {MONADMIN | NOMONADMIN}
    | {OPRADMIN | NOOPRADMIN}
  ```

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```
    | {POLADMIN | NOPOLADMIN}
    | {USEFT | NOUSEFT}
    | {LOGIN | NOLOGIN}
    | {REPLICATION | NOREPLICATION}
    | {INDEPENDENT | NOINDEPENDENT}
    | {VCADMIN | NOVCADMIN}
    | {PERSISTENCE | NOPERSISTENCE}
    | CONNECTION LIMIT connlimit
    | [ ENCRYPTED | UNENCRYPTED ] PASSWORD 'password'[EXPIRED]
    | [ ENCRYPTED | UNENCRYPTED ] IDENTIFIED BY 'password' [ REPLACE 'old_password' | EXPIRED ]
    | [ ENCRYPTED | UNENCRYPTED ] PASSWORD { 'password' | DISABLE | EXPIRED }
    | [ ENCRYPTED | UNENCRYPTED ] IDENTIFIED BY { 'password' [ REPLACE 'old_password' ] |
DISABLE }
    | VALID BEGIN 'timestamp'
    | VALID UNTIL 'timestamp'
    | RESOURCE POOL 'respool'
    | USER GROUP 'groupuser'
    | PERM SPACE 'spacelimit'
    | TEMP SPACE 'tmpspacelimit'
    | SPILL SPACE 'spillspacelimit'
    | NODE GROUP logic_cluster_name
    | PGUSER
```

- Rename a role.

```
ALTER ROLE role_name
    RENAME TO new_name;
```

- Lock or unlock.

```
ALTER ROLE role_name
    ACCOUNT { LOCK | UNLOCK };
```

- Set parameters for a role.

```
ALTER ROLE role_name [ IN DATABASE database_name ]
    SET configuration_parameter {{ TO | = } { value | DEFAULT } | FROM CURRENT};
```

- Reset parameters for a role.

```
ALTER ROLE role_name
    [ IN DATABASE database_name ] RESET {configuration_parameter|ALL};
```

## Parameter Description

- **role_name**

  Specifies a role name.

  **Value range**: an existing role name. If a role name contains uppercase letters, enclose the name with double quotation marks ("").

- **IN DATABASE database_name**

  Modifies the parameters of a role in a specified database.

- **SET configuration_parameter**

  Sets parameters for a role. Session parameters modified by **ALTER ROLE** apply to a specified role and take effect in the next session triggered by the role.

  **NOTICE**

  The current version does not support setting user-level parameters.

  Value range:

  For details about the values of **configuration_parameter** and **value**, see **12.14.161 SET**.

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**DEFAULT**: clears the value of **configuration_parameter**. **configuration_parameter** will inherit the default value of the new session generated for the role.

**FROM CURRENT**: uses the value of **configuration_parameter** of the current session.

- **RESET configuration_parameter/ALL**

  Clears the value of **configuration_parameter**. The statement has the same effect as that of **SET configuration_parameter TO DEFAULT**.

  **NOTICE**

  The current version does not support the resetting of user-level parameters.

  Value range: **ALL** indicates that the values of all parameters are cleared.

- **ACCOUNT LOCK | ACCOUNT UNLOCK**
  - **ACCOUNT LOCK**: locks an account to prevent it from logging in to the database.
  - **ACCOUNT UNLOCK**: unlocks an account and allows the account to log in to the database.
- **PGUSER**

  In the current version, the **PGUSER** permission of a role cannot be modified.
- **PASSWORD/IDENTIFIED BY** 'password'

  Resets or changes the user password. Except the initial user, other administrators and common users need to enter the correct old password when changing their own passwords. Only the initial user, the system administrator (**sysadmin**), or users who have the permission to create users (**CREATEROLE**) can reset the password of a common user without entering the old password. The initial user can reset passwords of system administrators. System administrators cannot reset passwords of other system administrators.
- **EXPIRED**

  Invalidates the password. Only initial users, system administrators (**sysadmin**), and users who have the permission to create users (**CREATEROLE**) can invalidate user passwords. System administrators can invalidate their own passwords or the passwords of other system administrators. The password of the initial user cannot be invalidated.

  The user whose password is invalid can log in to the database but cannot perform the query operation. The query operation can be performed only after the password is changed or the administrator resets the password.

For details about other parameters, see **Parameter Description** in **CREATE ROLE**.

## Examples

See **Examples** in **CREATE ROLE**.

## Helpful Links

**12.14.74 CREATE ROLE**, **12.14.119 DROP ROLE**, and **12.14.161 SET**

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# 12.14.23 ALTER ROW LEVEL SECURITY POLICY

## Function

**ALTER ROW LEVEL SECURITY POLICY** modifies an existing row-level access control policy, including the policy name and the users and expressions affected by the policy.

## Precautions

Only the table owner or a system administrator can perform this operation.

## Syntax

```
ALTER [ ROW LEVEL SECURITY ] POLICY [ IF EXISTS ] policy_name ON table_name RENAME TO
new_policy_name;

ALTER [ ROW LEVEL SECURITY ] POLICY policy_name ON table_name
    [ TO { role_name | PUBLIC } [, ...] ]
    [ USING ( using_expression ) ];
```

## Parameter Description

- policy_name

  Specifies the name of a row-level access control policy.

- table_name

  Specifies the name of a table to which a row-level access control policy is applied.

- new_policy_name

  Specifies the new name of a row-level access control policy.

- role_name

  Specifies names of users affected by a row-level access control policy. PUBLIC indicates that the row-level access control policy will affect all users.

- using_expression

  Specifies an expression defined for a row-level access control policy. The return value is of the Boolean type.

## Examples

```
-- Create the all_data data sheet.
openGauss=# CREATE TABLE all_data(id int, role varchar(100), data varchar(100));

-- Create a row-level access control policy to specify that the current user can view only their own data.
openGauss=# CREATE ROW LEVEL SECURITY POLICY all_data_rls ON all_data USING(role =
CURRENT_USER);
openGauss=# \d+ all_data
                        Table "public.all_data"
 Column |          Type          | Modifiers | Storage  | Stats target | Description
--------+------------------------+-----------+----------+--------------+-------------
 id     | integer                |           | plain    |              |
 role   | character varying(100) |           | extended |              |
 data   | character varying(100) |           | extended |              |
Row Level Security Policies:
    POLICY "all_data_rls"
      USING (((role)::name = "current_user"()))
Has OIDs: no
```

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```
Distribute By: HASH(id)
Location Nodes: ALL DATANODES
Options: orientation=row, compression=no

-- Change the name of the all_data_rls policy.
openGauss=# ALTER ROW LEVEL SECURITY POLICY all_data_rls ON all_data RENAME TO all_data_new_rls;

-- Change the users affected by the row-level access control policy.
openGauss=# ALTER ROW LEVEL SECURITY POLICY all_data_new_rls ON all_data TO alice, bob;
openGauss=# \d+ all_data
                        Table "public.all_data"
 Column |         Type          | Modifiers | Storage  | Stats target | Description
--------+-----------------------+-----------+----------+--------------+-------------
 id     | integer               |           | plain    |              |
 role   | character varying(100) |          | extended |              |
 data   | character varying(100) |          | extended |              |
Row Level Security Policies:
    POLICY "all_data_new_rls"
      TO alice,bob
      USING (((role)::name = "current_user"()))
Has OIDs: no
Distribute By: HASH(id)
Location Nodes: ALL DATANODES
Options: orientation=row, compression=no, enable_rowsecurity=true

-- Modify the expression defined for the access control policy.
openGauss=# ALTER ROW LEVEL SECURITY POLICY all_data_new_rls ON all_data USING (id > 100 AND role
= current_user);
openGauss=# \d+ all_data
                        Table "public.all_data"
 Column |         Type          | Modifiers | Storage  | Stats target | Description
--------+-----------------------+-----------+----------+--------------+-------------
 id     | integer               |           | plain    |              |
 role   | character varying(100) |          | extended |              |
 data   | character varying(100) |          | extended |              |
Row Level Security Policies:
    POLICY "all_data_new_rls"
      TO alice,bob
      USING (((id > 100) AND ((role)::name = "current_user"())))
Has OIDs: no
Distribute By: HASH(id)
Location Nodes: ALL DATANODES
Options: orientation=row, compression=no, enable_rowsecurity=true
```

## Helpful Links

**12.14.75 CREATE ROW LEVEL SECURITY POLICY** and **12.14.120 DROP ROW LEVEL SECURITY POLICY**

# 12.14.24 ALTER SCHEMA

## Function

**ALTER SCHEMA** alters the attributes of a schema.

## Precautions

Only the owner of a schema or users granted with the ALTER permission on the schema can run the **ALTER SCHEMA** command. The system administrator has this permission by default. To modify a schema owner, you must be the schema owner or system administrator and a member of the new owner role.

Only the initial user is allowed to change the owner of the **pg_catalog** system schema. Changing the names of the built-in schemas of the system may make

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some functions unavailable or even affect the normal running of the database. By default, the names of the built-in schemas of the system cannot be changed. To ensure forward compatibility, you can change the names of the built-in schemas only when the system is being started or upgraded or when **allow_system_table_mods** is set to **on**.

## Syntax

- Modify the tamper-proof attribute of a schema.
  ```
  ALTER SCHEMA schema_name { WITH | WITHOUT } BLOCKCHAIN
  ```
- Rename a schema.
  ```
  ALTER SCHEMA schema_name
    RENAME TO new_name;
  ```
- Change the owner of a schema.
  ```
  ALTER SCHEMA schema_name
    OWNER TO new_owner;
  ```

## Parameter Description

- **schema_name**

  Specifies the name of an existing schema.

  Value range: an existing schema name

- **RENAME TO new_name**

  Rename a schema.

  **new_name**: new name of the schema.

  Value range: a string. It must comply with the identifier naming convention.

- **OWNER TO new_owner**

  Change the owner of a schema. To do this as a non-administrator, you must be a direct or indirect member of the new owning role, and that role must have the CREATE permission on the database.

  **new_owner**: new owner of the schema.

  Value range: an existing username or role name.

- **{ WITH | WITHOUT } BLOCKCHAIN**

  Modify the tamper-proof attribute of a schema. Common row-store tables with the tamper-proof attribute are tamper-proof history tables, excluding foreign tables, temporary tables, and system catalogs. The tamper-proof attribute can be modified only when no table is contained in the schema. The tamper-proof attribute of the **toast table** schema, **dbe_perf** schema, and **blockchain** schema cannot be modified. This syntax can be used to convert between normal and tamper-proof modes only if the schema does not contain any tables.

## Examples

```
-- Create the ds schema.
openGauss=# CREATE SCHEMA ds;

-- Rename the current schema ds to ds_new.
openGauss=# ALTER SCHEMA ds RENAME TO ds_new;

-- Create user jack.
openGauss=# CREATE USER jack PASSWORD 'xxxxxxxxxx';
```

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```
-- Change the owner of ds_new to jack.
openGauss=# ALTER SCHEMA ds_new OWNER TO jack;

-- Modify the tamper-proof attribute of ds_new.
openGauss=# ALTER SCHEMA ds_new WITH BLOCKCHAIN;

-- Delete user jack and schema ds_new.
openGauss=# DROP SCHEMA ds_new;
openGauss=# DROP USER jack;
```

## Helpful Links

12.14.76 CREATE SCHEMA and 12.14.121 DROP SCHEMA

# 12.14.25 ALTER SEQUENCE

## Function

**ALTER SEQUENCE** modifies the parameters of an existing sequence.

## Precautions

- Only the sequence owner or a user granted with the ALTER permission can run the **ALTER SEQUENCE** command. The system administrator has this permission by default. To modify a sequence owner, you must be the sequence owner or system administrator and a member of the new owner role.
- In the current version, you can modify only the owner, owning column, and maximum value. To modify other parameters, delete the sequence and create it again. Then, use the **Setval** function to restore parameter values.
- **ALTER SEQUENCE MAXVALUE** cannot be used in transactions, functions, and stored procedures.
- After the maximum value of a sequence is changed, the cache of the sequence in all sessions is cleared.
- The **ALTER SEQUENCE** statement blocks the invoking of **nextval**, **setval**, **currval**, and **lastval**.

## Syntax

Change the owning column of a sequence.

```
ALTER SEQUENCE [ IF EXISTS ] name
    [MAXVALUE maxvalue | NO MAXVALUE | NOMAXVALUE]
    [ OWNED BY { table_name.column_name | NONE } ] ;
```

Change the owner of a sequence.

```
ALTER SEQUENCE [ IF EXISTS ] name OWNER TO new_owner;
```

## Parameter Description

- name

  Specifies the name of the sequence to be modified.

- IF EXISTS

  Sends a notice instead of an error when you are modifying a nonexisting sequence.

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- OWNED BY

  Associates a sequence with a specified column included in a table. In this way, the sequence will be deleted when you delete its associated column or the table where the column belongs to.

  If the sequence has been associated with another table before you use this option, the new association will overwrite the old one.

  The associated table and sequence must be owned by the same user and in the same schema.

  If **OWNED BY NONE** is used, all existing associations will be deleted.

- new_owner

  Specifies the username of the new owner of the sequence. To change the owner, you must also be a direct or indirect member of the new role, and this role must have **CREATE** permission on the sequence's schema.

## Examples

```
-- Create an ascending sequence named serial, which starts from 101.
openGauss=# CREATE SEQUENCE serial START 101;

-- Create a table and specify default values for the sequence.
openGauss=# CREATE TABLE T1(C1 bigint default nextval('serial'));

-- Change the owning column of serial to T1.C1.
openGauss=# ALTER SEQUENCE serial OWNED BY T1.C1;

-- Delete the sequence.
openGauss=# DROP SEQUENCE serial cascade;
openGauss=# DROP TABLE T1;
```

## Helpful Links

**12.14.77 CREATE SEQUENCE** and **12.14.122 DROP SEQUENCE**

# 12.14.26 ALTER SERVER

## Function

**ALTER SERVER** adds, modifies, or deletes the parameters of an existing server. You can query existing servers from the **pg_foreign_server** system catalog. The current feature is a lab feature. Contact Huawei technical support before using it.

## Precautions

Only the server owner or a user granted with the ALTER permission can run the **ALTER SERVER** command. The system administrator has this permission by default. To change the owner of a server, the current user must be the owner of the server or the system administrator, and the user must be a member of the new owner role.

When multi-layer quotation marks are used for sensitive columns (such as **password** and **secret_access_key**) in OPTIONS, the semantics is different from that in the scenario where quotation marks are not used. Therefore, sensitive columns are not identified for anonymization.

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## Syntax

- Change the parameters for a foreign server.

```
ALTER SERVER server_name [ VERSION 'new_version' ]
    [ OPTIONS ( {[ ADD | SET | DROP ] option ['value']} [, ... ] ) ];
```

In **OPTIONS**, **ADD**, **SET**, and **DROP** are operations to be performed. If these operations are not specified, **ADD** operations will be performed by default. **option** and **value** are the parameters of the corresponding operation.

- Change the owner of a foreign server.

```
ALTER SERVER server_name
    OWNER TO new_owner;
```

- Change the name of a foreign server.

```
ALTER SERVER server_name
    RENAME TO new_name;
```

## Parameter Description

The parameters for modifying the server are as follows:

- **server_name**

  Specifies the name of the server to be modified.

- **new_version**

  Specifies the new version of the server.

- The server parameters in **OPTIONS** are as follows:
  - **encrypt**

    Specifies whether to encrypt data. This parameter can be set only when **type** is set to **OBS**. The default value is **off**.

    Value range:

    - **on** indicates that data is encrypted.
    - **off** indicates that data is not encrypted.

  - **access_key**

    Specifies the access key (AK) (obtained by users from the OBS console) used for the OBS access protocol. When you create a foreign table, the AK value is encrypted and saved to the metadata table of the database. This parameter is available only when **type** is set to **OBS**.

  - **secret_access_key**

    Specifies the SK value (obtained by users from the OBS console) used for the OBS access protocol. When you create a foreign table, the SK value is encrypted and saved to the metadata table of the database. This parameter is available only when **type** is set to **OBS**.

- **new_owner**

  Specifies the new owner of the server. To change the owner, you must be the owner of the foreign server and a direct or indirect member of the new owner role, and must have the **USAGE** permission on the encapsulator of the foreign server.

- **new_name**

  Specifies the new name of the server.

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## Helpful Links

12.14.78 CREATE SERVER, 12.14.78 CREATE SERVER

# 12.14.27 ALTER SESSION

## Function

**ALTER SESSION** defines or modifies the conditions or parameters that affect the current session. Modified session parameters are kept until the current session is disconnected.

## Precautions

- If the **START TRANSACTION** statement is not executed before the **SET TRANSACTION** statement, the transaction is ended instantly and the statement does not take effect.
- You can use the **transaction_mode(s)** method declared in the **START TRANSACTION** statement to avoid using the **SET TRANSACTION** statement.

## Syntax

- Set transaction parameters of a session.

```
ALTER SESSION SET [ SESSION CHARACTERISTICS AS ] TRANSACTION
   { ISOLATION LEVEL { READ COMMITTED | READ UNCOMMITTED } | { READ ONLY  | READ
WRITE } } [, ...] ;
```

- Set other running parameters of a session.

```
ALTER SESSION SET
   {{config_parameter { { TO  | =  }  { value | DEFAULT }
     | FROM CURRENT }} | CURRENT_SCHEMA [ TO | = ] { schema | DEFAULT }
     | TIME ZONE time_zone
     | SCHEMA schema
     | NAMES encoding_name
     | ROLE role_name PASSWORD 'password'
     | SESSION AUTHORIZATION { role_name PASSWORD 'password' | DEFAULT }
     | XML OPTION { DOCUMENT | CONTENT }
   } ;
```

## Parameter Description

For details about the descriptions of parameters related to **ALTER SESSION**, see **Parameter Description** of the SET syntax.

## Examples

```
-- Create the ds schema.
openGauss=# CREATE SCHEMA ds;

-- Set the search path of a schema.
openGauss=# SET SEARCH_PATH TO ds, public;

-- Set the time/date type to the traditional postgres format (date before month).
openGauss=# SET DATESTYLE TO postgres, dmy;

-- Set the character code of the current session to UTF8.
openGauss=# ALTER SESSION SET NAMES 'UTF8';

-- Set the time zone to Berkeley of California.
openGauss=# SET TIME ZONE 'PST8PDT';
```

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```
-- Set the time zone to Italy.
openGauss=# SET TIME ZONE 'Europe/Rome';

-- Set the current schema.
openGauss=# ALTER SESSION SET CURRENT_SCHEMA TO tpcds;

-- Set XML OPTION to DOCUMENT.
openGauss=# ALTER SESSION SET XML OPTION DOCUMENT;

-- Create the role joe, and set the session role to joe.
openGauss=# CREATE ROLE joe WITH PASSWORD 'xxxxxxxxxx';
openGauss=# ALTER SESSION SET SESSION AUTHORIZATION joe PASSWORD 'xxxxxxxxxxx';

-- Switch to the default user.
openGauss=> ALTER SESSION SET SESSION AUTHORIZATION default;

-- Delete the ds schema.
openGauss=# DROP SCHEMA ds;

-- Delete the role joe.
openGauss=# DROP ROLE joe;
```

## Helpful Links

12.14.161 SET

# 12.14.28 ALTER SYNONYM

## Function

**ALTER SYNONYM** modifies the attributes of the **SYNONYM** object.

## Precautions

- Currently, only the owner of the **SYNONYM** object can be changed.
- Only the system administrator has the permission to modify the owner of the **SYNONYM** object.
- The new owner must have the **CREATE** permission on the schema where the **SYNONYM** object resides.

## Syntax

```
ALTER SYNONYM synonym_name
    OWNER TO new_owner;
```

## Parameter Description

- **synonym**

  Specifies the name of the synonym to be modified, which can contain the schema name.

  Value range: a string. It must comply with the naming convention.

- **new_owner**

  Specifies the new owner of the **SYNONYM** object.

  Value range: a string. It must be a valid username.

## Examples

```
-- Create synonym t1.
openGauss=#  CREATE OR REPLACE SYNONYM t1 FOR ot.t1;
```

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```
-- Create a user u1.
openGauss=# CREATE USER u1 PASSWORD 'user@111';

-- Change the owner of synonym t1 to u1.
openGauss=# ALTER SYNONYM t1 OWNER TO u1;

-- Delete synonym t1.
openGauss=# DROP SYNONYM t1;

-- Delete user u1.
openGauss=# DROP USER u1;
```

## Helpful Links

12.14.79 CREATE SYNONYM and 12.14.124 DROP SYNONYM

# 12.14.29 ALTER SYSTEM KILL SESSION

## Function

**ALTER SYSTEM KILL SESSION** ends a session.

## Precautions

None

## Syntax

```
ALTER SYSTEM KILL SESSION 'session_sid, serial' [ IMMEDIATE ];
```

## Parameter Description

- **session_sid, serial**

  Specifies **SID** and **SERIAL** of a session (see examples for format).

  Value range: **SID** and **SERIAL** of all sessions that can be queried from the system catalog **dv_sessions**

- **IMMEDIATE**

  Specifies that a session will be ended instantly after the statement is executed.

## Examples

```
-- Query session information.
openGauss=# SELECT sid,serial#,username FROM dv_sessions;

       sid       | serial# | username
-----------------+---------+----------
 140131075880720 |       0 | omm
 140131025549072 |       0 | omm
 140131073779472 |       0 | omm
 140131071678224 |       0 | omm
 140131125774096 |       0 |
 140131127875344 |       0 |
 140131113629456 |       0 |
 140131094742800 |       0 |
(8 rows)

-- End the session whose SID is 140131075880720.
openGauss=#  ALTER SYSTEM KILL SESSION '140131075880720,0' IMMEDIATE;
```

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# 12.14.30 ALTER TABLE

## Function

**ALTER TABLE** modifies tables, including modifying table definitions, renaming tables, renaming specified columns in tables, renaming table constraints, setting table schemas, enabling or disabling row-level access control, and adding or updating multiple columns.

## Precautions

- The owner of a table, users granted with the ALTER permission on the table, or users granted with the ALTER ANY TABLE permission can run the **ALTER TABLE** command. The system administrator has the permission to run the command by default. To modify the owner or schema of a table, you must be a table owner or system administrator and a member of the new owner role.
- The tablespace of a partitioned table cannot be modified, but the tablespace of the partition can be modified.
- The storage parameter **ORIENTATION** cannot be modified.
- Currently, SET SCHEMA can only set schemas to user schemas. It cannot set a schema to a system internal schema.
- The distribution key (or column) of a table cannot be modified.
- Column-store tables support only PARTIAL CLUSTER KEY table-level constraints, but do not support primary and foreign key table-level constraints.
- In a column-store table, you can perform ADD COLUMN, ALTER TYPE, SET STATISTICS, DROP COLUMN operations, and change table name and space. The types of new and modified columns should be the **12.3 Data Type** supported by column-store. The **USING** option of **ALTER TYPE** only supports constant expression and expression involved in the column.
- The column constraints supported by column-store tables include **NULL**, **NOT NULL**, and **DEFAULT** constant values. Only the **DEFAULT** value can be modified (by SET DEFAULT or DROP DEFAULT). Currently, **NULL** and **NOT NULL** constraints cannot be modified.
- Auto-increment columns cannot be added, or a column whose **DEFAULT** value contains the nextval() expression cannot be added.
- Row access control cannot be enabled for foreign tables and temporary tables.
- When you delete a PRIMARY KEY constraint by constraint name, the NOT NULL constraint is not deleted. If necessary, manually delete the NOT NULL constraint.
- When JDBC is used, the **DEFAULT** value can be set through **PrepareStatement**.
- If you add a column using **ADD COLUMN**, all existing rows in the table are initialized to the column's default value (**NULL** if no DEFAULT clause is specified).

  If no DEFAULT value is specified for the new column, **NULL** is used, and no full table update is triggered.

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If the new column has a DEFAULT value, the column must meet all the following requirements. Otherwise, the entire table is updated, leading to additional overheads and affecting online services.

1. The data type is BOOL, BYTEA, SMALLINT, BIGINT, SMALLINT, INTEGER, NUMERIC, FLOAT, DOUBLE PRECISION, CHAR, VARCHAR, TEXT, TIMESTAMPTZ, TIMESTAMP, DATE, TIME, TIMETZ, or INTERVAL.

2. The length of the DEFAULT value of the added column cannot exceed 128 bytes.

3. The DEFAULT value of the added column does not contain the volatile function.

4. The DEFAULT value is required and cannot be NULL.

If you are not sure whether condition 3 is met, check whether the **provolatile** attribute of the function in the PG_RPOC system catalog is **'v'**.

## Syntax

- Modify the definition of a table.

```
ALTER TABLE [ IF EXISTS ] { table_name [*] | ONLY table_name | ONLY ( table_name ) }
    action [, ... ];
```

The **action** can be one of the following clauses:

```
column_clause
    | ADD table_constraint [ NOT VALID ]
    | ADD table_constraint_using_index
    | VALIDATE CONSTRAINT constraint_name
    | DROP CONSTRAINT [ IF EXISTS ]  constraint_name [ RESTRICT | CASCADE ]
    | CLUSTER ON index_name
    | SET WITHOUT CLUSTER
    | SET ( {storage_parameter = value} [, ... ] )
    | RESET ( storage_parameter [, ... ] )
    | OWNER TO new_owner
    | SET TABLESPACE new_tablespace
    | SET {COMPRESS|NOCOMPRESS}
    | TO { GROUP groupname | NODE ( nodename [, ... ] ) }
    | ADD NODE ( nodename [, ... ] )
    | DELETE NODE ( nodename [, ... ] )
    | UPDATE SLICE LIKE table_name
    | DISABLE TRIGGER [ trigger_name | ALL | USER ]
    | ENABLE TRIGGER [ trigger_name | ALL | USER ]
    | ENABLE REPLICA TRIGGER trigger_name
    | ENABLE ALWAYS TRIGGER trigger_name
    | DISABLE/ENABLE [ REPLICA | ALWAYS ] RULE
    | DISABLE ROW LEVEL SECURITY
    | ENABLE ROW LEVEL SECURITY
    | FORCE ROW LEVEL SECURITY
    | NO FORCE ROW LEVEL SECURITY
    | ENCRYPTION KEY ROTATION
    | INHERIT parent_table
    | NO INHERIT parent_table
    | DISTRIBUTE BY { REPLICATION | { [ HASH ] ( column_name ) } }
    | OF type_name
    | NOT OF
    | REPLICA IDENTITY { DEFAULT | USING INDEX index_name | FULL | NOTHING }
```

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NOTE

- **ADD table_constraint [ NOT VALID ]**

  Adds a table constraint.

- **ADD table_constraint_using_index**

  Adds a primary key constraint or unique constraint to a table based on the existing unique index.

- **VALIDATE CONSTRAINT constraint_name**

  Validates a foreign key or a check-class constraint created with the **NOT VALID** option, and scans the entire table to ensure that all rows meet the constraint. Nothing happens if the constraint is already marked valid.

- **DROP CONSTRAINT [ IF EXISTS ] constraint_name [ RESTRICT | CASCADE ]**

  Drops a table constraint.

- **CLUSTER ON index_name**

  Selects the default index for future CLUSTER operations. Actually, the table is not re-clustered.

- **SET WITHOUT CLUSTER**

  Deletes the most recently used CLUSTER index from the table. This affects future CLUSTER operations that do not specify an index.

- **SET ( {storage_parameter = value} [, ... ] )**

  Changes one or more storage parameters for the table.

- **RESET ( storage_parameter [, ... ] )**

  Resets one or more storage parameters to their defaults. As with **SET**, a table rewrite might be needed to update the table entirely.

- **OWNER TO new_owner**

  Changes the owner of a table, sequence, or view to the specified user.

- **SET TABLESPACE new_tablespace**

  Changes the table's tablespace to the specified tablespace and moves the data files associated with the table to the new tablespace. Indexes on the table, if any, are not moved; but they can be moved separately with additional **SET TABLESPACE** option in ALTER INDEX.

- **SET {COMPRESS|NOCOMPRESS}**

  Sets the compression feature of a table. The table compression feature affects only the storage mode of data inserted in a batch subsequently and does not affect storage of existing data. Setting the table compression feature will result in the fact that there are both compressed and uncompressed data in the table. Row-store tables do not support compression.

- **TO { GROUP groupname | NODE ( nodename [, ... ] ) }**

  The syntax is only available in extended mode (when GUC parameter **support_extended_features** is **on**). Exercise caution when enabling the mode. It is mainly used for tools like internal dilatation tools. Common users should not use the mode. This command only modifies the logical mapping relationship of the table distribution nodes and does not migrate the table's metadata and data on the DN.

- **ADD NODE ( nodename [, ... ] )**

  It is only available for internal scale-out tools. Common users should not use the syntax.

- **DELETE NODE ( nodename [, ... ] )**

  It is only available for internal scale-in tools. Common users should not use the syntax.

- **UPDATE SLICE LIKE table_name**

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This syntax is used by internal scaling tools and cannot be used by common users.

- **DISABLE TRIGGER [ trigger_name | ALL | USER ]**

  Disables a single trigger specified by **trigger_name**, disables all triggers, or disables only user triggers (excluding internally generated constraint triggers, for example, deferrable unique constraint triggers and exclusion constraints triggers).

  NOTE

  Exercise caution when using this function because data integrity cannot be ensured as expected if the triggers are not executed.

- **| ENABLE TRIGGER [ trigger_name | ALL | USER ]**

  Enables a single trigger specified by **trigger_name**, enables all triggers, or enables only user triggers.

- **| ENABLE REPLICA TRIGGER trigger_name**

  Determines that the trigger firing mechanism is affected by the configuration variable **session_replication_role**. When the replication role is **origin** (default value) or **local**, a simple trigger is fired.

  When ENABLE REPLICA is configured for a trigger, it is triggered only when the session is in replica mode.

- **| ENABLE ALWAYS TRIGGER trigger_name**

  Determines that all triggers are fired regardless of the current replication mode.

- **| DISABLE/ENABLE [ REPLICA | ALWAYS ] RULE**

  Enables or disables a rule for tables. Disabled rules are still visible in the system, but are not applied during query rewriting. The ON SELECT rule cannot be disabled because it is related to the view implementation. Rules configured as ENABLE REPLICA are enabled only when the session is in replica mode, while those configured as ENABLE ALWAYS can be enabled regardless of the replica mode. Rule triggering is also affected by configuration variables in **session_replication_role**, which is similar to the preceding trigger setting.

- **| DISABLE/ENABLE ROW LEVEL SECURITY**

  Enables or disables row-level access control for a table.

  If row-level access control is enabled for a data table but no row-level access control policy is defined, the row-level access to the data table is not affected. If row-level access control for a table is disabled, the row-level access to the table is not affected even if a row-level access control policy has been defined. For details, see **12.14.75 CREATE ROW LEVEL SECURITY POLICY**.

- **| NO FORCE/FORCE ROW LEVEL SECURITY**

  Forcibly enables or disables row-level access control for a table.

  By default, the table owner is not affected by the row-level access control feature. However, if row-level access control is forcibly enabled, the table owner (excluding system administrators) will be affected. System administrators are not affected by any row-level access control policies.

- **| ENCRYPTION KEY ROTATION**

  Rotation of the transparent data encryption key.

  The data encryption key rotation of a table can be performed only when the transparent encryption function is enabled for the database and **enable_tde** of the table is set to **on**. After the key rotation operation is performed, the system automatically applies for a new KMS key. After the key rotation, the data encrypted using the old key is decrypted using the old key, and the newly written data is encrypted using the new key. To ensure the security of encrypted data, you can periodically update the key based on the amount of new data in the encryption table. It is recommended that the key be updated every two to three years.

- **INHERIT parent_table**

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Adds the target data table to a specified parent data table as a new child data table. After that, the query for the parent data table will contain the data in the target data table. Before being added as a child data table, the target data table must contain all the columns in the parent data table. These columns must have matching data categories, and if they have NOT NULL constraints in the parent data table, they must also have NOT NULL constraints in the child data table. For all CHECK constraints in the parent data table, there must be corresponding constraints in the child data table, unless the parent data table is marked as non-inheritable.

- **NO INHERIT parent_table**

  Generates the target data table from the child data table of a specified parent data table. Queries for the parent data table will no longer contain records generated from the target data table.

- **DISTRIBUTE BY { REPLICATION | { [ HASH ] ( column_name ) } }**

  Specifies how the table is distributed or replicated between DNs.

- **OF type_name**

  Joins a table to a composite type, which is similar to table creation by using the **CREATE TABLE OF** option. The name and type of a table column must exactly match those defined in the composite type, but the OID system column can be different. The table cannot be inherited from any other table. These restrictions ensure that the **CREATE TABLE OF** option allows the same table definition.

- **NOT OF**

  Removes the association between a table and a type.

- **REPLICA IDENTITY { DEFAULT | USING INDEX index_name | FULL | NOTHING }**

  Specifies the record level of old tuples in UPDATE and DELETE statements on a table in logical replication scenarios.

  - **DEFAULT**: The old value of the primary key column is recorded. If there is no primary key, no old value is recorded.
  - **USING INDEX**: Old values of columns covered by the named indexes are recorded. These values must be unique, non-local, and non-deferrable, and contain the values of columns marked with **NOT NULL**.
  - **FULL**: Old values of all columns in the row are recorded.
  - **NOTHING**: Information in old rows is recorded.

  In logical replication scenarios, when the UPDATE and DELETE statements of a table are parsed, the parsed old tuples consist of the information recorded in this method. For tables with primary keys, this option can be set to **DEFAULT** or **FULL**. For a table without a primary key, set this parameter to **FULL**. Otherwise, the old tuple will be parsed as empty during decoding. You are not advised to set this parameter to **NOTHING** in common scenarios because old tuples are always parsed as empty.

– The **column_clause** can be one of the following clauses:

```
ADD [ COLUMN ] column_name data_type [ compress_mode ] [ COLLATE collation ]
[ column_constraint [ ... ] ]
| MODIFY column_name data_type
| MODIFY column_name [ CONSTRAINT constraint_name ] NOT NULL [ ENABLE ]
| MODIFY column_name [ CONSTRAINT constraint_name ] NULL
| DROP [ COLUMN ] [ IF EXISTS ] column_name [ RESTRICT | CASCADE ]
| ALTER [ COLUMN ] column_name [ SET DATA ] TYPE data_type [ COLLATE collation ] [ USING
expression ]
| ALTER [ COLUMN ] column_name { SET DEFAULT expression | DROP DEFAULT }
| ALTER [ COLUMN ] column_name { SET | DROP } NOT NULL
| ALTER [ COLUMN ] column_name SET STATISTICS [PERCENT] integer
| ADD STATISTICS (( column_1_name, column_2_name [, ...] ))
| DELETE STATISTICS (( column_1_name, column_2_name [, ...] ))
| ALTER [ COLUMN ] column_name SET ( {attribute_option = value} [, ... ] )
| ALTER [ COLUMN ] column_name RESET ( attribute_option [, ... ] )
| ALTER [ COLUMN ] column_name SET STORAGE { PLAIN | EXTERNAL | EXTENDED | MAIN }
```

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NOTE

- **ADD [ COLUMN ] column_name data_type [ compress_mode ] [ COLLATE collation ] [ column_constraint [ ... ] ]**

  Adds a column to a table. If a column is added with ADD COLUMN, all existing rows in the table are initialized with the column's default value (**NULL** if no DEFAULT clause is specified).

- **ADD ( { column_name data_type [ compress_mode ] } [, ...] )**

  Adds columns in the table.

- **MODIFY ( { column_name data_type | column_name [ CONSTRAINT constraint_name ] NOT NULL [ ENABLE ] | column_name [ CONSTRAINT constraint_name ] NULL } [, ...] )**

  Modifies the data type of an existing column in the table.

- **DROP [ COLUMN ] [ IF EXISTS ] column_name [ RESTRICT | CASCADE ]**

  Drops a column from a table. Indexes and constraints related to the column are automatically dropped. If an object not belonging to the table depends on the column, CASCADE must be specified, such as foreign key reference and view.

  The DROP COLUMN statement does not physically remove the column, but simply makes it invisible to SQL operations. Subsequent INSERT and UPDATE operations in the table will store a **NULL** value for the column. Therefore, column deletion takes a short period of time but does not immediately release the tablespace on the disks, because the space occupied by the deleted column is not reclaimed. The space will be reclaimed when VACUUM is executed.

- **ALTER [ COLUMN ] column_name [ SET DATA ] TYPE data_type [ COLLATE collation ] [ USING expression ]**

  Modifies the type of a column in a table. Indexes and simple table constraints on the column will automatically use the new data type by reparsing the originally supplied expression.

- **ALTER [ COLUMN ] column_name { SET DEFAULT expression | DROP DEFAULT }**

  Sets or removes the default value for a column. The default values only apply to subsequent INSERT operations; they do not cause rows already in the table to change. Defaults can also be created for views, in which case they are inserted into INSERT statements on the view before the view's ON INSERT rule is applied.

- **ALTER [ COLUMN ] column_name { SET | DROP } NOT NULL**

  Changes whether a column is marked to allow null values or to reject null values. You can only use SET NOT NULL when the column contains no null values.

- **ALTER [ COLUMN ] column_name SET STATISTICS [PERCENT] integer**

  Specifies the per-column statistics-gathering target for subsequent ANALYZE operations. The target can be set in the range from 0 to 10000. Set it to **–1** to revert to using the default system statistics target.

- **{ADD | DELETE} STATISTICS ((column_1_name, column_2_name [, ...]))**

  Adds or deletes the declaration of collecting multi-column statistics to collect multi-column statistics as needed when **ANALYZE** is performed for a table or a database. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The statistics about a maximum of 32 columns can be collected at a time. You are not allowed to add or delete such declaration for system catalogs or foreign tables.

- **ALTER [ COLUMN ] column_name SET ( {attribute_option = value} [, ... ] )**

  **ALTER [ COLUMN ] column_name RESET ( attribute_option [, ... ] )**

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Sets or resets per-attribute options.

Currently, the only defined per-attribute options are **n_distinct** and **n_distinct_inherited**. **n_distinct** affects statistics of a table, while **n_distinct_inherited** affects the statistics of the table and its subtables. Currently, only **SET/RESET n_distinct** is supported, and **SET/RESET n_distinct_inherited** is forbidden.

- **ALTER [ COLUMN ] column_name SET STORAGE { PLAIN | EXTERNAL | EXTENDED | MAIN }**

  Sets the storage mode for a column. This clause specifies whether this column is held inline or in a secondary table, and whether the data should be compressed. It is set only for row-store tables and is invalid for column-store tables. If it is set for column-store tables, an error will be displayed when the statement is executed. SET STORAGE itself does not change anything in the table. It sets the strategy to be pursued during future table updates.

  - **column_constraint** is as follows:

    ```
    [ CONSTRAINT constraint_name ]
      { NOT NULL |
        NULL |
        CHECK ( expression ) |
        DEFAULT default_expr  |
        UNIQUE index_parameters |
        PRIMARY KEY index_parameters |
        ENCRYPTED WITH ( COLUMN_ENCRYPTION_KEY = column_encryption_key,
    ENCRYPTION_TYPE = encryption_type_value ) |
        REFERENCES reftable [ ( refcolumn ) ] [ MATCH FULL |  MATCH PARTIAL | MATCH
    SIMPLE ]
          [ ON DELETE action ] [ ON UPDATE action ] }
      [ DEFERRABLE | NOT DEFERRABLE ][ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]
    ```

  - **compress_mode** of a column is as follows:

    ```
    { DELTA | PREFIX | DICTIONARY | NUMSTR | NOCOMPRESS }
    ```

- **table_constraint_using_index** used to add the primary key constraint or unique constraint based on the unique index is as follows:

  ```
  [ CONSTRAINT constraint_name ]
    { UNIQUE | PRIMARY KEY } USING INDEX index_name
    [ DEFERRABLE | NOT DEFERRABLE ][ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]
  ```

- **table_constraint** is as follows:

  ```
  [ CONSTRAINT constraint_name ]
    { CHECK ( expression ) |
      UNIQUE ( column_name [, ... ] ) index_parameters |
      PRIMARY KEY ( column_name [, ... ] ) index_parameters |
      PARTIAL CLUSTER KEY ( column_name [, ... ] )  |
      FOREIGN KEY ( column_name [, ... ] ) REFERENCES reftable [ ( refcolumn [, ... ] ) ]
        [ MATCH FULL | MATCH PARTIAL | MATCH SIMPLE ] [ ON DELETE action ] [ ON UPDATE
  ACTION ] }
    [ DEFERRABLE | NOT DEFERRABLE ][ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]
  ```

  **index_parameters** is as follows:

  ```
  [ WITH ( {storage_parameter = value} [, ... ] ) ]
    [ USING INDEX TABLESPACE tablespace_name ]
  ```

- Rename a table. The renaming does not affect stored data.

  ```
  ALTER TABLE [ IF EXISTS ] table_name
    RENAME TO new_table_name;
  ```

- Rename the specified column in the table.

  ```
  ALTER TABLE [ IF EXISTS ] { table_name [*] | ONLY table_name | ONLY ( table_name )}
    RENAME [ COLUMN ] column_name TO new_column_name;
  ```

- Rename the constraint of the table.

  ```
  ALTER TABLE [ IF EXISTS ] { table_name [*] | ONLY table_name | ONLY ( table_name ) }
    RENAME CONSTRAINT constraint_name TO new_constraint_name;
  ```

- Set the schema of the table.

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```
ALTER TABLE [ IF EXISTS ] table_name
    SET SCHEMA new_schema;
```

NOTE

- The schema setting moves the table into another schema. Associated indexes and constraints owned by table columns are migrated as well. Currently, the schema for sequences cannot be changed. If the table has sequences, delete the sequences, and create them again or delete the ownership between the table and sequences. In this way, the table schema can be changed.
- To change the schema of a table, you must also have the CREATE permission on the new schema. To add the table as a new child of a parent table, you must own the parent table as well. To alter the owner, you must also be a direct or indirect member of the new owning role, and that role must have the CREATE permission on the table's schema. These restrictions enforce that the user can only recreate and delete the table. However, a system administrator can alter the ownership of any table anyway.
- All the actions except for RENAME and SET SCHEMA can be combined into a list of multiple alterations to apply in parallel. For example, it is possible to add several columns or alter the type of several columns in a single statement. This is useful with large tables, since only one pass over the tables need be made.
- Adding a CHECK or NOT NULL constraint will scan the table to validate that existing rows meet the constraint.
- Adding a column with a non-NULL default value or changing the type of an existing column will rewrite the entire table. Rewriting a large table may take much time and temporarily needs doubled disk space.

- Add columns.

```
ALTER TABLE [ IF EXISTS ] table_name
    ADD ( { column_name data_type [ compress_mode ] [ COLLATE collation ] [ column_constraint [ ... ] ]} [, ...] );
```

- Update columns.

```
ALTER TABLE [ IF EXISTS ] table_name
    MODIFY ( { column_name data_type | column_name [ CONSTRAINT constraint_name ] NOT NULL [ ENABLE ] | column_name [ CONSTRAINT constraint_name ] NULL } [, ...] );
```

## Parameter Description

- **IF EXISTS**

  Sends a notice instead of an error if no tables have identical names. The notice prompts that the table you are querying does not exist.

- **table_name [*] | ONLY table_name | ONLY ( table_name )**

  **table_name** is the name of the table that you need to modify.

  If **ONLY** is specified, only the table is modified. If **ONLY** is not specified, the table and all subtables are modified. You can add the asterisk (*) option following the table name to specify that all subtables are scanned, which is the default operation.

- **constraint_name**

  Specifies the name of an existing constraint to drop.

- **index_name**

  Specifies the name of an index.

- **storage_parameter**

  Specifies the name of a storage parameter.

  The following options are added for online scaling :

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- **append_mode** (enumerated type)

  Scales a table online or offline, or stops scaling it. You can modify certain content in the table during online scaling but cannot do so during offline scaling.

  To modify a table that is being scaled, append new data so that they can be recorded as incremental data.

  - **on**: scales a table online . New data will be appended.
  - **off**: stops scaling. New data will be written in normal mode, and options for online scaling will not be displayed in **pg_class.reloptions**.
  - **read_only**: scales a table offline, during which no other operations can be performed on the table.
  - **end_catchup**: reports errors for the write service in the last round of data increment. The read service is executed normally.

- **rel_cn_oid** (OID type)

  Records the OID of tables on the current CN to generate **delete_delta** on the DNs.

  If **append_mode** is set to **on**, **rel_cn_oid** must be specified.

  The **append_mode** and **rel_cn_oid** options are used only for online scaling tools.

- **exec_step** (integer)

  Records resumable transmission steps in **relOptions** of the temporary table.

  Value range: [1,4]

  It can be used only for data redistribution.

- **create_time** (long integer)

  Records the time when the temporary table is created during resumable transmission in **relOptions** of the temporary table.

  Only the data redistribution tool is supported.

- **wait_clean_cbi** (string type)

  Specifies whether the current global index contains the residual tuple generated during bucket migration for scaling. After scaling, **wait_clean_cbi** is set to **y**. After the residual tuple is cleared in the vacuum process, **wait_clean_cbi** is set to **n**.

  This option is used only in scaling tools.

The following option is added for creating an index:

- **parallel_workers** (int type)

  Number of bgworker threads started when an index is created. For example, value **2** indicates that two bgworker threads are started to create indexes concurrently.

  Value range: [0,32]. The value **0** indicates that this function is disabled.

  Default value: If this parameter is not set, the concurrent index creation function is disabled.

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The following option is added to the replication table:

- **primarynode** (Boolean type)

  Default value: **off**

  When **primarynode** is set to **on**, the primary node is selected for the replication table. Generally, the primary node is the first node recorded in the nodeoids field in the **pgxc_class** table. When the IUD operation is performed on the replication table, the operation is delivered to the primary node first. After the result is received, the operation is delivered to other DNs.

Transparent data encryption options:

- **enable_tde** (Boolean type)

  Specifies whether transparent data encryption is enabled for a table. Before enabling this function, ensure that the **enable_tde** in "GUC Parameter" has been enabled, the KMS service has been enabled, and the cluster master key ID in **tde_cmk_id** in "GUC Parameter" has been correctly configured.

  This parameter supports only row-store tables. Column-store tables and temporary tables are not supported. The ustore storage engine is not supported. This parameter can be modified only when **enable_tde** is specified during table creation. Changing the encryption state does not change the encryption algorithm and key information.

  Value range: **on** and **off** **on** indicates that transparent data encryption is enabled. After the value is changed from **off** to **on**, new data is automatically encrypted when being written to the data page, and old data is automatically encrypted when the data page is updated. **off** indicates that transparent data encryption is disabled. After the value is changed from **on** to **off**, newly written data is not encrypted, old encrypted data can be automatically decrypted when being read, and data is not encrypted when being written back to the data page.

  Default value: **off**

- **hasuids** (Boolean type)

  Default value: **off**

  If this parameter is set to **on**, a unique table-level ID is allocated to a tuple when the tuple is updated.

- **new_owner**

  Specifies the name of the new table owner.

- **new_tablespace**

  Specifies the new name of the tablespace to which the table belongs.

- column_name, column_1_name, column_2_name

  Specifies the name of a new or existing column.

- **data_type**

  Specifies the type of a new column or a new type of an existing column.

- **compress_mode**

  Compression option of a table field. The clause specifies the compression algorithm preferentially used by the column. Row-store tables do not support compression.

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- **collation**

  Specifies the collation rule name of a column. The optional COLLATE clause specifies a collation for the new column; if omitted, the collation is the default for the new column. You can run the **select * from pg_collation** command to query collation rules from the **pg_collation** system catalog. The default collation rule is the row starting with **default** in the query result.

- **USING expression**

  Specifies how to compute the new column value from the old; if omitted, the default conversion is an assignment cast from old data type to new. A USING clause must be provided if there is no implicit or assignment cast from the old to new type.

  NOTE

  **USING** in ALTER TYPE can specify any expression involving the old values of the row; that is, it can refer to any columns other than the one being cast. This allows general casting to be done with the ALTER TYPE syntax. Because of this flexibility, the USING expression is not applied to the column's default value (if any); the result might not be a constant expression as required for a default. This means that when there is no implicit or assignment cast from old to new type, ALTER TYPE might fail to convert the default even though a USING clause is supplied. In such cases, drop the default with DROP DEFAULT, perform ALTER TYPE, and then use SET DEFAULT to add a suitable new default. Similar considerations apply to indexes and constraints involving the column.

- **NOT NULL | NULL**

  Sets whether the column allows null values.

- **integer**

  Specifies the constant value of a signed integer. When using PERCENT, the range of **integer** is from 0 to 100.

- **attribute_option**

  Specifies an attribute option.

- **PLAIN | EXTERNAL | EXTENDED | MAIN**

  Specifies a column-store mode.

  - **PLAIN** must be used for fixed-length values (such as integers). It must be inline and uncompressed.
  - **MAIN** is for inline, compressible data.
  - **EXTERNAL** is for external, uncompressed data. Use of **EXTERNAL** will make substring operations on **text** and **bytea** values run faster, at the penalty of increased storage space.
  - **EXTENDED** is for external, compressed data. **EXTENDED** is the default for most data types that support non-**PLAIN** storage.

- **CHECK ( expression )**

  New rows or rows to be updated must satisfy for an expression to be true. If any row produces a false result, an error is raised and the database is not modified.

  A check constraint specified as a column constraint should reference only the column's values, while an expression appearing in a table constraint can reference multiple columns.

  Currently, CHECK (expression) does not include subqueries and cannot use variables apart from the current column.

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- **DEFAULT default_expr**

  Assigns a default data value for a column.

  The data type of the default expression must match the data type of the column.

  The default expression will be used in any insert operation that does not specify a value for the column. If there is no default value for a column, then the default value is null.

- **UNIQUE index_parameters**

  **UNIQUE ( column_name [, ... ] ) index_parameters**

  Specifies that a group of one or more columns of a table can contain only unique values.

- **PRIMARY KEY index_parameters**

  **PRIMARY KEY ( column_name [, ... ] ) index_parameters**

  Specifies that a column or columns of a table can contain only unique (non-duplicate) and non-null values.

- **DEFERRABLE | NOT DEFERRABLE | INITIALLY DEFERRED | INITIALLY IMMEDIATE**

  Sets whether the constraint can be deferrable.

  - **DEFERRABLE**: deferrable to the end of the transaction and checked using **SET CONSTRAINTS**.
  - **NOT DEFERRABLE**: checks immediately after the execution of each command.
  - **INITIALLY IMMEDIATE**: checks immediately after the execution of each statement.
  - **INITIALLY DEFERRED**: checks when the transaction ends.

- **WITH ( {storage_parameter = value} [, ... ] )**

  Specifies an optional storage parameter for a table or an index.

- **tablespace_name**

  Specifies the name of the tablespace where the index locates.

- **COMPRESS|NOCOMPRESS**

  - **NOCOMPRESS**: The existing compression feature of the table will not be changed.
  - **COMPRESS**: The table compression feature will be triggered by batch tuple insertion. Row-store tables do not support compression.

- **new_table_name**

  Specifies the new table name.

- **new_column_name**

  Specifies the new name of a specific column in a table.

- **new_constraint_name**

  Specifies the new name of a table constraint.

- **new_schema**

  Specifies the new schema name.

- **CASCADE**

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Automatically drops objects that depend on the dropped column or constraint (for example, views referencing the column).

- **RESTRICT**

  Refuses to drop the column or constraint if there are any dependent objects. This is the default processing.

- **schema_name**

  Specifies the schema name of a table.

## Examples

See **Examples** in **CREATE TABLE**.

## Helpful Links

**12.14.80 CREATE TABLE** and **12.14.125 DROP TABLE**

# 12.14.31 ALTER TABLE PARTITION

## Function

**ALTER TABLE PARTITION** modifies table partitions, including adding, deleting, splitting, merging, clearing, swapping, and renaming partitions, moving partition tablespaces, and modifying partition attributes.

## Precautions

- The tablespace for the added partition cannot be **PG_GLOBAL**.
- The name of the added partition must be different from names of existing partitions in the partition table.
- The partition key of the added partition must be the same type as that of the partitioned table. The key value of the added partition must exceed the upper limit of the last partition range.
- If the number of partitions in the target partitioned table reaches the maximum (**1048575**), no more partitions can be added.
- If a partitioned table has only one partition, the partition cannot be deleted.
- Use **PARTITION FOR()** to choose partitions. The number of specified values in the brackets should be the same as the column number in customized partition, and they must be consistent.
- The **Value** partition table does not support the **Alter Partition** operation.
- Column-store tables and row-store tables cannot be partitioned.
- Only the partitioned table owner or a user granted with the ALTER permission can run the **ALTER TABLE PARTITION** command. The system administrator has this permission by default.

## Syntax

- Modify the syntax of the table partition.

```
ALTER TABLE [ IF EXISTS ] { table_name  [*] | ONLY table_name | ONLY ( table_name  )}
    action [, ... ];
```

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**action** indicates the following clauses for maintaining partitions. For the partition continuity when multiple clauses are used for partition maintenance, GaussDB does **DROP PARTITION** and then **ADD PARTITION**, and finally runs the rest clauses in sequence.

```
move_clause |
  exchange_clause |
  row_clause |
  merge_clause |
  modify_clause |
  split_clause |
  add_clause |
  drop_clause
```

- The **move_clause** syntax is used to move the partition to a new tablespace.

  ```
  MOVE PARTITION { partion_name | FOR ( partition_value [, ...] ) } TABLESPACE tablespacename
  ```

- The **exchange_clause** syntax is used to move the data from a general table to a specified partition.

  ```
  EXCHANGE PARTITION { ( partition_name ) | FOR ( partition_value [, ...] ) }
     WITH TABLE {[ ONLY ] ordinary_table_name | ordinary_table_name * | ONLY
  ( ordinary_table_name )}
     [ { WITH | WITHOUT } VALIDATION ] [ VERBOSE ] [ UPDATE GLOBAL INDEX ]
  ```

  The ordinary table and partition whose data is to be exchanged must meet the following requirements:

  - The number of columns of the ordinary table is the same as that of the partition, and their information should be consistent, including: column name, data type, constraint, collation information, storage parameter, and compression information.
  - The compression information of the ordinary table and partition should be consistent.
  - The distribution key information of the ordinary table and partition should be consistent.
  - The number and information of indexes of the ordinary table and partition should be consistent.
  - The number and information of constraints of the ordinary table and partition should be consistent.
  - The ordinary table cannot be a temporary table.
  - When the built-in security policy is enabled, a common table cannot contain columns bound to a dynamic data anonymization policy.

  When the exchange is done, the data and tablespace of the ordinary table and partition are exchanged. The statistics of the ordinary table and partition are no longer inaccurate after the exchange, and they should be analyzed again. If the DROP COLUMN operation is performed on an ordinary or partitioned table, the deleted column still exists physically. Therefore, you need to ensure that the deleted column of the ordinary table is strictly aligned with that of the partition.

- The **row_clause** syntax is used to set row movement of a partitioned table.

  ```
  { ENABLE | DISABLE } ROW MOVEMENT
  ```

- The **merge_clause** syntax is used to merge partitions into one.

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```
MERGE PARTITIONS { partition_name } [, ...] INTO PARTITION partition_name
    [ TABLESPACE tablespacename ] [ UPDATE GLOBAL INDEX ]
```

- The **modify_clause** syntax is used to set whether a partition index is usable.

```
MODIFY PARTITION partition_name { UNUSABLE LOCAL INDEXES | REBUILD UNUSABLE LOCAL INDEXES }
```

- The **split_clause** syntax is used to split one partition into partitions.

```
SPLIT PARTITION { partition_name | FOR ( partition_value [, ...] ) } { split_point_clause | no_split_point_clause } [ UPDATE GLOBAL INDEX ]
```

  - The **split_point_clause** syntax is used to specify a split point.

```
AT ( partition_value ) INTO ( PARTITION partition_name [ TABLESPACE tablespacename ] , PARTITION partition_name [ TABLESPACE tablespacename ] )
```

    **NOTICE**

    - Column-store tables and row-store tables cannot be partitioned.
    - The size of the split point should be in the range of partition keys of the partition of to be split. The split point can only split one partition into two new partitions.

  - The **no_split_point_clause** syntax does not specify a split point.

```
INTO { ( partition_less_than_item [, ...] ) | ( partition_start_end_item [, ...] ) }
```

    **NOTICE**

    - The first new partition key specified by **partition_less_than_item** should be greater than that of the previously split partition (if any), and the last partition key specified by **partition_less_than_item** should equal that of the partition being split.
    - The first new partition key specified by **partition_start_end_item** should equal that of the former partition (if any), and the last partition key specified by **partition_start_end_item** should equal that of the partition being split.
    - **partition_less_than_item** supports a maximum of 4 partition keys, while **partition_start_end_item** supports only one partition key. For details about the supported data types, see **•PARTITION BY RANGE(part...**.
    - **partition_less_than_item** and **partition_start_end_item** cannot be used in the same statement.

  - The syntax of **partition_less_than_item** is as follows:

```
PARTITION partition_name VALUES LESS THAN ( { partition_value | MAXVALUE }  [, ...] )
    [ TABLESPACE tablespacename ]
```

  - The syntax of **partition_start_end_item** is as follows. For details about the constraints, see **partition_start_end_item syntax**.

```
PARTITION partition_name {
      {START(partition_value) END (partition_value) EVERY (interval_value)} |
      {START(partition_value) END ({partition_value | MAXVALUE})} |
      {START(partition_value)} |
```

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```
        {END({partition_value | MAXVALUE})}
    } [TABLESPACE tablespace_name]
```

  - The **add_clause** syntax is used to add one or more partitions to a specified partitioned table.

```
ADD PARTITION ( partition_col1_name = partition_col1_value [, partition_col2_name = partition_col2_value ] [, ...] )
   [ LOCATION 'location1' ]
   [ PARTITION (partition_colA_name = partition_colA_value [, partition_colB_name = partition_colB_value ] [, ...] ) ]
   [ LOCATION 'location2' ]
ADD {partition_less_than_item | partition_start_end_item}
```

  - The **drop_clause** syntax is used to remove a partition from a specified partitioned table.

```
DROP PARTITION  { partition_name | FOR (  partition_value [, ...] )  } [ UPDATE GLOBAL INDEX ]
```

- The syntax for modifying the name of a partition is as follows:

```
ALTER TABLE [ IF EXISTS ] { table_name [*] | ONLY table_name | ONLY ( table_name  )}
   RENAME PARTITION { partion_name | FOR ( partition_value [, ...] ) } TO partition_new_name;
```

## Parameter Description

- **table_name**

  Specifies the name of a partitioned table.

  Value range: an existing table name

- **partition_name**

  Specifies the name of a partition.

  Value range: an existing partition name

- **tablespacename**

  Specifies which tablespace the partition moves to.

  Value range: an existing tablespace name

- **partition_value**

  Specifies the key value of a partition.

  The value specified by **PARTITION FOR ( partition_value [, ...] )** can uniquely identify a partition.

  Value range: partition keys for the partition to be renamed

- **UNUSABLE LOCAL INDEXES**

  Sets all the indexes unusable in the partition.

- **REBUILD UNUSABLE LOCAL INDEXES**

  Rebuilds all the indexes in the partition.

- **ENABLE/DISABLE ROW MOVEMET**

  Sets row movement.

  If the tuple value is updated on the partition key during the **UPDATE** action, the partition where the tuple is located is altered. Setting this parameter enables error messages to be reported or movement of the tuple between partitions.

  Value range:

  - **ENABLE**: Row movement is enabled.
  - **DISABLE**: Row movement is disabled.

  By default, this parameter is disabled.

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- **ordinary_table_name**

  Specifies the name of the ordinary table whose data is to be migrated.

  Value range: an existing table name

- **{ WITH | WITHOUT } VALIDATION**

  Checks whether the ordinary table data meets the specified partition key range of the partition to be migrated.

  Value range:

  - **WITH**: checks whether the ordinary table data meets the partition key range of the partition to be migrated. If any data does not meet the required range, an error is reported.
  - **WITHOUT**: does not check whether the ordinary table data meets the partition key range of the partition to be migrated.

  The default value is **WITH**.

  The check is time consuming, especially when the data volume is large. Therefore, use **WITHOUT** when you are sure that the current ordinary table data meets the partition key range of the partition to be migrated.

- **VERBOSE**

  When **VALIDATION** is **WITH**, if the ordinary table contains data that is out of the partition key range, insert the data to the correct partition. If there is no correct partition where the data can be inserted to, an error is reported.

  NOTICE

  Only when **VALIDATION** is **WITH**, **VERBOSE** can be specified.

- **partition_new_name**

  Specifies the new name of a partition.

  Value range: a string. It must comply with the naming convention.

- **UPDATE GLOBAL INDEX**

  If this parameter is used, all global indexes in a partitioned table are updated to ensure that correct data can be queried using global indexes.

  If this parameter is not used, all global indexes in a partitioned table will become invalid.

## Examples

See **Examples** in **CREATE TABLE PARTITION**.

## Helpful Links

**12.14.83 CREATE TABLE PARTITION** and **12.14.125 DROP TABLE**

# 12.14.32 ALTER TABLESPACE

## Function

**ALTER TABLESPACE** modifies the attributes of a tablespace.

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## Precautions

- The **ALTER TABLESPACE** syntax cannot be used in the current version.
- Only the tablespace owner or a user granted with the ALTER permission can run the **ALTER TABLESPACE** command. The system administrator has this permission by default. To modify a tablespace owner, you must be the tablespace owner or system administrator and a member of the new owner role.
- The **ALTER TABLESPACE** operation on a row-store table cannot be performed in a transaction block.
- To change the owner, you must also be a direct or indirect member of the new owning role.

  NOTE

  If **new_owner** is the same as **old_owner**, the current user will not be verified. A message indicating successful **ALTER** execution is displayed.

## Syntax

- The syntax of renaming a tablespace is as follows:
```
ALTER TABLESPACE tablespace_name
    RENAME TO new_tablespace_name;
```
- The syntax of setting the owner of a tablespace is as follows:
```
ALTER TABLESPACE tablespace_name
    OWNER TO new_owner;
```
- The syntax of setting the attributes of a tablespace is as follows:
```
ALTER TABLESPACE tablespace_name
    SET ( {tablespace_option = value} [, ... ] );
```
- The syntax of resetting the attributes of a tablespace is as follows:
```
ALTER TABLESPACE tablespace_name
    RESET ( { tablespace_option } [, ...] );
```
- The syntax of setting the quota of a tablespace is as follows:
```
ALTER TABLESPACE tablespace_name
    RESIZE MAXSIZE { UNLIMITED | 'space_size'};
```

## Parameter Description

- **tablespace_name**

  Specifies the tablespace to be modified.

  Value range: an existing table name
- **new_tablespace_name**

  Specifies the new name of a tablespace.

  The new name cannot start with **PG_**.

  Value range: a string. It must comply with the naming convention.
- **new_owner**

  Specifies the new owner of the tablespace.

  Value range: an existing username
- **tablespace_option**

  Sets or resets the parameters of a tablespace.

  Value range:

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  - seq_page_cost: sets the optimizer to calculate the cost of obtaining disk pages in sequence. The default value is **1.0**.
  - **random_page_cost**: sets the optimizer to calculate the cost of obtaining disk pages in a non-sequential manner. The default value is **4.0**.

    NOTE

    - The value of **random_page_cost** is relative to that of **seq_page_cost**. It is meaningless when the value is equal to or less than the value of **seq_page_cost**.
    - The prerequisite for the default value **4.0** is that the optimizer uses indexes to scan table data and the hit ratio of table data in the cache is about 90%.
    - If the size of the table data space is smaller than that of the physical memory, decrease the value to a proper level. On the contrary, if the hit ratio of table data in the cache is lower than 90%, increase the value.
    - If random-access memory like SSD is adopted, the value can be decreased to a certain degree to reflect the cost of true random scan.

  Value range: a positive floating point number

- **RESIZE MAXSIZE**

  Resets the maximum size of tablespace.

  Value range:

  - **UNLIMITED**: No limit is set for the tablespace.
  - Determined by **space_size**. For details about the format, see **12.14.81 CREATE TABLESPACE**.

    NOTE

    - If the adjusted quota is smaller than the current tablespace usage, the adjustment is successful. You need to decrease the tablespace usage to a value less than the new quota before writing data to the tablespace.
    - You can also use the following statement to change the value of **MAXSIZE**:

      ```
      ALTER TABLESPACE tablespace_name RESIZE MAXSIZE
       { 'UNLIMITED' | 'space_size'};
      ```

## Examples

See **Examples** in **CREATE TABLESPACE**.

## Helpful Links

**12.14.81 CREATE TABLESPACE** and **12.14.126 DROP TABLESPACE**

# 12.14.33 ALTER TEXT SEARCH CONFIGURATION

## Function

**ALTER TEXT SEARCH CONFIGURATION** modifies the definition of a text search configuration. You can modify its mappings from token types to dictionaries, change the configuration's name or owner, or modify the parameters.

The **ADD MAPPING FOR** form installs a list of dictionaries to be consulted for the specified token types; an error will be generated if there is already a mapping for any of the token types.

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The **ALTER MAPPING FOR** form removes existing mapping for those token types and then adds specified mappings.

**ALTER MAPPING REPLACE ... WITH ...** and **ALTER MAPPING FOR... REPLACE ... WITH ...** options replace **old_dictionary** with **new_dictionary**. Note that only when **pg_ts_config_map** has tuples corresponding to **maptokentype** and **old_dictionary**, the update will succeed. If the update fails, no messages are returned.

The **DROP MAPPING FOR** form deletes all dictionaries for the specified token types in the text search configuration. If **IF EXISTS** is not specified and the string type mapping specified by **DROP MAPPING FOR** does not exist in text search configuration, an error will occur in the database.

## Precautions

- If a search configuration is referenced (to create indexes), users are not allowed to modify the text search configuration.
- To use **ALTER TEXT SEARCH CONFIGURATION**, you must be the owner of the configuration.

## Syntax

- Add text search configuration string mapping.

```
ALTER TEXT SEARCH CONFIGURATION name
    ADD MAPPING FOR token_type [, ... ] WITH dictionary_name [, ... ];
```

- Modify the text search configuration dictionary syntax.

```
ALTER TEXT SEARCH CONFIGURATION name
    ALTER MAPPING FOR token_type [, ... ] REPLACE old_dictionary WITH new_dictionary;
```

- Modify the text search configuration string.

```
ALTER TEXT SEARCH CONFIGURATION name
    ALTER MAPPING FOR token_type [, ... ] WITH dictionary_name [, ... ];
```

- Change the text search configuration dictionary.

```
ALTER TEXT SEARCH CONFIGURATION name
    ALTER MAPPING REPLACE old_dictionary WITH new_dictionary;
```

- Remove text search configuration string mapping.

```
ALTER TEXT SEARCH CONFIGURATION name
    DROP MAPPING [ IF EXISTS ] FOR token_type [, ... ];
```

- Rename the owner of text search configuration.

```
ALTER TEXT SEARCH CONFIGURATION name OWNER TO new_owner;
```

- Rename the text search configuration.

```
ALTER TEXT SEARCH CONFIGURATION name RENAME TO new_name;
```

- Rename the namespace of text search configuration.

```
ALTER TEXT SEARCH CONFIGURATION name SET SCHEMA new_schema;
```

- Modify the attributes of the text search configuration.

```
ALTER TEXT SEARCH CONFIGURATION name SET ( { configuration_option = value } [, ...] );
```

- Reset the attributes of text search configuration.

```
ALTER TEXT SEARCH CONFIGURATION name RESET ( {configuration_option} [, ...] );
```

## Parameter Description

- **name**

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Specifies the name (optionally schema-qualified) of an existing text search configuration.

- **token_type**

  Specifies the name of a token type that is emitted by the configuration's parser. For details, see **12.8.5 Parser**.

- **dictionary_name**

  Specifies the name of a text search dictionary. If multiple dictionaries are listed, they are searched in the specified order.

- **old_dictionary**

  Specifies the name of a text search dictionary to be replaced in the mapping.

- **new_dictionary**

  Specifies the name of a text search dictionary to be substituted for **old_dictionary**.

- **new_owner**

  Specifies the new owner of the text search configuration.

- **new_name**

  Specifies the new name of the text search configuration.

- **new_schema**

  Specifies the new schema for the text search configuration.

- **configuration_option**

  Specifies the text search configuration option. For details, see **12.14.84 CREATE TEXT SEARCH CONFIGURATION**.

- **value**

  Specifies the value of text search configuration option.

## Examples

```
-- Create a text search configuration.
openGauss=# CREATE TEXT SEARCH CONFIGURATION english_1 (parser=default);
CREATE TEXT SEARCH CONFIGURATION

-- Add text search configuration string mapping.
openGauss=# ALTER TEXT SEARCH CONFIGURATION english_1 ADD MAPPING FOR word WITH
simple,english_stem;
ALTER TEXT SEARCH CONFIGURATION

-- Add text search configuration string mapping.
openGauss=# ALTER TEXT SEARCH CONFIGURATION english_1 ADD MAPPING FOR email WITH
english_stem, french_stem;
ALTER TEXT SEARCH CONFIGURATION

-- Query information about the text search configuration.
openGauss=# SELECT b.cfgname,a.maptokentype,a.mapseqno,a.mapdict,c.dictname FROM
pg_ts_config_map a,pg_ts_config b, pg_ts_dict c WHERE a.mapcfg=b.oid AND a.mapdict=c.oid AND
b.cfgname='english_1' ORDER BY 1,2,3,4,5;
  cfgname  | maptokentype | mapseqno | mapdict |   dictname
-----------+--------------+----------+---------+--------------
 english_1 |            2 |        1 |    3765 | simple
 english_1 |            2 |        2 |   12960 | english_stem
 english_1 |            4 |        1 |   12960 | english_stem
 english_1 |            4 |        2 |   12964 | french_stem
(4 rows)

-- Add text search configuration string mapping.
```

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```
openGauss=# ALTER TEXT SEARCH CONFIGURATION english_1 ALTER MAPPING REPLACE french_stem with
german_stem;
ALTER TEXT SEARCH CONFIGURATION

-- Query information about the text search configuration.
openGauss=# SELECT b.cfgname,a.maptokentype,a.mapseqno,a.mapdict,c.dictname FROM
pg_ts_config_map a,pg_ts_config b, pg_ts_dict c WHERE a.mapcfg=b.oid AND a.mapdict=c.oid AND
b.cfgname='english_1' ORDER BY 1,2,3,4,5;
  cfgname  | maptokentype | mapseqno | mapdict |   dictname
-----------+--------------+----------+---------+--------------
 english_1 |            2 |        1 |    3765 | simple
 english_1 |            2 |        2 |   12960 | english_stem
 english_1 |            4 |        1 |   12960 | english_stem
 english_1 |            4 |        2 |   12966 | german_stem
(4 rows)
```

See **Examples** in **CREATE TEXT SEARCH CONFIGURATION**.

## Helpful Links

**12.14.84 CREATE TEXT SEARCH CONFIGURATION** and **12.14.127 DROP TEXT SEARCH CONFIGURATION**

# 12.14.34 ALTER TEXT SEARCH DICTIONARY

## Function

**ALTER TEXT SEARCH DICTIONARY** modifies the definition of a full-text search dictionary, including its parameters, name, owner, and schema.

## Precautions

- Predefined dictionaries do not support the **ALTER** operations.
- Only the owner of a dictionary or a system administrator can perform the **ALTER** operations.
- After a dictionary is created or modified, any modification to the customized dictionary definition file in the **filepath** directory does not affect the dictionary in the database. To use these modifications in the database, run the **ALTER TEXT SEARCH DICTIONARY** statement to update the definition file of the corresponding dictionary.

## Syntax

- Modify the dictionary definition.
  ```
  ALTER TEXT SEARCH DICTIONARY name (
      option [ = value ] [, ... ]
  );
  ```
- Rename a dictionary.
  ```
  ALTER TEXT SEARCH DICTIONARY name RENAME TO new_name;
  ```
- Set the schema of the dictionary.
  ```
  ALTER TEXT SEARCH DICTIONARY name SET SCHEMA new_schema;
  ```
- Change the owner of the dictionary.
  ```
  ALTER TEXT SEARCH DICTIONARY name OWNER TO new_owner;
  ```

## Parameter Description

- **name**

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Specifies the name of an existing dictionary. (If you do not specify a schema name, the dictionary in the current schema will be used.)

Value range: an existing dictionary name

- **option**

  Specifies the name of a parameter to be modified. Each type of dictionaries has a template containing their custom parameters. Parameters function in a way irrelevant to their setting sequence. For details about the parameters, see **option**.

  NOTE

  - The value of **TEMPLATE** in the dictionary cannot be changed.
  - To specify a dictionary, specify both the dictionary definition file path (**FILEPATH**) and the file name.
  - The name of a dictionary definition file can contain only lowercase letters, digits, and underscores (_).

- **value**

  Specifies the new value of a parameter. If the equal sign (=) and *value* are omitted, the previous settings of the option are deleted and the default value is used.

  Value range: valid values defined by **option**.

- **new_name**

  Specifies the new name of a dictionary.

  Value range: a string, which complies with the identifier naming convention. A value can contain a maximum of 63 characters.

- **new_owner**

  Specifies the new owner of a dictionary.

  Value range: an existing username

- **new_schema**

  Specifies the new schema of a dictionary.

  Value range: an existing schema

## Examples

```
-- Modify the definition of stop words in Snowball dictionaries. Retain the values of other parameters.
openGauss=# ALTER TEXT SEARCH DICTIONARY my_dict ( StopWords = newrussian, FilePath = 'file:///home/dicts' );

-- Modify the Language parameter in Snowball dictionaries and delete the definition of stop words.
openGauss=# ALTER TEXT SEARCH DICTIONARY my_dict (Language = dutch, StopWords);

-- Update the dictionary definition and do not change any other content.
openGauss=# ALTER TEXT SEARCH DICTIONARY my_dict ( dummy );
```

## Helpful Links

**12.14.85 CREATE TEXT SEARCH DICTIONARY** and **12.14.128 DROP TEXT SEARCH DICTIONARY**

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# 12.14.35 ALTER TRIGGER

## Function

**ALTER TRIGGER** renames a trigger.

NOTE

Currently, only the name can be modified.

## Precautions

Only the owner of a table where the trigger is created and a system administrator can run the **ALTER TRIGGER** statement.

## Syntax

```
ALTER TRIGGER trigger_name ON table_name RENAME TO new_name;
```

## Parameter Description

- **trigger_name**

  Specifies the name of the trigger to be modified.

  Value range: an existing trigger

- **table_name**

  Specifies the name of the table where the trigger to be modified is located.

  Value range: an existing table having a trigger

- **new_name**

  Specifies the new name after modification.

  Value range: a string that complies with the identifier naming convention. A value contains a maximum of 63 characters and cannot be the same as other triggers on the same table.

## Examples

For details, see **12.14.86 CREATE TRIGGER**.

## Helpful Links

**12.14.86 CREATE TRIGGER**, **12.14.129 DROP TRIGGER**, and **12.14.30 ALTER TABLE**

# 12.14.36 ALTER TYPE

## Function

**ALTER TYPE** modifies the definition of a type.

## Precautions

Only the type owner or a user granted with the ALTER permission can run the **ALTER TYPE** command. The system administrator has this permission by default.

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To modify the owner or schema of a type, you must be a type owner or system administrator and a member of the new owner role.

## Syntax

- Modify a type.

```
ALTER TYPE name action [, ... ]
ALTER TYPE name OWNER TO { new_owner | CURRENT_USER | SESSION_USER }
ALTER TYPE name RENAME ATTRIBUTE attribute_name TO new_attribute_name [ CASCADE |
RESTRICT ]
ALTER TYPE name RENAME TO new_name
ALTER TYPE name SET SCHEMA new_schema
ALTER TYPE name ADD VALUE [ IF NOT EXISTS ] new_enum_value [ { BEFORE | AFTER }
neighbor_enum_value ]
ALTER TYPE name RENAME VALUE existing_enum_value TO new_enum_value

where action is one of:
    ADD ATTRIBUTE attribute_name data_type [ COLLATE collation ] [ CASCADE | RESTRICT ]
    DROP ATTRIBUTE [ IF EXISTS ] attribute_name [ CASCADE | RESTRICT ]
    ALTER ATTRIBUTE attribute_name [ SET DATA ] TYPE data_type [ COLLATE collation ] [ CASCADE |
RESTRICT ]
```

- Add a new attribute to a composite type.

```
ALTER TYPE name ADD ATTRIBUTE attribute_name data_type [ COLLATE collation ] [ CASCADE |
RESTRICT ]
```

- Delete an attribute from a composite type.

```
ALTER TYPE name DROP ATTRIBUTE [ IF EXISTS ] attribute_name [ CASCADE | RESTRICT ]
```

- Change the type of an attribute in a composite type.

```
ALTER TYPE name ALTER ATTRIBUTE attribute_name [ SET DATA ] TYPE data_type [ COLLATE
collation ] [ CASCADE | RESTRICT ]
```

- Change the owner of a type.

```
ALTER TYPE name OWNER TO { new_owner | CURRENT_USER | SESSION_USER }
```

- Change the name of a type or the name of an attribute in a composite type.

```
ALTER TYPE name RENAME TO new_name
ALTER TYPE name RENAME ATTRIBUTE attribute_name TO new_attribute_name [ CASCADE |
RESTRICT ]
```

- Move a type to a new schema.

```
ALTER TYPE name SET SCHEMA new_schema
```

- Add a new value to an enumerated type.

```
ALTER TYPE name ADD VALUE [ IF NOT EXISTS ] new_enum_value [ { BEFORE | AFTER }
neighbor_enum_value ]
```

- Change an enumerated value in the value list.

```
ALTER TYPE name RENAME VALUE existing_enum_value TO new_enum_value
```

## Parameter Description

- **name**

  Specifies the name of an existing type that needs to be modified (optionally schema-qualified).

- **new_name**

  Specifies the new name of the type.

- **new_owner**

  Specifies the new owner of the type.

- **new_schema**

  Specifies the new schema of the type.

- **attribute_name**

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Specifies the name of the attribute to be added, modified, or deleted.

- **new_attribute_name**

  Specifies the new name of the attribute to be renamed.

- **data_type**

  Specifies the data type of the attribute to be added, or the new type of the attribute to be modified.

- **new_enum_value**

  Specifies a new enumerated value. It is a non-null string with a maximum length of 64 bytes.

- **neighbor_enum_value**

  Specifies an existing enumerated value before or after which a new enumerated value will be added.

- **existing_enum_value**

  Specifies an enumerated value to be changed. It is a non-null string with a maximum length of 64 bytes.

- **CASCADE**

  Determines that the type to be modified, its associated records, and subtables that inherit the type will all be updated.

- **RESTRICT**

  Refuses to update the associated records of the modified type. This is the default action.

**NOTICE**

- **ADD ATTRIBUTE**, **DROP ATTRIBUTE**, and **ALTER ATTRIBUTE** can be combined for processing. For example, it is possible to add several attributes or change the types of several attributes at the same time in one command.
- To modify a schema of a type, you must have the **CREATE** permission on the new schema. To alter the owner, you must be a direct or indirect member of the new owner role, and that member must have **CREATE** permission on the schema of this type (these restrictions enforce that the alter owner will not do anything that cannot be done by deleting and rebuilding the type). However, the system administrator can modify the rights of any type in any way. To add an attribute or modify the type of an attribute, you must also have the **USAGE** permission of this type.

## Example

See **Examples** in **CREATE TYPE**.

## Helpful Links

**12.14.87 CREATE TYPE** and **12.14.130 DROP TYPE**

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# 12.14.37 ALTER USER

## Function

**ALTER USER** modifies the attributes of a database user.

## Precautions

Session parameters modified by **ALTER USER** apply to a specified user and take effect in the next session.

## Syntax

- Modify user permissions or other information.

```
ALTER USER user_name [ [ WITH ] option [ ... ] ];
```

The **option** clause is as follows:

```
{ CREATEDB | NOCREATEDB }
    | { CREATEROLE | NOCREATEROLE }
    | { INHERIT | NOINHERIT }
    | { AUDITADMIN | NOAUDITADMIN }
    | { SYSADMIN | NOSYSADMIN }
    | {MONADMIN | NOMONADMIN}
    | {OPRADMIN | NOOPRADMIN}
    | {POLADMIN | NOPOLADMIN}
    | { USEFT | NOUSEFT }
    | { LOGIN | NOLOGIN }
    | { REPLICATION | NOREPLICATION }
    | {INDEPENDENT | NOINDEPENDENT}
    | {VCADMIN | NOVCADMIN}
    | {PERSISTENCE | NOPERSISTENCE}
    | CONNECTION LIMIT connlimit
    | [ ENCRYPTED | UNENCRYPTED ] PASSWORD { 'password' [EXPIRED] | DISABLE | EXPIRED }
    | [ ENCRYPTED | UNENCRYPTED ] IDENTIFIED BY { 'password' [ REPLACE 'old_password' |
EXPIRED ] | DISABLE }
    | VALID BEGIN 'timestamp'
    | VALID UNTIL 'timestamp'
    | RESOURCE POOL 'respool'
    | USER GROUP 'groupuser'
    | PERM SPACE 'spacelimit'
    | TEMP SPACE 'tmpspacelimit'
    | SPILL SPACE 'spillspacelimit'
    | NODE GROUP logic_cluster_name
    | PGUSER
```

- Change the username.

```
ALTER USER user_name
    RENAME TO new_name;
```

- Lock or unlock.

```
ALTER USER user_name
    ACCOUNT { LOCK | UNLOCK };
```

## Parameter Description

- **user_name**

  Specifies the current username.

  **Value range**: an existing username. If a username contains uppercase letters, enclose the name with double quotation marks ("").

- **new_password**

  Specifies a new password.

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The new password must:

- Differ from the old password.
- Contain at least eight characters. This is the default length.
- Differ from the username or the username spelled backward.
- Contain at least three types of the following four types of characters: uppercase characters (A to Z), lowercase characters (a to z), digits (0 to 9), and special characters, including: ~!@#$%^&*()-_=+\|[{}];:,<.>/? If the password contains characters other than the preceding characters, an error will be reported during statement execution.

Value range: a string

- **old_password**

  Specifies the old password.

- **ACCOUNT LOCK | ACCOUNT UNLOCK**
  - **ACCOUNT LOCK**: locks an account to forbid login to databases.
  - **ACCOUNT UNLOCK**: unlocks an account to allow login to databases.
- **PGUSER**

  In the current version, the **PGUSER** attribute of a user cannot be modified.

For details about other parameters, see "Parameter Description" in **12.14.74 CREATE ROLE** and **12.14.22 ALTER ROLE**.

**NOTICE**

The current version does not support the setting of user-level parameters.

## Examples

See **Examples** in **CREATE USER**.

## Helpful Links

**12.14.74 CREATE ROLE**, **12.14.88 CREATE USER**, and **12.14.131 DROP USER**

# 12.14.38 ALTER VIEW

## Function

**ALTER VIEW** modifies all auxiliary attributes of a view. (To modify the query definition of a view, use **CREATE OR REPLACE VIEW**.)

## Precautions

Only the view owner or a user granted with the ALTER permission can run the **ALTER VIEW** command. The system administrator has this permission by default. The following is permission constraints depending on attributes to be modified:

- To modify the schema of a view, you must be the owner of the view or system administrator and have the CREATE permission on the new schema.

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- To modify the owner of a view, you must be the owner of the view or system administrator and a member of the new owner role, with the CREATE permission on the schema of the view.
- Do not change the type of a column in a view.

## Syntax

- Set the default value of a view column.
```
ALTER VIEW [ IF EXISTS ] view_name
    ALTER [ COLUMN ] column_name SET DEFAULT expression;
```
- Remove the default value of a view column.
```
ALTER VIEW [ IF EXISTS ] view_name
    ALTER [ COLUMN ] column_name DROP DEFAULT;
```
- Change the owner of a view.
```
ALTER VIEW [ IF EXISTS ] view_name
    OWNER TO new_owner;
```
- Rename a view.
```
ALTER VIEW [ IF EXISTS ] view_name
    RENAME TO new_name;
```
- Set the schema of a view.
```
ALTER VIEW [ IF EXISTS ] view_name
    SET SCHEMA new_schema;
```
- Set the options of a view.
```
ALTER VIEW [ IF EXISTS ] view_name
    SET ( { view_option_name [ = view_option_value ] } [, ... ] );
```
- Reset the options of a view.
```
ALTER VIEW [ IF EXISTS ] view_name
    RESET ( view_option_name [, ... ] );
```

## Parameter Description

- **IF EXISTS**

  If this option is used, no error is generated when the view does not exist, and only a message is displayed.
- **view_name**

  Specifies the view name, which can be schema-qualified.

  Value range: a string. It must comply with the naming convention.
- **column_name**

  Specifies an optional list of names to be used for columns of the view. If not given, the column names are deduced from the query.

  Value range: a string. It must comply with the naming convention.
- **SET/DROP DEFAULT**

  Sets or deletes the default value of a column. This parameter does not take effect.
- **new_owner**

  Specifies the new owner of a view.
- **new_name**

  Specifies the new view name.
- **new_schema**

  Specifies the new schema of the view.

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- **view_option_name [ = view_option_value ]**

  Specifies an optional parameter for a view.

  Currently, **view_option_name** supports only the **security_barrier** parameter. This parameter is used when the view attempts to provide row-level security.

  Value range: Boolean type. It can be **TRUE** or **FALSE**.

## Examples

```
-- Create a view consisting of rows with c_customer_sk less than 150.
openGauss=# CREATE VIEW tpcds.customer_details_view_v1 AS
    SELECT * FROM tpcds.customer
    WHERE c_customer_sk < 150;

-- Rename a view.
openGauss=# ALTER VIEW tpcds.customer_details_view_v1 RENAME TO customer_details_view_v2;

-- Change the schema of a view.
openGauss=# ALTER VIEW tpcds.customer_details_view_v2 SET schema public;

-- Delete a view.
openGauss=# DROP VIEW public.customer_details_view_v2;
```

## Helpful Links

**12.14.89 CREATE VIEW** and **12.14.132 DROP VIEW**

# 12.14.39 ALTER WORKLOAD GROUP

## Function

**ALTER WORKLOAD GROUP** modifies a workload group and sets the number of concurrent SQL statements.

## Precautions

Only a user with the **ALTER** permission on the current database can perform this operation.

## Syntax

```
ALTER WORKLOAD GROUP wg_name
    USING RESOURCE POOL pool_name [ WITH ( ACT_STATEMENTS = count ) ];
```

## Parameter Description

- **wg_name**

  Specifies the workload group name.

  NOTE

  The workload group must be unique in a database.

  Value range: a string. It must comply with the naming convention.

- **pool_name**

  Specifies the name of a resource pool.

  Value range: a string that indicates an existing resource pool

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- **counts**

  Specifies the number of concurrent SQL statements in the resource pool that the workload group belongs to.

  Value range: an integer ranging from –1 to 2147483647

## Examples

```
-- Create a resource pool named pool1.
openGauss=# CREATE RESOURCE POOL pool1;

-- Create a workload group named group1.
openGauss=# CREATE WORKLOAD GROUP group1;

-- Change the maximum number of concurrent SQL statements in workload group group1 to 10. The workload group is associated with the resource pool pool1.
openGauss=# ALTER WORKLOAD GROUP group1 USING RESOURCE POOL pool1 WITH (ACT_STATEMENTS=10);

-- Delete workload group group1 and resource pool pool1.
openGauss=# DROP WORKLOAD GROUP group1;
openGauss=# DROP RESOURCE POOL pool1;
```

## Helpful Links

**12.14.90 CREATE WORKLOAD GROUP** and **12.14.133 DROP WORKLOAD GROUP**

# 12.14.40 ANALYZE | ANALYSE

## Function

**ANALYZE** collects statistics on ordinary tables in a database, and stores the results in the **PG_STATISTIC** system catalog. The execution plan generator uses these statistics to determine which one is the most effective execution plan.

If no parameter is specified, **ANALYZE** analyzes each table and partitioned table in the current database. You can also specify the **table_name**, **column**, and **partition_name** parameters to restrict the analysis to a specific table, column, or partitioned table.

**ANALYZE | ANALYSE VERIFY** is used to check whether data files of common tables (row-store and column-store tables) in a database are damaged.

## Precautions

Non-temporary tables cannot be analyzed in an anonymous block, transaction block, function, or stored procedure. Temporary tables in a stored procedure can be analyzed but their statistics updates cannot be rolled back.

The **ANALYZE VERIFY** operation is used to detect abnormal scenarios. The **RELEASE** version is required. In the **ANALYZE VERIFY** scenario, remote read is not triggered. Therefore, the remote read parameter does not take effect. If the system detects that a page is damaged due to an error in a key system table, the system directly reports an error and does not continue the detection.

With no table specified, **ANALYZE** processes all the tables that the current user has permission to analyze in the current database. With a table specified, **ANALYZE** processes only that table.

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To perform ANALYZE operation to a table, you must be a table owner or a user granted the VACUUM permission on the table. By default, the system administrator has this permission. However, database owners are allowed to **ANALYZE** all tables in their databases, except shared catalogs. (The restriction for shared catalogs means that a true database-wide **ANALYZE** can only be executed by the system administrator). **ANALYZE** skips tables on which users do not have permissions.

**ANALYZE** does not collect columns for which comparison or equivalent operations cannot be performed, for example, columns of the cursor type.

## Syntax

- Collect statistics information about a table.
```
{ ANALYZE | ANALYSE } [ VERBOSE ]
    [ table_name [ ( column_name [, ...] ) ] ];
```
- Collect partition statistics on a partitioned table. This syntax is not supported currently.
```
{ ANALYZE | ANALYSE } [ VERBOSE ]
    table_name [ ( column_name [, ...] ) ] PARTITION ( patrition_name ) ;
```

  **NOTE**

  An ordinary partitioned table supports the syntax but not the function of collecting statistics about specified partitions.
- Collect statistics about a foreign table.
```
{ ANALYZE | ANALYSE } [ VERBOSE ]
    { foreign_table_name | FOREIGN TABLES };
```
- Collect statistics about multiple columns. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)
```
{ ANALYZE | ANALYSE } [ VERBOSE ]
    table_name (( column_1_name, column_2_name [, ...] ));
```

  **NOTE**

  - When collecting statistics about multiple columns, set GUC parameter **default_statistics_target** to a negative value to sample data in percentage.
  - The statistics about a maximum of 32 columns can be collected at a time.
  - You are not allowed to collect statistics about multiple columns in system catalogs.
  - In logical cluster mode, only the administrator can perform ANALYZE on all tables in the database. Users associated with a logical cluster collect statistics only on tables in the logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)
- Check the data files in the current database.
```
{ ANALYZE | ANALYSE } VERIFY { FAST | COMPLETE };
```

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NOTE

- In fast mode, DML operations need to be performed on the tables to be verified concurrently. As a result, an error is reported during the verification. In the current fast mode, data is directly read from the disk. When other threads modify files concurrently, the obtained data is incorrect. Therefore, you are advised to perform the verification offline.
- You can perform operations on the entire database. Because a large number of tables are involved, you are advised to save the result **gsql -d database -p port -f "verify.sql"> verify_warning.txt 2>&1** in redirection mode.
- Temporary tables and unlogged tables are not supported.
- NOTICE is used to check only tables that are visible to external systems. The detection of internal tables is included in the external tables on which NOTICE depends and is not displayed externally.
- This statement can be executed with error tolerance. The **Assert** of the debug version may cause the core to fail to execute commands. Therefore, you are advised to perform the operations in release mode.
- If a key system table is damaged during a full database operation, an error is reported and the operation stops.

- Check data files of tables and indexes.

```
{ ANALYZE | ANALYSE } VERIFY { FAST  |COMPLETE } table_name | index_name [ CASCADE ];
```

NOTE

- Operations on ordinary tables and index tables are supported, but **CASCADE** operations on indexes of index tables are not supported. The **CASCADE** mode is used to process all index tables of the primary table. When the index tables are checked separately, the **CASCADE** mode is not required.
- Temporary tables and unlogged tables are not supported.
- When the primary table is checked, the internal tables of the primary table, such as the toast table and cudesc table, are also checked.
- When the system displays a message indicating that the index table is damaged, you are advised to run the **reindex** command to recreate the index.

- Check the data files of the table partition.

```
{ ANALYZE | ANALYSE } VERIFY { FAST | COMPLETE } table_name PARTITION { (patrition_name) }
[ CASCADE ];
```

NOTE

- You can check a single partition of a table, but cannot perform the **CASCADE** operation on the indexes of an index table.
- Temporary tables and unlogged tables are not supported.

## Parameter Description

- **VERBOSE**

  Enables the display of progress messages.

  NOTE

  If **VERBOSE** is specified, **ANALYZE** displays the progress information, indicating the table that is being processed. Statistics about tables are also displayed.

- **table_name**

  Specifies the name (possibly schema-qualified) of a specific table to analyze. If omitted, all regular tables (but not foreign tables) in the current database are analyzed.

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Currently, you can use ANALYZE to collect statistics on foreign tables of row-store tables and column-store tables.

Value range: an existing table name

- **column_name**, column_1_name, column_2_name

  Specifies the name of a specific column to analyze. All columns are analyzed by default.

  Value range: an existing column name

- **partition_name**

  Assumes the table is a partitioned table. You can specify **partition_name** following the keyword **PARTITION** to analyze the statistics of this table. Currently, **ANALYZE** can be performed on partitioned tables, but statistics of specified partitions cannot be analyzed.

  Value range: a partition name of a table

- **foreign_table_name**

  Specifies the name of the specific table to be analyzed (possibly schema-qualified).

  Value range: an existing table name

- **FOREIGN TABLES**

  Analyzes all foreign tables accessible to the current user.

- **index_name**

  Specifies the name of the specific index table to be analyzed (possibly schema-qualified).

  Value range: an existing table name

- **FAST|COMPLETE**

  For a row-store table, the **FAST** mode verifies the CRC and page header of the row-store table. If the verification fails, an alarm is generated. In **COMPLETE** mode, the pointer and tuple of the row-store table are parsed and verified. For a column-store table, the **FAST** mode verifies the CRC and magic of the column-store table. If the verification fails, an alarm is generated. In **COMPLETE** mode, the CU of the column-store table is parsed and verified.

- **CASCADE**

  In **CASCADE** mode, all indexes of the current table are verified.

## Examples

-- Create a table.

```
openGauss=# CREATE TABLE customer_info
(
WR_RETURNED_DATE_SK       INTEGER                  ,
WR_RETURNED_TIME_SK       INTEGER                  ,
WR_ITEM_SK                INTEGER            NOT NULL,
WR_REFUNDED_CUSTOMER_SK   INTEGER
)
DISTRIBUTE BY HASH (WR_ITEM_SK);
```

-- Create a partitioned table.

```
openGauss=# CREATE TABLE customer_par
(
WR_RETURNED_DATE_SK       INTEGER                  ,
```

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```
WR_RETURNED_TIME_SK       INTEGER                       ,
WR_ITEM_SK                INTEGER                NOT NULL,
WR_REFUNDED_CUSTOMER_SK   INTEGER
)
DISTRIBUTE BY HASH (WR_ITEM_SK)
PARTITION BY RANGE(WR_RETURNED_DATE_SK)
(
PARTITION P1 VALUES LESS THAN(2452275),
PARTITION P2 VALUES LESS THAN(2452640),
PARTITION P3 VALUES LESS THAN(2453000),
PARTITION P4 VALUES LESS THAN(MAXVALUE)
)
ENABLE ROW MOVEMENT;
```

-- Run **ANALYZE** to update statistics.

```
openGauss=# ANALYZE customer_info;
```

-- Run **ANALYZE VERBOSE** statement to update statistics and display table information.

```
openGauss=# ANALYZE VERBOSE customer_info;
INFO:  analyzing "cstore.pg_delta_3394584009"(cn_5002 pid=53078)
INFO:  analyzing "public.customer_info"(cn_5002 pid=53078)
INFO:  analyzing "public.customer_info" inheritance tree(cn_5002 pid=53078)
ANALYZE
```

**NOTE**

If any environment-related fault occurs, check the logs of the CN.

-- Delete the table.

```
openGauss=# DROP TABLE customer_info;
openGauss=# DROP TABLE customer_par;
```

# 12.14.41 BEGIN

## Function

**BEGIN** may be used to initiate an anonymous block or a single transaction. This section describes the syntax of **BEGIN** used to initiate an anonymous block. For details about the **BEGIN** syntax that initiates transactions, see **12.14.168 START TRANSACTION**.

An anonymous block is a structure that can dynamically create and execute stored procedure code instead of permanently storing code as a database object in the database.

## Precautions

None

## Syntax

- Enable an anonymous block.

```
[DECLARE [declare_statements]]
BEGIN
execution_statements
END;
/
```

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- Start a transaction.

```
BEGIN [ WORK | TRANSACTION ]
 [
  {
    ISOLATION LEVEL { READ COMMITTED | READ UNCOMMITTED | SERIALIZABLE | REPEATABLE
READ }
    | { READ WRITE | READ ONLY }
   } [, ...]
 ];
```

## Parameter Description

- **declare_statements**

  Declares a variable, including its name and type, for example, **sales_cnt int**.

- **execution_statements**

  Specifies the statement to be executed in an anonymous block.

  Value range: an existing function name

## Examples

```
-- Generate a string using an anonymous block.
openGauss=# BEGIN
dbe_output.print_line('Hello');
END;
/
```

## Helpful Links

12.14.168 START TRANSACTION

# 12.14.42 CALL

## Function

**CALL** calls defined functions and stored procedures.

## Precautions

The owner of a function or stored procedure, users granted with the **EXECUTE** permission on the function or stored procedure, or users granted with the **EXECUTE ANY FUNCTION** permission can call the function or stored procedure. The system administrator has the permission to call the function or stored procedure by default.

## Syntax

```
CALL [ schema. ] { func_name | procedure_name } ( param_expr );
```

## Parameter Description

- **schema**

  Specifies the name of the schema where a function or stored procedure is located.

- **func_name**

  Specifies the name of the function or stored procedure to be called.

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Value range: an existing role name

- **param_expr**

  Specifies a list of parameters in the function. Use := or => to separate a parameter name and its value. This method allows parameters to be placed in any order. If only parameter values are in the list, the value order must be the same as that defined in the function or stored procedure.

  Value range: an existing function parameter name or stored procedure parameter name

  NOTE

  The parameters include input parameters (whose name and type are separated by **IN**) and output parameters (whose name and type are separated by **OUT**). When you run the **CALL** statement to call a function or stored procedure, the parameter list must contain an output parameter for non-overloaded functions. You can set the output parameter to a variable or any constant. For details, see **Examples**. For an overloaded package function, the parameter list can have no output parameter, but the function may not be found. If an output parameter is contained, it must be a constant.

## Examples

```
-- Create a function func_add_sql, calculate the sum of two integers, and return the result.
openGauss=# CREATE FUNCTION func_add_sql(num1 integer, num2 integer) RETURN integer
AS
BEGIN
RETURN num1 + num2;
END;
/

-- Transfer by parameter value.
openGauss=# CALL func_add_sql(1, 3);

-- Transfer by naming tag method.
openGauss=# CALL func_add_sql(num1 => 1,num2 => 3);
openGauss=# CALL func_add_sql(num2 := 2, num1 := 3);

-- Delete the function.
openGauss=# DROP FUNCTION func_add_sql;

-- Create a function with output parameters.
openGauss=# CREATE FUNCTION func_increment_sql(num1 IN integer, num2 IN integer, res OUT integer)
RETURN integer
AS
BEGIN
res := num1 + num2;
END;
/

-- Transfer a constant as an output parameter.
openGauss=# CALL func_increment_sql(1,2,1);

-- Transfer a variable as an output parameter.
openGauss=# DECLARE
res int;
BEGIN
func_increment_sql(1, 2, res);
dbe_output.print_line(res);
END;
/
-- Create an overloaded function.
openGauss=# create or replace procedure package_func_overload(col int, col2 out int) package
as
declare
    col_type text;
begin
```

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```
    col := 122;
        dbe_output.print_line('two out parameters ' || col2);
end;
/

openGauss=# create or replace procedure package_func_overload(col int, col2 out varchar)
package
as
declare
   col_type text;
begin
    col2 := '122';
        dbe_output.print_line('two varchar parameters ' || col2);
end;
/
-- Call the function.
openGauss=# call package_func_overload(1, 'test');
openGauss=# call package_func_overload(1, 1);

-- Delete the function.
openGauss=# DROP FUNCTION func_increment_sql;
```

# 12.14.43 CHECKPOINT

## Function

A checkpoint is a point in the transaction log sequence at which all data files have been updated to reflect the information in the log. All data files will be flushed to a disk.

**CHECKPOINT** forces a transaction log checkpoint. By default, WALs periodically specify checkpoints in a transaction log. You may use **gs_guc** to specify run-time parameters **checkpoint_segments**, **checkpoint_timeout**, and **incremental_checkpoint_timeout** to adjust the atomized checkpoint intervals.

## Precautions

- Only the system administrator and O&M administrator can invoke **CHECKPOINT**.
- **CHECKPOINT** forces an immediate checkpoint when the related command is issued, without waiting for a regular checkpoint scheduled by the system.

## Syntax

```
CHECKPOINT;
```

## Parameter Description

None

## Examples

```
-- Set a checkpoint.
openGauss=# CHECKPOINT;
```

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# 12.14.44 CLEAN CONNECTION

## Function

Clear idle or invalid network connections between the current CN and other specified CNs or DNs. This statement is used to clear the specified database and idle or invalid connections of a specified user cached in the current CN on a specified CN.

## Precautions

1. In non-force mode, this function only clears connections between database cluster nodes (CNs/DNs) and does not affect client connections.
2. This function clears only idle and invalid connections cached on the CN. Normal connections that are being used are not cleared.
3. This function takes effect only on CNs and does not take effect on DNs.
4. You can query the **PG_STAT_GET_POOLER_STATUS()** function to check the cache connection and verify the clearing effect.
5. You are advised to perform this operation only when the network connection of the database is abnormal.

## Syntax

```
CLEAN CONNECTION
   TO { COORDINATOR ( nodename [, ... ] ) | NODE ( nodename [, ... ] )| ALL [ CHECK ] [ FORCE ] }
   { FOR DATABASE dbname | TO USER username | FOR DATABASE dbname TO USER username };
```

## Parameter Description

- **CHECK**

  This parameter can be specified only when the node list is specified as **TO ALL**. Setting this parameter will check whether a database is accessed by other sessions before its connections are cleared. If any sessions are detected before **DROP DATABASE** is executed, an error will be reported and the database will not be deleted.

- **FORCE**

  This parameter can be specified only when the node list is TO ALL. If this parameter is specified, all threads related to the specified dbname and username in the current CN receive the SIGTERM signal, the corresponding session is forcibly closed, the transaction is terminated, and the network connection is cleared.

- **COORDINATOR ( nodename ,nodename ... } ) | NODE ( nodename , nodename ... ) | ALL**

  This command is used to delete the idle or invalid connections between the current CN node and a specified node. There are three scenarios:

  – **COORDINATOR**: Delete the idle or invalid connections from the current CN to a specified CN.

  – **NODE**: Delete the idle or invalid connections from the current CN to a specified DN.

  – **ALL**: Delete the idle or invalid connections from the current CN to all nodes, including CNs and DNs.

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Value range: **nodename** is an existing node name.

- **dbname**

  Deletes connections to a specified database from the current CN. If this parameter is not specified, connections to all databases will be deleted.

  Value range: an existing database name

- **username**

  Deletes connections to a specified user from the current CN. If this parameter is not specified, connections of all users will be deleted.

  Value range: an existing username

## Examples

```
-- Create user jack.
openGauss=# CREATE USER jack PASSWORD 'xxxxxxxxxx';

-- Delete the idle and invalid connections between the current CN and dn1 and dn2 in the template1 database.
openGauss=# CLEAN CONNECTION TO NODE (dn_6001_6002,dn_6003_6004) FOR DATABASE template1;

-- Delete the idle and invalid connections between the current CN and dn1 that are related to user jack.
openGauss=# CLEAN CONNECTION TO NODE (dn_6001_6002) TO USER jack;

-- Delete the connections between the current CN related to the postgres database and all nodes.
openGauss=# CLEAN CONNECTION TO ALL FORCE FOR DATABASE postgres;

-- Delete user jack.
openGauss=# DROP USER jack;
```

# 12.14.45 CLOSE

## Function

**CLOSE** frees the resources associated with an open cursor.

## Precautions

- After a cursor is closed, no subsequent operations are allowed on it.
- A cursor should be closed when it is no longer needed.
- Every non-holdable open cursor is implicitly closed when a transaction is terminated by **COMMIT** or **ROLLBACK**.
- A holdable cursor is implicitly closed if the transaction that created it aborts by **ROLLBACK**.
- If the cursor creation transaction is successfully committed, the holdable cursor remains open until an explicit **CLOSE** operation is executed, or the client disconnects.
- GaussDB does not have an explicit **OPEN** cursor statement. A cursor is considered open when it is declared. You can view all available cursors by querying the **pg_cursors** system view.

## Syntax

```
CLOSE { cursor_name | ALL } ;
```

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## Parameter Description

- **cursor_name**

  Specifies the name of a cursor to be closed.

- **ALL**

  Closes all open cursors.

## Examples

See **Examples** in **FETCH**.

## Helpful Links

**12.14.139 FETCH** and **12.14.143 MOVE**

# 12.14.46 CLUSTER

## Function

**CLUSTER** is used to cluster a table based on an index.

**CLUSTER** instructs GaussDB to cluster the table specified by **table_name** based on the index specified by **index_name**. The index must have been defined by **table_name**.

When a table is clustered, it is physically reordered based on the index information. Clustering is a one-time operation. When the table is subsequently updated, the changes are not clustered. That is, no attempt is made to store new or updated rows according to their index order.

When a table is clustered, GaussDB records which index the table was clustered by. The form **CLUSTER table_name** reclusters the table using the same index as before. You can also use the **CLUSTER** or **SET WITHOUT CLUSTER** form of **ALTER TABLE** to set the index to be used for future cluster operations, or to clear any previous settings.

**CLUSTER** without any parameter reclusters all the previously-clustered tables in the current database that the calling user owns, or all such tables if called by an administrator.

When a table is being clustered, an **ACCESS EXCLUSIVE** lock is acquired on it. This prevents any other database operations (both read and write) from operating on the table until the **CLUSTER** is finished.

## Precautions

- Only row-store B-tree indexes support **CLUSTER**.
- In the case where you are accessing single rows randomly within a table, the actual order of the data in the table is unimportant. However, if you tend to access some data more than others, and there is an index that groups them together, it is helpful by using **CLUSTER**. If you are requesting a range of indexed values from a table, or a single indexed value that has multiple rows that match, **CLUSTER** will help because once the index identifies the table page for the first row that matches, all other rows that match are probably

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already on the same table page, and so you save disk accesses and speed up the query.

- When an index scan is used, a temporary copy of the table is created that contains the table data in the index order. Temporary copies of each index on the table are created as well. Therefore, you need free space on disk at least equal to the sum of the table size and the total index size.
- Because **CLUSTER** remembers which indexes are clustered, one can cluster the tables manually the first time, then set up a time like **VACUUM** without any parameters, so that the desired tables are periodically reclustered.
- Because the optimizer records statistics about the ordering of tables, it is advisable to run **ANALYZE** on the newly clustered table. Otherwise, the optimizer might make poor choices of query plans.
- **CLUSTER** cannot be executed in transactions.
- If the **xc_maintenance_mode** parameter is not enabled, **CLUSTER** skips all system catalogs.

## Syntax

- Cluster a table.
  ```
  CLUSTER [ VERBOSE ] table_name [ USING index_name ];
  ```
- Cluster a partition.
  ```
  CLUSTER [ VERBOSE ] table_name PARTITION ( partition_name ) [ USING index_name ];
  ```
- Recluster a table.
  ```
  CLUSTER [ VERBOSE ];
  ```

## Parameter Description

- **VERBOSE**

  Enables the display of progress messages.
- **table_name**

  Specifies the table name.

  Value range: an existing table name
- **index_name**

  Specifies the index name.

  Value range: an existing index name
- **partition_name**

  Specifies the partition name.

  Value range: an existing partition name

## Examples

```
-- Create a partitioned table.
openGauss=# CREATE TABLE tpcds.inventory_p1
(
    INV_DATE_SK             INTEGER             NOT NULL,
    INV_ITEM_SK             INTEGER             NOT NULL,
    INV_WAREHOUSE_SK        INTEGER             NOT NULL,
    INV_QUANTITY_ON_HAND    INTEGER
)
DISTRIBUTE BY HASH(INV_ITEM_SK)
PARTITION BY RANGE(INV_DATE_SK)
(
```

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```
    PARTITION P1 VALUES LESS THAN(2451179),
    PARTITION P2 VALUES LESS THAN(2451544),
    PARTITION P3 VALUES LESS THAN(2451910),
    PARTITION P4 VALUES LESS THAN(2452275),
    PARTITION P5 VALUES LESS THAN(2452640),
    PARTITION P6 VALUES LESS THAN(2453005),
    PARTITION P7 VALUES LESS THAN(MAXVALUE)
);

-- Create an index named ds_inventory_p1_index1.
openGauss=# CREATE INDEX ds_inventory_p1_index1 ON tpcds.inventory_p1 (INV_ITEM_SK) LOCAL;

-- Cluster the tpcds.inventory_p1 table.
openGauss=# CLUSTER tpcds.inventory_p1 USING ds_inventory_p1_index1;

-- Cluster the p3 partition.
openGauss=# CLUSTER tpcds.inventory_p1 PARTITION (p3) USING ds_inventory_p1_index1;

-- Cluster the tables that can be clustered in the database.
openGauss=# CLUSTER;

-- Delete the index.
openGauss=# DROP INDEX tpcds.ds_inventory_p1_index1;

-- Drop the partitioned table.
openGauss=# DROP TABLE tpcds.inventory_p1;
```

## Suggestions

- cluster
  - It is recommended that you run **ANALYZE** on a newly clustered table. Otherwise, the optimizer might make poor choices of query plans.
  - **CLUSTER** cannot be executed in transactions.

# 12.14.47 COMMENT

## Function

**COMMENT** defines or changes the comment of an object.

## Precautions

- Each object stores only one comment. Therefore, you need to modify a comment and issue a new **COMMENT** command to the same object. To delete the comment, write **NULL** at the position of the text string. When an object is deleted, the comment is automatically deleted.
- Currently, there is no security protection for viewing comments. Any user connected to a database can view all the comments for objects in the database. For shared objects such as databases, roles, and tablespaces, comments are stored globally so any user connected to any database in the cluster can see all the comments for shared objects. Therefore, do not put security-critical information in comments.
- To comment objects, you must be an object owner or user granted the COMMENT permission. The system administrator has this permission by default.
- Roles do not have owners, so the rule for **COMMENT ON ROLE** is that you must be an administrator to comment on an administrator role, or have the **CREATEROLE** permission to comment on non-administrator roles. A system administrator can comment on all objects.

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## Syntax

```
COMMENT ON
{
  AGGREGATE agg_name (agg_type [, ...] ) |
  CAST (source_type AS target_type) |
  COLLATION object_name |
  COLUMN { table_name.column_name | view_name.column_name } |
  CONSTRAINT constraint_name ON table_name |
  CONVERSION object_name |
  DATABASE object_name |
  DOMAIN object_name |
  EXTENSION object_name |
  FOREIGN DATA WRAPPER object_name |
  FOREIGN TABLE object_name |
  FUNCTION function_name ( [ {[ argname ] [ argmode ] argtype} [, ...] ] ) |
  INDEX object_name |
  LARGE OBJECT large_object_oid |
  OPERATOR operator_name (left_type, right_type) |
  OPERATOR CLASS object_name USING index_method |
  OPERATOR FAMILY object_name USING index_method |
  [ PROCEDURAL ] LANGUAGE object_name |
  ROLE object_name |
  RULE rule_name ON table_name |
  SCHEMA object_name |
  SERVER object_name |
  TABLE object_name |
  TABLESPACE object_name |
  TEXT SEARCH CONFIGURATION object_name |
  TEXT SEARCH DICTIONARY object_name |
  TEXT SEARCH PARSER object_name |
  TEXT SEARCH TEMPLATE object_name |
  TYPE object_name |
  VIEW object_name
}
   IS 'text';
```

## Parameter Description

- **agg_name**

  Specifies the new name of an aggregation function.

- **agg_type**

  Specifies the data type of the aggregation function parameters.

- **source_type**

  Specifies the source data type of the cast.

- **target_type**

  Specifies the target data type of the cast.

- **object_name**

  Specifies the name of an object.

- **table_name.column_name**

  **view_name.column_name**

  Specifies the column whose comment is defined or modified. You can add the table name or view name as the prefix.

- **constraint_name**

  Specifies the table constraint whose comment is defined or modified.

- **table_name**

  Specifies the name of a table.

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- **function_name**

  Specifies the function whose comment is defined or modified.

- **argmode,argname,argtype**

  Specifies the schema, name, and type of the function parameters.

- **large_object_oid**

  Specifies the OID of the large object whose comment is defined or modified.

- **operator_name**

  Specifies the name of the operator.

- **left_type,right_type**

  Specifies the data type of the operator parameters (optionally schema-qualified). If the prefix or suffix operator does not exist, the **NONE** option can be added.

- **text**

  Specifies the comment content.

## Examples

```
openGauss=# CREATE TABLE tpcds.customer_demographics_t2
(
   CD_DEMO_SK               INTEGER               NOT NULL,
   CD_GENDER                CHAR(1)                     ,
   CD_MARITAL_STATUS        CHAR(1)                     ,
   CD_EDUCATION_STATUS      CHAR(20)                    ,
   CD_PURCHASE_ESTIMATE     INTEGER                     ,
   CD_CREDIT_RATING         CHAR(10)                    ,
   CD_DEP_COUNT             INTEGER                     ,
   CD_DEP_EMPLOYED_COUNT    INTEGER                     ,
   CD_DEP_COLLEGE_COUNT     INTEGER
)
WITH (ORIENTATION = COLUMN,COMPRESSION=MIDDLE)
DISTRIBUTE BY HASH (CD_DEMO_SK);

-- Comment out the tpcds.customer_demographics_t2.cd_demo_sk column.
openGauss=# COMMENT ON COLUMN tpcds.customer_demographics_t2.cd_demo_sk IS 'Primary key of
customer demographics table.';

-- Create a view consisting of rows with c_customer_sk less than 150.
openGauss=# CREATE VIEW tpcds.customer_details_view_v2 AS
   SELECT *
   FROM tpcds.customer
   WHERE c_customer_sk < 150;

-- Comment out the tpcds.customer_details_view_v2 view.
openGauss=# COMMENT ON VIEW tpcds.customer_details_view_v2 IS 'View of customer detail';

-- Delete the view.
openGauss=# DROP VIEW tpcds.customer_details_view_v2;

-- Delete tpcds.customer_demographics_t2.
openGauss=# DROP TABLE tpcds.customer_demographics_t2;
```

# 12.14.48 COMMIT | END

## Function

**COMMIT** or **END** commits all operations of a transaction.

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## Precautions

Only the creator of a transaction or a system administrator can run the **COMMIT** command. The creation and commit operations must be in different sessions.

## Syntax

```
{ COMMIT | END } [ WORK | TRANSACTION ] ;
```

## Parameter Description

- **COMMIT | END**

  Commits the current transaction and makes all changes made by the transaction become visible to others.

- **WORK | TRANSACTION**

  Specifies an optional keyword, which has no effect except increasing readability.

## Examples

```
-- Create a table.
openGauss=# CREATE TABLE tpcds.customer_demographics_t2
(
   CD_DEMO_SK               INTEGER               NOT NULL,
   CD_GENDER                CHAR(1)                     ,
   CD_MARITAL_STATUS        CHAR(1)                     ,
   CD_EDUCATION_STATUS      CHAR(20)                    ,
   CD_PURCHASE_ESTIMATE     INTEGER                     ,
   CD_CREDIT_RATING         CHAR(10)                    ,
   CD_DEP_COUNT             INTEGER                     ,
   CD_DEP_EMPLOYED_COUNT    INTEGER                     ,
   CD_DEP_COLLEGE_COUNT     INTEGER
)
WITH (ORIENTATION = COLUMN,COMPRESSION=MIDDLE)
DISTRIBUTE BY HASH (CD_DEMO_SK);

-- Start a transaction.
openGauss=# START TRANSACTION;

-- Insert data.
openGauss=# INSERT INTO tpcds.customer_demographics_t2 VALUES(1,'M', 'U', 'DOCTOR DEGREE', 1200,
'GOOD', 1, 0, 0);
openGauss=# INSERT INTO tpcds.customer_demographics_t2 VALUES(2,'F', 'U', 'MASTER DEGREE', 300,
'BAD', 1, 0, 0);

-- Commit the transaction to make all changes permanent.
openGauss=# COMMIT;

-- Query data.
openGauss=# SELECT * FROM tpcds.customer_demographics_t2;

-- Delete the tpcds.customer_demographics_t2 table.
openGauss=# DROP TABLE tpcds.customer_demographics_t2;
```

## Helpful Links

**12.14.155 ROLLBACK**

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# 12.14.49 COMMIT PREPARED

## Function

**COMMIT PREPARED** commits a prepared two-phase transaction.

## Precautions

- The function is only available in maintenance mode (when GUC parameter **xc_maintenance_mode** is **on**). Exercise caution when enabling the mode. It is used by maintenance engineers for troubleshooting. Common users should not use the mode.
- Only the transaction creators or system administrators can run the **COMMIT PREPARED** command. The creation and commit operations must be in different sessions.
- The transaction function is maintained automatically by the database, and should be not visible to users.

## Syntax

```
COMMIT PREPARED transaction_id ;
COMMIT PREPARED transaction_id WITH CSN;
```

## Parameter Description

- **transaction_id**

  Specifies the identifier of the transaction to be committed. The identifier must be different from those for current prepared transactions.

- **CSN(commit sequence number)**

  Specifies the sequence number of the transaction to be committed. It is a 64-bit, incremental, unsigned number.

## Examples

```
--Commit the transaction whose identifier is trans_test.
openGauss=# COMMIT PREPARED 'trans_test';
```

## Helpful Links

**12.14.147 PREPARE TRANSACTION** and **12.14.156 ROLLBACK PREPARED**

# 12.14.50 COPY

## Function

**COPY** copies data between tables and files.

**COPY FROM** copies data from a file to a table, and **COPY TO** copies data from a table to a file.

## Precautions

- When the **enable_copy_server_files** parameter is disabled, only the initial user is allowed to run the **COPY FROM FILENAME** or **COPY TO FILENAME**

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statement. When the **enable_copy_server_files** parameter is enabled, users with the **SYSADMIN** permission or users who inherit the **gs_role_copy_files** permission of the built-in role are allowed to run the **COPY FROM FILENAME** or **COPY TO FILENAME** statement. By default, database configuration files and key files are not allowed, and you can run **COPY FROM FILENAME** or **COPY TO FILENAME** for certificate files and audit logs to prevent unauthorized users from viewing or modifying sensitive files. When **enable_copy_server_files** is enabled, the administrator can use the GUC parameter **safe_data_path** to set the path for common users to import and export to the subpath of the set path. If this GUC parameter is not set (by default), the path used by common users is not blocked.

- **COPY** applies only to tables but not views.
- **COPY TO** requires the select permission on the table to be read, and **COPY FROM** requires the insert permission on the table to be inserted.
- If a list of columns is specified, **COPY** copies only the data of the specified columns between the file and the table. If a table has any columns that are not in the column list, **COPY FROM** inserts default values for those columns.
- If a data source file is specified, the server must be able to access the file. If **STDIN** is specified, data flows between the client and the server. When entering data, use the **TAB** key to separate the columns of the table and use a backslash and a period (\.) in a new row to indicate the end of the input.
- **COPY FROM** throws an error if any row in the data file contains more or fewer columns than expected.
- The end of the data can be represented by a line that contains only backslashes and periods (\.). If data is read from a file, the end flag is unnecessary. If data is copied between client applications, an end tag must be provided.
- In **COPY FROM**, **\N** is an empty string. To enter the actual value **\N**, use **\\N**.
- **COPY FROM** does not support data preprocessing during data import, such as expression operation and default value filling. If you need to preprocess data during the import, you need to import the data to a temporary table and then run SQL statements to insert the data to the table through operations. However, this method causes I/O expansion and reduces the import performance.
- When a data format error occurs during **COPY FROM** execution, the transaction is rolled back. However, the error information is insufficient, making it difficult to locate the error data from a large amount of raw data.
- **COPY FROM** and **COPY TO** apply to low concurrency and local import and export of a small amount of data.

## Syntax

- Copy data from a file to a table.

```
COPY table_name [ ( column_name [, ...] ) ]
    FROM { 'filename' | STDIN }
    [ [ USING ] DELIMITERS 'delimiters' ]
    [ WITHOUT ESCAPING ]
    [ LOG ERRORS ]
    [ REJECT LIMIT 'limit' ]
    [ [ WITH ] ( option [, ...] ) ]
    | copy_option
    | TRANSFORM  ( { column_name [ data_type ] [ AS transform_expr ] } [, ...] )
```

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```
   | FIXED FORMATTER ( { column_name( offset, length ) } [, ...] ) [ ( option [, ...] ) | copy_option
[  ...] ] ];
```

**NOTE**

In the syntax, **FIXED FORMATTER ( { column_name( offset, length ) } [, ...] )** and non-conflicting items of **[copy_option [...]]** can be in any sequence.

- Copy data from a table to a file.

```
COPY table_name [ ( column_name [, ...] ) ]
   TO { 'filename' | STDOUT }
   [ [ USING ] DELIMITERS 'delimiters' ]
   [ WITHOUT ESCAPING ]
   [ [ WITH ] ( option [, ...] ) ]
   | copy_option
   | FIXED FORMATTER ( { column_name( offset, length ) } [, ...] ) [ ( option [, ...] ) | copy_option
[  ...] ] ];

COPY query
   TO { 'filename' | STDOUT }
   [ WITHOUT ESCAPING ]
   [ [ WITH ] ( option [, ...] ) ]
   | copy_option
   | FIXED FORMATTER ( { column_name( offset, length ) } [, ...] ) [ ( option [, ...] ) | copy_option
[  ...] ] ];
```

**NOTE**

1. The syntax constraints of **COPY TO** are as follows:

   **(query)** is incompatible with **[USING] DELIMITERS**. If the data comes from a query result, **COPY TO** cannot specify **[USING] DELIMITERS**.

2. Use spaces to separate **copy_option** following **FIXED FORMATTTER**.
3. **copy_option** is the native parameter, while **option** is the parameter imported by a compatible foreign table.
4. In the syntax, **FIXED FORMATTER ( { column_name( offset, length ) } [, ...] )** and non-conflicting items of **[ copy_option [...]]** can be in any sequence.

The syntax of the optional parameter **option** is as follows:

```
FORMAT 'format_name'
| OIDS [ boolean ]
| DELIMITER 'delimiter_character'
| NULL 'null_string'
| HEADER [ boolean ]
| FILEHEADER 'header_file_string'
| FREEZE [ boolean ]
| QUOTE 'quote_character'
| ESCAPE 'escape_character'
| EOL 'newline_character'
| NOESCAPING [ boolean ]
| FORCE_QUOTE { ( column_name [, ...] ) | * }
| FORCE_NOT_NULL ( column_name [, ...] )
| ENCODING 'encoding_name'
| IGNORE_EXTRA_DATA [ boolean ]
| FILL_MISSING_FIELDS [ boolean ]
| COMPATIBLE_ILLEGAL_CHARS [ boolean ]
| DATE_FORMAT 'date_format_string'
| TIME_FORMAT 'time_format_string'
| TIMESTAMP_FORMAT 'timestamp_format_string'
| SMALLDATETIME_FORMAT 'smalldatetime_format_string'
```

The syntax of the optional parameter **copy_option** is as follows:

```
OIDS
| NULL 'null_string'
| HEADER
| FILEHEADER 'header_file_string'
| FREEZE
| FORCE_NOT_NULL column_name [, ...]
| FORCE_QUOTE { column_name [, ...] | * }
```

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```
| BINARY
| CSV
| QUOTE [ AS ] 'quote_character'
| ESCAPE [ AS ] 'escape_character'
| EOL 'newline_character'
| ENCODING 'encoding_name'
| IGNORE_EXTRA_DATA
| FILL_MISSING_FIELDS
| COMPATIBLE_ILLEGAL_CHARS
| DATE_FORMAT 'date_format_string'
| TIME_FORMAT 'time_format_string'
| TIMESTAMP_FORMAT 'timestamp_format_string'
| SMALLDATETIME_FORMAT 'smalldatetime_format_string'
```

## Parameter Description

- **query**

  Specifies that the results are to be copied.

  Valid value: a **SELECT** or **VALUES** command in parentheses

- **table_name**

  Specifies the name (possibly schema-qualified) of an existing table.

  Value range: an existing table name

- **column_name**

  Specifies an optional list of columns to be copied.

  Value range: any columns. All columns will be copied if no column list is specified.

- **STDIN**

  Specifies that input comes from the standard input.

- **STDOUT**

  Specifies that output goes to the standard output.

- **FIXED**

  Fixes column length. When the column length is fixed, **DELIMITER**, **NULL**, and **CSV** cannot be specified. When **FIXED** is specified, **BINARY**, **CSV**, and **TEXT** cannot be specified by **option** or **copy_option**.

  NOTE

  The definition of fixed length is as follows:

  1. The column length of each record is the same.
  2. Spaces are used for column padding. Columns of the numeric type are left-aligned and columns of the string type are right-aligned.
  3. No delimiters are used between columns.

- **[USING] DELIMITERS 'delimiters'**

  The string that separates columns within each row (line) of the file, and it cannot be larger than 10 bytes.

  Value range: The delimiter cannot include any of the following characters: \.abcdefghijklmnopqrstuvwxyz0123456789

  Value range: The default value is a tab character in text format and a comma in CSV format.

- **WITHOUT ESCAPING**

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Specifies, in the TEXT format, whether to escape the backslash (\) and its following characters.

Value range: text only

- **LOG ERRORS**

  If this parameter is specified, the error tolerance mechanism for data type errors in the **COPY FROM** statement is enabled. Row errors are recorded in the **public.pgxc_copy_error_log** table in the database for future reference.

  Value range: a value set while data is imported using **COPY FROM**.

  NOTE

  The restrictions of this error tolerance parameter are as follows:

  - This error tolerance mechanism captures only the data type errors (**DATA_EXCEPTION**) that occur during data parsing of **COPY FROM** on a CN. Other errors, such as network errors between CNs and DNs or expression conversion errors on DNs, are not captured.
  - Before enabling error tolerance for **COPY FROM** for the first time in a database, check whether the **public.pgxc_copy_error_log** table exists. If it does not, call the **copy_error_log_create()** function to create it. If it does, copy its data elsewhere, delete it, and call the **copy_error_log_create()** function to create the table. For details about columns in the **public.pgxc_copy_error_log** table, see **Table 12-56**.
  - While a **COPY FROM** statement with specified **LOG ERRORS** is being executed, if **public.pgxc_copy_error_log** does not exist or does not have the table definitions compliant with those predefined in **copy_error_log_create()**, an error will be reported. Ensure that the error table is created using the **copy_error_log_create()** function. Otherwise, **COPY FROM** statements with error tolerance may fail to be run.
  - If existing error tolerance parameters (for example, **IGNORE_EXTRA_DATA**) of the **COPY** statement are enabled, the error of the corresponding type will be processed as specified by the parameters and no error will be reported. Therefore, the error table does not contain such error data.
  - The coverage scope of this error tolerance mechanism is the same as that of a GDS foreign table. You are advised to filter query results based on table names or the timestamp of marking the start of **COPY FROM** statement execution. For details about error handling, see **8.1.7 Handling Import Errors**.

- **LOG ERRORS DATA**

  The differences between **LOG ERRORS DATA** and **LOG ERRORS** are as follows:

  a. **LOG ERRORS DATA** fills the **rawrecord** column in the error tolerance table.

  b. Only users with the **super** permission can use the **LOG ERRORS DATA** parameter.

  CAUTION

  If error content is too complex, it may fail to be written to the error tolerance table by using **LOG ERRORS DATA**, causing the task failure.

  For errors that cannot be read in certain code, the error codes are ERRCODE_CHARACTER_NOT_IN_REPERTOIRE and ERRCODE_UNTRANSLATABLE_CHARACTER. The rawrecord column is not recorded.

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- **REJECT LIMIT 'limit'**

  Used with the **LOG ERROR** parameter to set the upper limit of the tolerated errors in the **COPY FROM** statement. If the number of errors exceeds the limit, later errors will be reported based on the original mechanism.

  Value range: a positive integer (1 to 2147483647) or **unlimited**

  Default value: If **LOG ERRORS** is not specified, an error will be reported. If **LOG ERRORS** is specified, the default value is **0**.

  NOTE

  Different from the GDS error tolerance mechanism, in the error tolerance mechanism described in **LOG ERRORS**, the count of **REJECT LIMIT** is calculated based on the number of data parsing errors on the CN where the **COPY FROM** statement is run, not based on the number of errors on each DN.

- **FORMATTER**

  Defines the place of each column in the data file in fixed length mode. Defines the place of each column in the data file in the **column(***offset*,*length***)** format.

  Value range:

  – The value of **offset** must be larger than 0. The unit is byte.

  – The value of **length** must be larger than 0. The unit is byte.

  The total length of all columns must be less than 1 GB.

  Replace columns that are not in the file with null.

- **OPTION { option_name ' value ' }**

  Specifies all types of parameters of a compatible foreign table.

  – FORMAT

    Specifies the format of the source data file in the foreign table.

    Value range: **CSV**, **TEXT**, **FIXED**, and **BINARY**

    - The CSV file can process newline characters efficiently, but cannot process certain special characters well.
    - The TEXT file can process certain special characters efficiently, but cannot process newline characters well.
    - In FIXED files, the column length of each record is the same. Spaces are used for padding, and the excessive part will be truncated.
    - All data in the BINARY file is stored/read as binary format rather than as text. It is faster than the text and CSV formats, but a binary-format file is less portable.

    Default value: **TEXT**

  – OIDS

    Copies the OID for each row.

    NOTE

    An error is raised if OIDs are specified for a table that does not have OIDs, or in the case of copying a query.

    Value range: **true/on** and **false/off**

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Default value: **false**

– DELIMITER

Specifies the character that separates columns within each row (line) of the file.

NOTE

- The value of **delimiter** cannot be **\r** or **\n**.
- A delimiter cannot be the same as the null value. The delimiter for the CSV format cannot be same as the **quote** value.
- The delimiter for the TEXT format data cannot contain lowercase letters, digits, or special characters (.\).
- The data length of a single row should be less than 1 GB. A row that has many columns using long delimiters cannot contain much valid data.
- You are advised to use multi-character delimiters or invisible delimiters. For example, you can use multi-characters (such as $^&) and invisible characters (such as 0x07, 0x08, and 0x1b).
- To use a tab to isolate CSV data, set **delimiter** to **E'\t'**.

Value range: a multi-character delimiter within 10 bytes

Default value:

- A tab character in text format
- A comma (,) in CSV format
- No delimiter in FIXED format

– NULL

Specifies the string that represents a null value.

Value range:

- A null value cannot be **\r** or **\n**. The maximum length is 100 characters.
- A null value cannot be the same as the **delimiter** or **quote** value.

Default value:

- The default value for the CSV format is an empty string without quotation marks.
- The default value for the TEXT format is **\N**.

– HEADER

Specifies whether a file contains a header with the names of each column in the file. **header** is available only for CSV and FIXED files.

When data is imported, if **header** is **on**, the first row of the data file will be identified as the header and ignored. If **header** is **off**, the first row will be identified as a data row.

When data is exported, if header is **on**, **fileheader** must be specified. If **header** is **off**, an exported file does not contain a header.

Value range: **true/on** and **false/off**

Default value: **false**

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- QUOTE

  Specifies a quoted character string for a CSV file.

  Default value: single quotation marks ('')

  NOTE

  - The value of **quote** cannot be the same as that of the **delimiter** or **null** parameter.
  - The value of **quote** must be a single-byte character.
  - Invisible characters are recommended, such as 0x07, 0x08, and 0x1b.

- ESCAPE

  Specifies an escape character for a CSV file. The value must be a single-byte character.

  Default value: single quotation marks ('') If the value is the same as that of **quote**, it will be replaced by **\0**.

- EOL 'newline_character'

  Specifies the newline character style of the imported or exported data file.

  Value range: multi-character newline characters within 10 bytes. Common newline characters include **\r** (0x0D), **\n** (0x0A), and **\r\n** (0x0D0A). Special newline characters include **$** and **#**.

  NOTE

  - The EOL parameter supports only the TEXT format for data import and export and does not support the CSV or FIXED format for data import. For forward compatibility, the EOL parameter can be set to **0x0D** or **0x0D0A** for data export in the CSV or FIXED format.
  - The value of **EOL** cannot be the same as that of the **delimiter** or **null** parameter.
  - The EOL parameter value cannot contain the following characters: .abcdefghijklmnopqrstuvwxyz0123456789.

- FORCE_QUOTE { ( column_name [, ...] ) | * }

  In **CSV COPY TO** mode, forces quotation marks to be used for all non-null values in each specified column. Null values are not quoted.

  Value range: an existing column name

- FORCE_NOT_NULL ( column_name [, ...] )

  Assigns a value to a specified column in **CSV COPY FROM** mode.

  Value range: an existing column name

- ENCODING

  Specifies that the file is encoded in the **encoding_name**. If this option is omitted, the current encoding format is used by default.

- IGNORE_EXTRA_DATA

  Specifies whether to ignore excessive columns when the number of data source files exceeds the number of foreign table columns. This parameter is used only during data import.

  Value range: **true/on** and **false/off**

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- **true/on**: If the number of columns in a data source file is greater than that defined by the foreign table, the extra columns at the end of a row are ignored.
- **false/off**: If the number of columns in a data source file is greater than that defined by the foreign table, the following error message is reported:
  ```
  extra data after last expected column
  ```

Default value: **false**

**NOTICE**

If a newline character at the end of a row is missing and the row and another row are integrated into one, data in another row is ignored after the parameter is set to **true**.

– COMPATIBLE_ILLEGAL_CHARS

Specifies whether to tolerate invalid characters during data import. The parameter is valid only for data import using **COPY FROM**.

Value range: **true/on** and **false/off**

- **true/on**: No error message is reported and data import is not interrupted when there are invalid characters. Invalid characters are converted into valid ones, and then imported to the database.
- **false/off**: An error occurs when there are invalid characters, and the import stops.

Default value: **false/off**

NOTE

The rules for converting invalid characters are as follows:

1. **\0** is converted to a space.
2. Other invalid characters are converted to question marks.
3. When **compatible_illegal_chars** is set to **true**/**on**, after invalid characters such as **NULL**, **DELIMITER**, **QUOTE**, and **ESCAPE** are converted to spaces or question marks, an error message stating "illegal chars conversion may confuse COPY escape 0x20" will be displayed to remind you of possible parameter confusion caused by the conversion.

– FILL_MISSING_FIELDS

Specifies how to handle the problem that the last column of a row in a source data file is lost during data import.

Value range: **true/on** and **false/off**

Default value: **false/off**

– DATE_FORMAT

Specifies the DATE format for data import. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

Value range: a valid DATE value. For details, see **12.5.8 Date and Time Processing Functions and Operators**.

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NOTE

If Oracle is specified as the compatible database, the DATE format is **TIMESTAMP**. For details, see **timestamp_format** below.

- TIME_FORMAT

  Specifies the TIME format for data import. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

  Value range: a valid TIME value. Time zones cannot be used. For details, see **12.5.8 Date and Time Processing Functions and Operators**.

- TIMESTAMP_FORMAT

  Specifies the TIMESTAMP format for data import. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

  Value range: a valid TIMESTAMP value. Time zones cannot be used. For details, see **12.5.8 Date and Time Processing Functions and Operators**.

- SMALLDATETIME_FORMAT

  Specifies the SMALLDATETIME format for data import. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

  Value range: a valid SMALLDATETIME value. For details, see **12.5.8 Date and Time Processing Functions and Operators**.

- **COPY_OPTION { option_name ' value ' }**

  Specifies all types of native parameters of **COPY**.

  - OIDS

    Specifies the internal OID to be copied for each row.

    NOTE

    An error is raised if OIDs are specified for a table that does not have OIDs, or in the case of copying a query.

  - NULL null_string

    Specifies that a string represents a null value in a data file.

    NOTICE

    When using **COPY FROM**, any data item that matches this string will be stored as a null value, so make sure that you use the same string as you used with **COPY TO**.

    Value range:

    - A null value cannot be **\r** or **\n**. The maximum length is 100 characters.

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- A null value cannot be the same as the **delimiter** or **quote** value.

Default value:

- The default value for the TEXT format is **\N**.
- The default value for the CSV format is an empty string without quotation marks.

– HEADER

Specifies whether a file contains a header with the names of each column in the file. **header** is available only for CSV and FIXED files.

When data is imported, if **header** is **on**, the first row of the data file will be identified as the header and ignored. If **header** is **off**, the first row will be identified as a data row.

When data is exported, if header is **on**, **fileheader** must be specified. If **header** is **off**, an exported file does not contain a header.

– FILEHEADER

Specifies a file that defines the content in the header for exported data. The file contains data description of each column.

**NOTICE**

- This parameter is available only when **header** is **on** or **true**.
- **fileheader** specifies an absolute path.
- The file can contain only one row of header information, and ends with a newline character. Excess rows will be discarded. (Header information cannot contain newline characters.)
- The length of the file including the newline character cannot exceed 1 MB.

– FREEZE

Sets the **COPY** loaded data row as **frozen**, like these data have executed **VACUUM FREEZE**.

This is a performance option of initial data loading. The data will be frozen only when the following three requirements are met:

- The table being loaded has been created or truncated in the same transaction before copying.
- There are no cursors open in the current transaction.
- There are no original snapshots in the current transaction.

**NOTE**

When **COPY** is completed, all the other sessions will see the data immediately. However, this violates the general principle of MVCC visibility, and users should understand that this may cause potential risks.

– FORCE NOT NULL column_name [, ...]

Assigns a value to a specified column in **CSV COPY FROM** mode.

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Value range: an existing column

- FORCE QUOTE { column_name [, ...] | * }

  In **CSV COPY TO** mode, forces quotation marks to be used for all non-null values in each specified column. Null values are not quoted.

  Value range: an existing column name

- BINARY

  Specifies that data is stored and read in binary mode instead of text mode. In binary mode, you cannot declare **DELIMITER**, **NULL**, or **CSV**. When **BINARY** is specified, **CSV**, **FIXED**, and **TEXT** cannot be specified through **option** or **copy_option**.

- CSV

  Enables the CSV mode. When **CSV** is specified, **BINARY**, **FIXED**, and **TEXT** cannot be specified through **option** or **copy_option**.

- QUOTE [AS] 'quote_character'

  Specifies a quoted character string for a CSV file.

  Default value: single quotation marks ('')

  NOTE

  - The value of **quote** cannot be the same as that of the **delimiter** or **null** parameter.
  - The value of **quote** must be a single-byte character.
  - Invisible characters are recommended, such as 0x07, 0x08, and 0x1b.

- ESCAPE [AS] 'escape_character'

  Specifies an escape character for a CSV file. The value must be a single-byte character.

  The default value is single quotation marks (''). If the value is the same as that of **quote**, it will be replaced by **\0**.

- EOL 'newline_character'

  Specifies the newline character style of the imported or exported data file.

  Value range: multi-character newline characters within 10 bytes. Common newline characters include **\r** (0x0D), **\n** (0x0A), and **\r\n** (0x0D0A). Special newline characters include **$** and **#**.

  NOTE

  - The **EOL** parameter supports only the TEXT format for data import and export and does not support the CSV or FIXED format. For forward compatibility, the **EOL** parameter can be set to **0x0D** or **0x0D0A** for data export in the CSV or FIXED format.
  - The value of **EOL** cannot be the same as that of the **delimiter** or **null** parameter.
  - The EOL parameter value cannot contain the following characters: .abcdefghijklmnopqrstuvwxyz0123456789.

- ENCODING 'encoding_name'

  Specifies the name of a file encoding format.

  Value range: a valid encoding format

  Default value: current encoding format

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- IGNORE_EXTRA_DATA

  **true/on**: If the number of columns in a data source file is greater than that defined by the foreign table, the extra columns at the end of a row are ignored. This parameter is used only during data import.

  If this parameter is not used and the number of columns in the data source file is greater than that defined in the foreign table, the following error information is displayed:

  ```
  extra data after last expected column
  ```

- COMPATIBLE_ILLEGAL_CHARS

  Specifies that invalid characters are tolerated during data import. Invalid characters are converted and then imported to the database. No error is reported and the import is not interrupted. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

  If this parameter is not used, an error is reported when invalid characters are encountered during the import, and the import is interrupted.

  NOTE

  The rules for converting invalid characters are as follows:

  1. **\0** is converted to a space.

  2. Other invalid characters are converted to question marks.

  3. When **compatible_illegal_chars** is set to **true**/**on**, after invalid characters such as **NULL**, **DELIMITER**, **QUOTE**, and **ESCAPE** are converted to spaces or question marks, an error message stating "illegal chars conversion may confuse COPY escape 0x20" will be displayed to remind you of possible parameter confusion caused by the conversion.

- FILL_MISSING_FIELDS

  Specifies how to handle the problem that the last column of a row in a source data file is lost during data import.

  Value range: **true/on** and **false/off**

  Default value: **false/off**

  NOTICE

  Do not specify this option. Currently, it does not enable error tolerance, but will make the parser ignore the said errors during data parsing on the CN. Such errors will not be recorded in the **COPY** error table (enabled using **LOG ERRORS REJECT LIMIT**) but will be reported later by DNs. Therefore, do not specify this option.

- DATE_FORMAT 'date_format_string'

  Specifies the DATE format for data import. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

  Value range: a valid DATE value For details, see **12.5.8 Date and Time Processing Functions and Operators**.

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NOTE

If Oracle is specified as the compatible database, the DATE format is **TIMESTAMP**. For details, see **timestamp_format** below.

- TIME_FORMAT 'time_format_string'

  Specifies the TIME format for data import. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

  Value range: a valid TIME value. Time zones are not supported. For details, see **12.5.8 Date and Time Processing Functions and Operators**.

- TIMESTAMP_FORMAT 'timestamp_format_string'

  Specifies the TIMESTAMP format for data import. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

  Value range: a valid TIMESTAMP value. Time zones cannot be used. For details, see **12.5.8 Date and Time Processing Functions and Operators**.

- SMALLDATETIME_FORMAT 'smalldatetime_format_string'

  Specifies the SMALLDATETIME format for data import. The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur. The parameter is valid only for data import using **COPY FROM**.

  Value range: a valid SMALLDATETIME value For details, see **12.5.8 Date and Time Processing Functions and Operators**.

- TRANSFORM ( { column_name [ data_type ] [ AS transform_expr ] } [, ...] )

  Specify the conversion expression of each column in the table. **data_type** specifies the data type of the column in the expression parameter. **transform_expr** is the target expression that returns the result value whose data type is the same as that of the target column in the table. For details about the expression, see **12.6 Expressions**.

NOTE

**COPY FROM** does not support expression conversion for distribution columns.

The following special backslash sequences are recognized by **COPY FROM**:

- **\b**: Backslash (ASCII 8)
- **\f**: Form feed (ASCII 12)
- **\n**: Newline character (ASCII 10)
- **\r**: Carriage return character (ASCII 13)
- **\t**: Tab (ASCII 9)
- **\v**: Vertical tab (ASCII 11)
- **\digits**: Backslash followed by one to three octal digits specifies that the ASCII value is the character with that numeric code.
- **\xdigits**: Backslash followed by an x and one or two hex digits specifies the character with that numeric code.

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## Permission Control Examples

```
openGauss=> copy t1 from '/home/xy/t1.csv';
ERROR:  COPY to or from a file is prohibited for security concerns
HINT:  Anyone can COPY to stdout or from stdin. gsql's \copy command also works for anyone.
openGauss=> grant gs_role_copy_files to xxx;
```

This error occurs because a non-initial user does not have the COPY permission. To solve this problem, enable the **enable_copy_server_files** parameter. Then, the administrator can use the COPY function, and common users need to join the **gs_role_copy_files** group.

## Examples

```
-- Copy the data from tpcds.ship_mode to the /home/omm/ds_ship_mode.dat file:
openGauss=# COPY tpcds.ship_mode TO '/home/omm/ds_ship_mode.dat';

-- Output tpcds.ship_mode to stdout.
openGauss=# COPY tpcds.ship_mode TO stdout;

-- Create the tpcds.ship_mode_t1 table.
openGauss=# CREATE TABLE tpcds.ship_mode_t1
(
    SM_SHIP_MODE_SK           INTEGER               NOT NULL,
    SM_SHIP_MODE_ID           CHAR(16)              NOT NULL,
    SM_TYPE                   CHAR(30)                      ,
    SM_CODE                   CHAR(10)                      ,
    SM_CARRIER                CHAR(20)                      ,
    SM_CONTRACT               CHAR(20)
)
WITH (ORIENTATION = COLUMN,COMPRESSION=MIDDLE)
DISTRIBUTE BY HASH(SM_SHIP_MODE_SK );

-- Copy data from stdin to the tpcds.ship_mode_t1.
openGauss=# COPY tpcds.ship_mode_t1 FROM stdin;

-- Copy data from the /home/omm/ds_ship_mode.dat file to the tpcds.ship_mode_t1 table.
openGauss=# COPY tpcds.ship_mode_t1 FROM '/home/omm/ds_ship_mode.dat';

-- Copy data from the /home/omm/ds_ship_mode.dat file to the tpcds.ship_mode_t1 table, convert the data using the TRANSFORM expression, and insert the 10 characters on the left of the SM_TYPE column into the table.
openGauss=# COPY tpcds.ship_mode_t1 FROM '/home/omm/ds_ship_mode.dat' TRANSFORM (SM_TYPE AS LEFT(SM_TYPE, 10));

-- Copy data from the /home/omm/ds_ship_mode.dat file to the tpcds.ship_mode_t1 table, with the import format set to TEXT (format 'text'), the delimiter set to \t' (delimiter E'\t'), excessive columns ignored (ignore_extra_data 'true'), and characters not escaped (noescaping 'true').
openGauss=# COPY tpcds.ship_mode_t1 FROM '/home/omm/ds_ship_mode.dat' WITH(format 'text', delimiter E'\t', ignore_extra_data 'true', noescaping 'true');

-- Copy data from the /home/omm/ds_ship_mode.dat file to the tpcds.ship_mode_t1 table, with the import format set to FIXED, fixed-length format specified (FORMATTER(SM_SHIP_MODE_SK(0, 2), SM_SHIP_MODE_ID(2,16), SM_TYPE(18,30), SM_CODE(50,10), SM_CARRIER(61,20), SM_CONTRACT(82,20))), excessive columns ignored (ignore_extra_data), and headers included (header).
openGauss=# COPY tpcds.ship_mode_t1 FROM '/home/omm/ds_ship_mode.dat' FIXED FORMATTER(SM_SHIP_MODE_SK(0, 2), SM_SHIP_MODE_ID(2,16), SM_TYPE(18,30), SM_CODE(50,10), SM_CARRIER(61,20), SM_CONTRACT(82,20)) header ignore_extra_data;

-- Delete tpcds.ship_mode_t1.
openGauss=# DROP TABLE tpcds.ship_mode_t1;
```

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# 12.14.51 CREATE APP WORKLOAD GROUP MAPPING

## Function

**ALTER APP WORKLOAD GROUP MAPPING** creates an application mapping group and associates it with an existing workload group.

## Precautions

Only a user with the **CREATE** permission on the current database can perform this operation.

## Syntax

```
CREATE APP WORKLOAD GROUP MAPPING app_name
    [ WITH ( WORKLOAD_GPNAME  = workload_gpname ) ];
```

## Parameter Description

- **app_name**

  Specifies the name of an application mapping group. The name of an application mapping group must be unique in the current database.

  Value range: a string. It must comply with the naming convention.

- **workload_gpname**

  Specifies the workload group name.

  Value range: a string, which indicates the created workload group.

## Examples

```
-- Create a resource pool and specify the High Timeshare Workload Cgroup under the DefaultClass Cgroup.
openGauss=# CREATE RESOURCE POOL pool1 WITH (CONTROL_GROUP="High");

-- Create a workload group and associate it with the created resource pool.
openGauss=# CREATE WORKLOAD GROUP group1 USING RESOURCE POOL pool1;

-- Create an application mapping group and associate it with the created workload group.
openGauss=# CREATE APP WORKLOAD GROUP MAPPING app_wg_map1 WITH
(WORKLOAD_GPNAME=group1);

-- Create a default application mapping group and associate it with the default workload group.
openGauss=# CREATE APP WORKLOAD GROUP MAPPING app_wg_map2;

-- Delete the application mapping group.
openGauss=# DROP APP WORKLOAD GROUP MAPPING app_wg_map1;
openGauss=# DROP APP WORKLOAD GROUP MAPPING app_wg_map2;

-- Delete the workload group.
openGauss=# DROP WORKLOAD GROUP group1;

-- Delete the resource pool.
openGauss=# DROP RESOURCE POOL pool1;
```

## Helpful Links

**12.14.2 ALTER APP WORKLOAD GROUP MAPPING** and **12.14.97 DROP APP WORKLOAD GROUP MAPPING**

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# 12.14.52 CREATE AUDIT POLICY

## Function

**CREATE AUDIT POLICY** creates a unified audit policy.

## Precautions

Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.

The masking policy takes effect only after the security policy is enabled, that is, **enable_security_policy** is set to **on**. For details, see "Database Configuration > Database Security Management Policies > Unified Auditing" in the *Security Hardening Guide*.

## Syntax

```
CREATE AUDIT POLICY [ IF NOT EXISTS ] policy_name { { privilege_audit_clause | access_audit_clause }
[ filter_group_clause ] [ ENABLE | DISABLE ] };
```

- privilege_audit_clause
  ```
  PRIVILEGES { DDL | ALL } [ ON LABEL ( resource_label_name [, ... ] ) ]
  ```
- access_audit_clause
  ```
  ACCESS { DML | ALL } [ ON LABEL ( resource_label_name [, ... ] ) ]
  ```
- filter_group_clause
  ```
  FILTER ON { ( FILTER_TYPE ( filter_value [, ... ] ) ) [, ... ] }
  ```

## Parameter Description

- **policy_name**

  Specifies the audit policy name, which must be unique.

  Value range: a string. It must comply with the naming convention.

- **DDL**

  Specifies the operations that are audited within the database: **CREATE**, **ALTER**, **DROP**, **ANALYZE**, **COMMENT**, **GRANT**, **REVOKE**, **SET**, **SHOW**, **LOGIN_ANY**, **LOGIN_FAILURE**, **LOGIN_SUCCESS**, and **LOGOUT**.

- **ALL**

  Indicates all operations supported by the specified DDL statements in the database.

- **resource_label_name**

  Specifies the resource label name.

- **DML**

  Specifies the operations that are audited within the database: **SELECT**, **COPY**, **DEALLOCATE**, **DELETE**, **EXECUTE**, **INSERT**, **PREPARE**, **REINDEX**, **TRUNCATE**, and **UPDATE**.

- **FILTER_TYPE**

  Specifies the types of information to be filtered by the policy, including **APP**, **ROLES**, and **IP**.

- **filter_value**

  Indicates the detailed information to be filtered.

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- **ENABLE|DISABLE**

  Enables or disables the unified audit policy. If **ENABLE|DISABLE** is not specified, **ENABLE** is used by default.

## Examples

```
-- Create users dev_audit and bob_audit.
openGauss=# CREATE USER dev_audit PASSWORD 'dev@1234';
openGauss=# CREATE USER bob_audit password 'bob@1234';

-- Create table tb_for_audit.
openGauss=# CREATE TABLE tb_for_audit(col1 text, col2 text, col3 text);

-- Create a resource label.
openGauss=# CREATE RESOURCE LABEL adt_lb0 add TABLE(tb_for_audit);

-- Perform the CREATE operation on the database to create an audit policy.
openGauss=# CREATE AUDIT POLICY adt1 PRIVILEGES CREATE;

-- Perform the SELECT operation on the database to create an audit policy.
openGauss=# CREATE AUDIT POLICY adt2 ACCESS SELECT;

-- Create an audit policy to audit only the CREATE operations performed on the adt_lb0 resource by users dev_audit and bob_audit.
openGauss=# CREATE AUDIT POLICY adt3 PRIVILEGES CREATE ON LABEL(adt_lb0) FILTER ON ROLES(dev_audit, bob_audit);

-- Create an audit policy to audit only the SELECT, INSERT, and DELETE operations performed on the adt_lb0 resource by users dev_audit and bob_audit using client tools psql and gsql on the servers whose IP addresses are 10.20.30.40 and 127.0.0.0/24.
openGauss=# CREATE AUDIT POLICY adt4 ACCESS SELECT ON LABEL(adt_lb0), INSERT ON LABEL(adt_lb0), DELETE FILTER ON ROLES(dev_audit, bob_audit), APP(psql, gsql), IP('10.20.30.40', '127.0.0.0/24');
```

## Helpful Links

**12.14.3 ALTER AUDIT POLICY** and **12.14.98 DROP AUDIT POLICY**

# 12.14.53 CREATE BARRIER

## Function

**CREATE BARRIER** creates a barrier for cluster nodes. The barrier can be used for data restoration.

## Precautions

Generally, **CREATE BARRIER** is used only for backup and restoration. Therefore, **CREATE BARRIER** can be executed only in the following scenarios:

- The database initial user can run this command.
- If the backup and restoration mode is enabled on the CN, that is, the GUC parameter **operation_mode** is set to **on**, users with the **OPRADMIN** permission can run this command.

## Syntax

```
CREATE BARRIER [ barrier_name  ] ;
```

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## Parameter Description

**barrier_name**

(Optional) Specifies the name of a barrier.

Value range: a string. It must comply with the naming convention.

## Examples

```
-- Create a barrier without specifying its name.
openGauss=# CREATE BARRIER;

-- Specify the barrier name.
openGauss=# CREATE BARRIER 'barrier1';
```

# 12.14.54 CREATE CLIENT MASTER KEY

## Function

**CREATE CLIENT MASTER KEY** creates a CMK object that can be used to encrypt a CEK object.

## Precautions

This syntax is specific to a fully-encrypted database.

When using gsql to connect to a database server, you need to use the **-C** parameter to enable the fully-encrypted database.

In the CMK object created using this syntax, only the method for reading keys from independent key management tools, services, or components is stored. The key itself is not stored.

## Syntax

```
CREATE CLIENT MASTER KEY client_master_key_name WITH (KEY_STORE = key_store_name, KEY_PATH =
"key_path_value", ALGORITHM = algorithm_type);
```

## Parameter Description

- **client_master_key_name**

  This parameter is used as the name of a key object. In the same namespace, the value of this parameter must be unique.

  Value range: a string. It must comply with the identifier naming convention.

- **KEY_STORE**

  Tool or service that independently manages keys. Currently, only the key management tool gs_ktool provided by GaussDB and the online key management service huawei_kms provided by Huawei Cloud are supported.
  Value range: **gs_ktool** and **huawei_kms**

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**NOTICE**

Because only the client interacts with **KEY_STORE**, the types supported by the **KEY_STORE** parameter in this syntax vary according to the client. When gsql is used to execute this syntax, **KEY_STORE** supports only gs_ktool. When JDBC is used to execute this syntax, **KEY_STORE** supports only huawei_kms.

- **KEY_PATH**

  Key in the key management tool or service. The **KEY_STORE** and **KEY_PATH** parameters can be used to uniquely identify a key entity. When **KEY_STORE** is set to **gs_ktool**, the value is **gs_ktool** or **KEY_ID**. When **KEY_STORE** is set to **huawei_kms**, the value is a 36-byte key ID.

  **NOTE**

  The CMK object created by this syntax stores the **KEY_STORE** and **KEY_PATH** information. When the key entity needs to be read, GaussDB can automatically read the specified key entity from the specified **KEY_STORE** based on the information stored in the CMK object. Therefore, in this syntax, the **KEY_PATH** parameter should point to an existing key entity.

- **ALGORITHM**

  Encryption algorithm used by the key entity. When **KEY_STORE** is set to **gs_ktool**, the value can be **AES_256_CBC** or **SM4**. When **KEY_STORE** is set to **huawei_kms**, the value is **AES_256**.

## Example (Using gsql to Connect to the Database Server)

```
-- (1) Use the key management tool gs_ktool to create a key. The tool returns the ID of the newly generated key.
[cmd] gs_ktool -g

-- (2) Use a privileged account to create a common user named alice.
openGauss=# CREATE USER alice PASSWORD '********';
-- (3) Use a common account alice to connect to the encrypted database and execute the syntax.
gsql -p 57101 postgres -U alice -r -C
gsql((GaussDB Kernel VxxxRxxxCxx build f521c606) compiled at 2021-09-16 14:55:22 commit 2935 last mr 6385 release)
Non-SSL connection (SSL connection is recommended when requiring high-security)
Type "help" for help.

openGauss=>

-- Create a CMK object.
openGauss=> CREATE CLIENT MASTER KEY alice_cmk WITH ( KEY_STORE = gs_ktool , KEY_PATH = "gs_ktool/1" , ALGORITHM = AES_256_CBC);
```

## Example (Using JDBC to Connect to the Database Server)

```
/*
 * (1) Log in to the Huawei Cloud official website (https://www.huaweicloud.com), choose Console > Service List > Data Encryption Workshop > Key Management Service, and create a key.
 *     KMS is a key management service provided by Huawei Cloud. You can also use APIs to manage keys. For details, see the following public document of Huawei Cloud:
 *    (https://support.huaweicloud.com/dew_faq/dew_01_0053.html)
 */

/*
 * (2) Establish a connection to the database server and execute the syntax. In the URL, set enable_ce to 1.
 *      Note: The code in this section is used as an example. Consider using the minimum code to implement the most basic functions.
 */
```

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```
import java.sql.*;

public class CrtCmkTest {
    public static void main(String[] args) {
        String driver = "org.postgresql.Driver";
        try {
            Class.forName(driver);
        } catch (Exception e) {
            e.printStackTrace();
            return;
        }

        /* Information used to establish a connection to the database server */
        String dbUrl = "jdbc:postgresql://localhost:19900/postgres?enable_ce=1";
        String dbUser = "alice";
        String dbPassword = "********";

       /*
        * Used to access the identity authentication information of Huawei Cloud KMS and KMS project information.
        * Note: All parameters in this part can be found on the page displayed after you choose Console > My Credential on the Huawei Cloud official website.
        */
        String iamUser = "alice_for_kms";
        String iamPassword = "********";
        String kmsDomain = "hw00000000";
        String kmsProjectName = "cn-east-3";
        String kmsProjectId = "00000000000000000000000000000000";

        /* SQL statement for creating a CMK object */
        String sql = "CREATE CLIENT MASTER KEY alice_cmk WITH ( " +
         "KEY_STORE = huawei_kms, KEY_PATH = \"00000000-0000-0000-0000-000000000000\" , ALGORITHM = AES_256);";

        try {
            Connection conn = DriverManager.getConnection(dbUrl, dbUser, dbPassword);
            conn.setClientInfo("iamUser", iamUser);
            conn.setClientInfo("iamPassword", iamPassword);
            conn.setClientInfo("kmsDomain", kmsDomain);
            conn.setClientInfo("kmsProjectName", kmsProjectName);
            conn.setClientInfo("kmsProjectId", kmsProjectId );
            Statement stmt = conn.createStatement();
            System.out.println("results: " + stmt.executeUpdate(sql));
        } catch (SQLException e) {
            e.printStackTrace();
        }
    }
}
```

# 12.14.55 CREATE COLUMN ENCRYPTION KEY

## Function

**CREATE COLUMN ENCRYPTION KEY** creates a CEK that can be used to encrypt a specified column in a table.

## Precautions

This syntax is specific to a fully-encrypted database.

When using **gsql** to connect to a database server, you need to use the **-C** parameter to enable the fully-encrypted database.

The CEK object created using this syntax can be used for column-level encryption. When defining a column in a table, you can specify a CEK object to encrypt the column.

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## Syntax

```
CREATE COLUMN ENCRYPTION KEY column_encryption_key_name WITH VALUES(CLIENT_MASTER_KEY =
client_master_key_name, ALGORITHM = algorithm_type, ENCRYPTED_VALUE = encrypted_value);
```

## Parameter Description

- **column_encryption_key_name**

  This parameter is used as the name of a key object. In the same namespace, the value of this parameter must be unique.

  Value range: a string. It must comply with the naming convention.

- **CLIENT_MASTER_KEY**

  Specifies the CMK used to encrypt the CEK. The value is the CMK object name, which is created using the **CREATE CLIENT MASTER KEY** syntax.

- **ALGORITHM**

  Encryption algorithm to be used by the CEK. The value can be **AEAD_AES_256_CBC_HMAC_SHA256**, **AEAD_AES_128_CBC_HMAC_SHA256**, or **SM4_SM3**.

- **ENCRYPTED_VALUE (optional)**

  Specifies the key password defined by the user. The key password contains 28 to 256 characters. The security strength of a key containing 28 characters complies with AES128. If AES256 is used, the key password must contain 39 characters. If this parameter is not specified, a 256-bit key is automatically generated.

**NOTICE**

- SM algorithm constraints: SM2, SM3, and SM4 are Chinese national cryptography standards. To avoid legal risks, these algorithms must be used together. If you specify the SM4 algorithm to encrypt CEKs when creating a CMK, you must specify the SM3 and SM4 algorithms (SM4_SM3) to encrypt data when creating CEKs.
- Constraints on the **ENCRYPTED_VALUE** field: If the CMK generated by Huawei KMS is used to encrypt the CEK and the **ENCRYPTED_VALUE** field is used to transfer the key in the **CREATE COLUMN ENCRYPTION KEY** syntax, the length of the input key must be an integer multiple of 16 bytes.

## Examples

```
-- Create a CEK.
openGauss=> CREATE COLUMN ENCRYPTION KEY a_cek WITH VALUES (CLIENT_MASTER_KEY = a_cmk,
ALGORITHM  = AEAD_AES_256_CBC_HMAC_SHA256);
CREATE COLUMN ENCRYPTION KEY
openGauss=> CREATE COLUMN ENCRYPTION KEY another_cek WITH VALUES (CLIENT_MASTER_KEY =
a_cmk, ALGORITHM  = SM4_SM3);
CREATE COLUMN ENCRYPTION KEY
```

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# 12.14.56 CREATE CONVERSION

## Function

**CREATE CONVERSION** defines a new conversion between two character set encodings.

## Precautions

- The **DEFAULT** parameter indicates that the conversion between the source encoding and the target encoding is executed by default between the client and the server. To support this usage, bidirectional conversion must be defined, that is, both conversion from A to B and conversion from B to A are supported.
- To perform conversion, you must have the EXECUTE permission on function and the CREATE permission on the target schema.
- SQL_ASCII cannot be used for either source encoding or target encoding because the server behavior is hardwired when SQL_ASCII "encoding" is involved.
- You can remove user-defined conversions using DROP CONVERSION.

## Syntax

```
CREATE [ DEFAULT ] CONVERSION name
    FOR source_encoding TO dest_encoding FROM function_name
```

## Parameter Description

- **DEFAULT**

  Specifies that the conversion is the default conversion from the source encoding to the target encoding. There should be only one default conversion for each encoding pair in a schema.

- **name**

  Specifies the name of the conversion, which can be restricted by the schema. If not restricted by a schema, the conversion is defined in the current schema. The conversion name must be unique in a schema.

- **source_encoding**

  Source encoding name.

- **dest_encoding**

  Target encoding name.

- **function_name**

  Function used for conversion. A function name can be restricted by a schema. If not, the function is found in the path.

  ```
  conv_proc(
      integer, -- Source encoding ID
      integer, -- Target encoding ID
      cstring, -- Source character string (C character string ending with a null value)
      internal,-- Target (filled with a null-terminated C character string)
      integer  -- Length of the source string
  ) RETURNS void;
  ```

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## Example

```
-- Use myfunc to create an encoding conversion from UTF8 to LATIN1.
CREATE CONVERSION myconv FOR 'UTF8' TO 'LATIN1' FROM myfunc;
```

# 12.14.57 CREATE DATABASE

## Function

**CREATE DATABASE** is used to create a database. By default, the new database will be created only by cloning the standard system database **template0**.

## Precautions

- A user that has the **CREATEDB** permission or a system administrator can create a database.
- **CREATE DATABASE** cannot be executed inside a transaction block.
- If an error message similar to "could not initialize database directory" is displayed during database creation, the possible cause is that the permission on the data directory in the file system is insufficient or the disk is full.

## Syntax

```
CREATE DATABASE database_name
   [ [ WITH ] { [ OWNER [=] user_name ] |
            [ TEMPLATE [=] template ] |
            [ ENCODING [=] encoding ] |
            [ LC_COLLATE [=] lc_collate ] |
            [ LC_CTYPE [=] lc_ctype ] |
            [ DBCOMPATIBILITY [=] compatibilty_type ] |
            [ TABLESPACE [=] tablespace_name ] |
            [ CONNECTION LIMIT [=] connlimit ]}[...] ];
```

## Parameter Description

- **database_name**

  Specifies the database name.

  Value range: a string. It must comply with the naming convention.

- **OWNER [ = ] user_name**

  Specifies the owner of the new database. If omitted, the default owner is the current user.

  Value range: an existing username

- **TEMPLATE [ = ] template**

  Specifies a template name. That is, the template from which the database is created. GaussDB creates a database by copying data from a template database. GaussDB has two default template databases **template0** and **template1** and a default user database **postgres**.

  Value range: **template0**

- **ENCODING [ = ] encoding**

  Specifies the character encoding used by the database. The value can be a string (for example, **SQL_ASCII**) or an integer.

  If this parameter is not specified, the encoding of the template database is used by default. By default, the codes of the template databases **template0**

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and **template1** are related to the operating system environment. The character encoding of **template1** cannot be changed. To change the encoding, use **template0** to create a database.

Common values are **GBK**, **UTF8**, **Latin1**, and **GB18030**. The supported character sets are as follows:

**Table 12-119** Supported character sets

| Name | Description | Language | Server-side Encoding | ICU Support | Number of Bytes/ Characters | Alias |
|---|---|---|---|---|---|---|
| BIG5 | Big Five | Traditional Chinese | No | No | 1–2 | WIN950, Windows950 |
| EUC_CN | Extended UNIX Code-CN | Simplified Chinese | Yes | Yes | 1–3 | - |
| EUC_JP | Extended UNIX Code-JP | Japanese | Yes | Yes | 1–3 | - |
| EUC_JIS_2004 | Extended UNIX Code-JP, JIS X 0213 | Japanese | Yes | No | 1–3 | - |
| EUC_KR | Extended UNIX Code-KR | Korean | Yes | Yes | 1–3 | - |
| EUC_TW | Extended UNIX Code-Taiwan, China | Traditional Chinese | Yes | Yes | 1–3 | - |
| GB18030 | National standards | Chinese | Yes | No | 1–4 | - |
| GBK | Extended national standards | Simplified Chinese | Yes | No | 1–2 | WIN936, Windows936 |

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| Name | Description | Language | Server-side Encoding | ICU Support | Number of Bytes/ Characters | Alias |
|---|---|---|---|---|---|---|
| ISO_8859_5 | ISO 8859-5, ECMA 113 | Latin/ Cyrillic | Yes | Yes | 1 | - |
| ISO_8859_6 | ISO 8859-6, ECMA 114 | Latin/ Arabic | Yes | Yes | 1 | - |
| ISO_8859_7 | ISO 8859-7, ECMA 118 | Latin/ Greek | Yes | Yes | 1 | - |
| ISO_8859_8 | ISO 8859-8, ECMA 121 | Latin/ Hebrew | Yes | Yes | 1 | - |
| JOHAB | JOHAB | Korean | No | No | 1–3 | - |
| KOI8R | KOI8-R | Cyrillic (Russian) | Yes | Yes | 1 | KOI8 |
| KOI8U | KOI8-U | Cyrillic (Ukrainian) | Yes | Yes | 1 | - |
| LATIN1 | ISO 8859-1, ECMA 94 | Western European languages | Yes | Yes | 1 | ISO88591 |
| LATIN2 | ISO 8859-2, ECMA 94 | Central European languages | Yes | Yes | 1 | ISO88592 |
| LATIN3 | ISO 8859-3, ECMA 94 | South European languages | Yes | Yes | 1 | ISO88593 |

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| Name | Description | Language | Server-side Encoding | ICU Support | Number of Bytes/ Characters | Alias |
|---|---|---|---|---|---|---|
| LATIN4 | ISO 8859-4, ECMA 94 | North European languages | Yes | Yes | 1 | ISO8859 4 |
| LATIN5 | ISO 8859-9, ECMA 128 | Turkish | Yes | Yes | 1 | ISO8859 9 |
| LATIN6 | ISO 8859-10, ECMA 144 | Germanic languages | Yes | Yes | 1 | ISO8859 10 |
| LATIN7 | ISO 8859-13 | Baltic languages | Yes | Yes | 1 | ISO8859 13 |
| LATIN8 | ISO 8859-14 | Celtic languages | Yes | Yes | 1 | ISO8859 14 |
| LATIN9 | ISO 8859-15 | LATIN1 with Euro and accents | Yes | Yes | 1 | ISO8859 15 |
| LATIN10 | ISO 8859-16, ASRO SR 14111 | Romanian | Yes | No | 1 | ISO8859 16 |
| MULE_INTERNAL | Mule internal code | Multilingual Emacs | Yes | No | 1–4 | - |
| SJIS | Shift JIS | Japanese | No | No | 1–2 | Mskanji, ShiftJIS, WIN932, Windows932 |
| SHIFT_JIS_2004 | Shift JIS, JIS X 0213 | Japanese | No | No | 1–2 | - |

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| Name | Description | Language | Server-side Encoding | ICU Support | Number of Bytes/ Characters | Alias |
|---|---|---|---|---|---|---|
| SQL_ASCII | Unspecified (see the text) | *Any* | Yes | No | 1 | - |
| UHC | Unified Hangul Code | Korean | No | No | 1–2 | WIN949, Windows949 |
| UTF8 | Unicode, 8-bit | ***All*** | Yes | Yes | 1–4 | Unicode |
| WIN866 | Windows CP866 | Cyrillic | Yes | Yes | 1 | ALT |
| WIN874 | Windows CP874 | Thai | Yes | No | 1 | - |
| WIN1250 | Windows CP1250 | Central European languages | Yes | Yes | 1 | - |
| WIN1251 | Windows CP1251 | Cyrillic | Yes | Yes | 1 | WIN |
| WIN1252 | Windows CP1252 | Western European languages | Yes | Yes | 1 | - |
| WIN1253 | Windows CP1253 | Greek | Yes | Yes | 1 | - |
| WIN1254 | Windows CP1254 | Turkish | Yes | Yes | 1 | - |
| WIN1255 | Windows CP1255 | Hebrew | Yes | Yes | 1 | - |
| WIN1256 | Windows CP1256 | Arabic | Yes | Yes | 1 | - |

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| Name | Description | Language | Server-side Encoding | ICU Support | Number of Bytes/ Characters | Alias |
|---|---|---|---|---|---|---|
| WIN1257 | Windows CP1257 | Baltic languages | Yes | Yes | 1 | - |
| WIN1258 | Windows CP1258 | Vietnamese | Yes | Yes | 1 | ABC, TCVN, TCVN5712, VSCII |

**CAUTION**

Note that not all client APIs support the preceding character sets.

The SQL_ASCII setting performs quite differently from other settings. If the character set of the server is SQL_ASCII, the server interprets the byte values 0 to 127 according to the ASCII standard. The byte values 128 to 255 are regarded as the characters that cannot be parsed. If this parameter is set to SQL_ASCII, no code conversion occurs. Therefore, this setting is not basically used to declare the specified encoding used, because this declaration ignores the encoding. In most cases, if you use any non-ASCII data, it is unwise to use the SQL_ASCII setting because the database will not be able to help you convert or verify non-ASCII characters.

**NOTICE**

- The character set encoding of the new database must be compatible with the local settings (**LC_COLLATE** and **LC_CTYPE**).
- When the specified character encoding set is **GBK**, some uncommon Chinese characters cannot be directly used as object names. This is because the byte encoding overlaps with the ASCII characters @A-Z[\]^_`a-z{|} when the second byte of the GBK ranges from 0x40 to 0x7E. **@[\]^_'{|}** is an operator in the database. If it is directly used as an object name, a syntax error will be reported. For example, the GBK hexadecimal code is **0x8240**, and the second byte is **0x40**, which is the same as the ASCII character @. Therefore, the character cannot be used as an object name. If you do need to use this function, you can add double quotation marks ("") to avoid this problem when creating and accessing objects.

- **LC_COLLATE [ = ] lc_collate**

  Specifies the character set used by the new database. For example, set this parameter by using **lc_collate = 'zh_CN.gbk'**.

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The use of this parameter affects the sort order of strings (for example, the order of using **ORDER BY** for execution and the order of using indexes on text columns). By default, the sorting order of the template database is used.

Value range: character sets supported by the OS.

- **LC_CTYPE [ = ] lc_ctype**

  Specifies the character class used by the new database. For example, set this parameter by using **lc_ctype = 'zh_CN.gbk'**. The use of this parameter affects the classification of characters, such as uppercase letters, lowercase letters, and digits. By default, the character classification of the template database is used.

  Value range: character classes supported by the OS.

  NOTE

  The value ranges of **lc_collate** and **lc_ctype** depend on the character sets supported by the local environment. For example, in the Linux operating system, you can run the **locale -a** command to obtain the list of character sets supported by the operating system. When using the **lc_collate** and **lc_ctype** parameters, you can select the required character sets and character classes.

- **DBCOMPATIBILITY [ = ] compatibilty_type**

  Specifies the compatible database type. The default value is **MySQL**.

  Value range: **MYSQL**, **TD**, **ORA**, and **PG**. MySQL, Teradata, Oracle and PostgreSQL are compatible, respectively.

  NOTE

  - For ORA compatibility, the database treats empty strings as **NULL** and replaces **DATE** with **TIMESTAMP(0) WITHOUT TIME ZONE**.
  - When a character string is converted to an integer, if the input is invalid, the input will be converted to 0 due to MYSQL compatibility, and an error will be reported due to other compatibility issues.
  - For PG compatibility, CHAR and VARCHAR are counted by character. For other compatibility types, they are counted by byte. For example, for the UTF-8 character set, CHAR(3) can store three Chinese characters in PG compatibility scenarios, but can store only one Chinese character in other compatibility scenarios.

- **TABLESPACE [ = ] tablespace_name**

  Specifies the tablespace of the database.

  Value range: an existing tablespace name

- **CONNECTION LIMIT [ = ] connlimit**

  Specifies the maximum number of concurrent connections that can be made to the new database.

  NOTICE

  - The system administrator is not restricted by this parameter.
  - **connlimit** is calculated for each CN. The number of connections in a cluster is calculated using the following formula: Number of connections in a cluster = **connlimit** x Number of normal CNs.

  Value range: an integer greater than or equal to -1 The default value is **-1**, indicating that there is no limit.

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The restrictions on character encoding are as follows:

- If the locale is set to **C** (or **POSIX**), all encoding types are allowed. For other locale settings, the character encoding must be the same as that of the locale.
- The encoding and region settings must match the template database, except that **template0** is used as a template. This is because other databases may contain data that does not match the specified encoding, or may contain indexes whose sorting order is affected by **LC_COLLATE** and **LC_CTYPE**. Copying this data will invalidate the indexes in the new database. **template0** does not contain any data or indexes that may be affected.

## Examples

```
-- Create users jim and tom.
openGauss=# CREATE USER jim PASSWORD 'xxxxxxxxxx';
openGauss=# CREATE USER tom PASSWORD 'xxxxxxxxxx';

-- Create database music using GBK (the local encoding type is also GBK).
openGauss=# CREATE DATABASE music ENCODING 'GBK' template = template0;

-- Create database music2 and specify user jim as its owner.
openGauss=# CREATE DATABASE music2 OWNER jim;

-- Create database music3 using template template0 and specify user jim as its owner.
openGauss=# CREATE DATABASE music3 OWNER jim TEMPLATE template0;

-- Set the maximum number of connections to database music to 10.
openGauss=# ALTER DATABASE music CONNECTION LIMIT= 10;

-- Rename database music to music4.
openGauss=# ALTER DATABASE music RENAME TO music4;

-- Change the owner of database music2 to user tom.
openGauss=# ALTER DATABASE music2 OWNER TO tom;

-- Delete the database.
openGauss=# DROP DATABASE music2;
openGauss=# DROP DATABASE music3;
openGauss=# DROP DATABASE music4;

-- Delete the jim and tom users.
openGauss=# DROP USER jim;
openGauss=# DROP USER tom;

-- Create a database compatible with the TD format.
openGauss=# CREATE DATABASE td_compatible_db DBCOMPATIBILITY 'TD';

-- Create a database compatible with the ORA format.
openGauss=# CREATE DATABASE ora_compatible_db DBCOMPATIBILITY 'ORA';

-- Delete the databases that are compatible with the TD and ORA formats.
openGauss=# DROP DATABASE td_compatible_db;
openGauss=# DROP DATABASE ora_compatible_db;
```

## Helpful Links

**12.14.5 ALTER DATABASE** and **12.14.101 DROP DATABASE**

## Suggestions

- **create database**

  Database cannot be created in a transaction.

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- **ENCODING**

  If the new database Encoding does not match the template database (SQL_ASCII) (**'GBK'**, **'UTF8'**, **'LATIN1'**, or **'GB18030'**), **template [=] template0** must be specified.

# 12.14.58 CREATE DATA SOURCE

## Function

**CREATE DATA SOURCE** creates an external data source object, which defines the information about the database that GaussDB will connect to.

## Precautions

- The data source name must be unique in the database and comply with the identifier naming rules. Its length cannot exceed 63 bytes. Otherwise, it will be truncated.
- Only the system administrator or initial user has the permission to create data sources. The user who creates the object is the default owner of the object.
- If the **password** option is displayed, ensure that the **datasource.key.cipher** and **datasource.key.rand** files exist in the *$GAUSSHOME*/**bin** directory of each node in the cluster. If the two files do not exist, use the **gs_guc** tool to generate them and use the **gs_ssh** tool to release them to the *$GAUSSHOME*/**bin** directory on each node in the cluster.

## Syntax

```
CREATE DATA SOURCE src_name
   [TYPE 'type_str']
   [VERSION {'version_str' | NULL}]
   [OPTIONS (optname 'optvalue' [, ...])];
```

## Parameter Description

- **src_name**

  Specifies the name of the new data source, which must be unique in the database.

  Value range: a string. It must comply with the naming convention.

- **TYPE**

  Specifies the type of the data source. This parameter can be left empty, and its default value will be used.

  Value range: an empty string or a non-empty string

- **VERSION**

  Specifies the version number of the new data source object. This parameter can be left empty or set to null.

  Value range: an empty string, a non-empty string, or null

- **OPTIONS**

  Specifies the options of the data source object. This parameter can be left empty or specified using the following keywords:

  – optname

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Specifies the option name.

Value range: **dsn**, **username**, **password**, and **encoding**. The value is case-insensitive.

- **dsn** corresponds to the DSN in the ODBC configuration file.
- **username** and **password** indicate the username and password for connecting to the destination database.

  The user name and password entered by the user are encrypted in the GaussDB background to ensure security. The key file required for encryption must be generated using the **gs_guc** tool and released to the *$GAUSSHOME*/**bin** directory of each node in the cluster using the **gs_ssh** tool. **username** and **password** shall not contain the prefix **encryptOpt**. Otherwise, the values of **username** and **password** will be considered as encrypted ciphertext.
- **encoding** indicates the character string encoding mode used for interaction with the destination database (including the sent SQL statements and returned data of the character type). Its validity is not checked during object creation. Whether data can be encoded and decoded depends on whether the encoding you specified can be used in the database.

– optvalue

Specifies the option value.

Value range: an empty string or a non-empty string

## Examples

```
-- Create an empty data source object that does not contain any information.
openGauss=# CREATE DATA SOURCE ds_test1;

-- Create a data source object with TYPE information and VERSION being null.
openGauss=# CREATE DATA SOURCE ds_test2 TYPE 'MPPDB' VERSION NULL;

-- Create a data source object that contains only OPTIONS.
openGauss=# CREATE DATA SOURCE ds_test3 OPTIONS (dsn 'GaussDB', encoding 'utf8');

-- Create a data source object that contains TYPE, VERSION, and OPTIONS.
openGauss=# CREATE DATA SOURCE ds_test4 TYPE 'unknown' VERSION '11.2.3' OPTIONS (dsn 'GaussDB',
username 'userid', password 'pwd@123456', encoding '');

-- Delete the data source object.
openGauss=# DROP DATA SOURCE ds_test1;
openGauss=# DROP DATA SOURCE ds_test2;
openGauss=# DROP DATA SOURCE ds_test3;
openGauss=# DROP DATA SOURCE ds_test4;
```

## Helpful Links

**12.14.6 ALTER DATA SOURCE** and **12.14.102 DROP DATA SOURCE**

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# 12.14.59 CREATE DIRECTORY

## Function

**CREATE DIRECTORY** creates a directory. The directory defines an alias for a path in the server file system and is used to store data files used by users. Users can read and write these files through the **dbe_file** advanced package.

The read and write permissions for the directory can be granted to specified users to provide permission control for **dbe_file**.

## Precautions

- When **enable_access_server_directory** is set to **off**, only the initial user is allowed to create directory objects. When **enable_access_server_directory** is set to **on**, the user with the SYSADMIN permission and the user who inherits the **gs_role_directory_create** permission of the built-in role can create directory objects.
- By default, the user who creates a directory has the read and write permissions on the directory.
- The default owner of a directory is the user who creates the directory.
- A directory cannot be created for the following paths:
  - The path contains special characters.
  - The path is a relative path.
  - The path is a symbolic link.
- The following validity check is performed during directory creation:
  - Check whether the path exists in the OS. If it does not exist, a message is displayed, indicating the potential risks.
  - Check whether the database initial user **omm** has the read, write, and execution permissions on the created directory. If the user does not have all the permissions, a message is displayed, indicating the potential risks.
- In a cluster, ensure that the path is the same on all the nodes. Otherwise, the path may fail to be found on some nodes when the directory is used.

## Syntax

```
CREATE [OR REPLACE] DIRECTORY directory_name
AS 'path_name';
```

## Parameter Description

- **directory_name**

  Specifies name of a directory.

  Value range: a string. It must comply with the naming convention.

- **path_name**

  Specifies the OS path for which a directory is to be created.

  Value range: a valid OS path

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## Examples

```
-- Create a directory.
openGauss=# CREATE OR REPLACE DIRECTORY  dir  as '/tmp/';
```

## Helpful Links

**12.14.8 ALTER DIRECTORY** and **12.14.103 DROP DIRECTORY**

# 12.14.60 CREATE FOREIGN TABLE (for Import and Export)

**CREATE FOREIGN TABLE** creates a GDS foreign table.

## Function

**CREATE FOREIGN TABLE** creates a GDS foreign table in the current database for concurrent data import and export. The GDS foreign table can be read-only or write-only, used for concurrent data import and export, respectively. The OBS foreign table is read-only by default.

## Precautions

- The foreign table is owned by the user who runs the statement.
- The distribution mode of a GDS foreign table does not need to be explicitly specified. The default mode is **ROUNDROBIN**.
- All constraints (including column and row constraints) are invalid to the GDS foreign table.
- When multi-layer quotation marks are used for sensitive columns (such as **password** and **secret_access_key**) in OPTIONS, the semantics is different from that in the scenario where quotation marks are not used. Therefore, sensitive columns are not identified for anonymization.

## Syntax

```
CREATE FOREIGN TABLE [ IF NOT EXISTS  ] table_name
   ( [ { column_name type_name POSITION ( offset, length ) | LIKE source_table } [, ...] ] )
   SERVER gsmpp_server
   OPTIONS (  { option_name ' value '  }  [, ...] )
   [ { WRITE ONLY  |  READ ONLY  }]
   [ WITH error_table_name | LOG INTO error_table_name]
   [REMOTE LOG 'name']
   [PER NODE REJECT LIMIT 'value']
   [ TO { GROUP groupname | NODE ( nodename [, ... ] ) } ];
```

## Parameter Overview

**CREATE FOREIGN TABLE** provides multiple parameters, which are classified as follows:

- Mandatory parameters
  - **table_name**
  - **column_name**
  - **type_name**
  - **SERVER gsmpp_server**

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  - **OPTIONS**
- Optional parameters
  - Data source location parameter in foreign tables: **location**
  - Data format parameters
    - **format**
    - **header** (only for CSV and FIXED source data files)
    - **fileheader** (only for CSV and FIXED source data files)
    - **out_filename_prefix**
    - **delimiter**
    - **quote** (only for CSV source data files)
    - **escape** (only for CSV source data files)
    - **null**
    - **noescaping** (only for TEXT source data files)
    - **encoding**
    - **eol**
  - Error-tolerance parameters
    - **fill_missing_fields**
    - **ignore_extra_data**
    - **reject_limit**
    - **compatible_illegal_chars**
    - **WITH error_table_name**
    - **LOG INTO error_table_nam...**
    - **REMOTE LOG 'name'**
    - **PER NODE REJECT LIMIT 'v...**

## Parameter Description

- **IF NOT EXISTS**

  Sends a notice, but does not throw an error, if a table with the same name exists.
- **table_name**

  Specifies the name of a foreign table.

  Value range: a string. It must comply with the naming convention.
- **column_name**

  Specifies the name of a column in the foreign table.

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Value range: a string. It must comply with the naming convention.

- **type_name**

  Specifies the data type of the column.

- **POSITION(offset,length)**

  Defines the place of each column in the data file in fixed length mode.

  NOTE

  **offset** is the start of the column in the source file, and **length** is the length of the column.

  Value range: **offset** must be greater than 0, and its unit is byte.

  The length of each record must be less than or equal to 1 GB. By default, columns not in the file are replaced with null.

- **SERVER gsmpp_server**

  Specifies the server name of the foreign table. For the GDS foreign table, its server is created by the initial database, which is **gsmpp_server**.

- **OPTIONS ( { option_name ' value ' } [, ...] )**

  Specifies all types of parameters of foreign table data.

  – location

    Specifies the data source location of the foreign table, which can be expressed through URLs or in local files. Separate URLs and local files with vertical bars (|).

    NOTE

    - For a read-only foreign table imported by GDS from a remote server in parallel, its URL must end with its corresponding schema or file name. (Read-only is the default file attribute.)

      For example: **gsfs://192.168.0.90:5000/***, **file:///data/data.txt**, or **gsfs:// 192.168.0.90:5000/* | gsfs:// 192.168.0.91:5000/***.

    - For a writable foreign table exported by GDS to a remote server in parallel, its URL does not need to contain a file name. If the data source is local, for example, **file:///data/**, only one data source in the foreign table can be specified, and the hosting directory must be created in advance on each node. If the data source location is a remote URL, for example, **gsfs:// 192.168.0.90:5000/**, multiple data sources can be specified. If the number of exported data file locations is less than or equal to the number of DNs, when you use the foreign table for export, data is evenly distributed to each data source location. If the number of exported data file locations is greater than the number of DNs, when you export data, the data is evenly distributed to data source locations corresponding to the DNs. Blank data files are created on the excess data source locations.
    - For a read-only foreign table imported by GDS from a remote server in parallel, the number of URLs must be less than the number of DNs, and URLs in the same location cannot be used.
    - If the URL begins with **gsfss://**, data is imported and exported in encryption mode, and DOP cannot exceed 10.

  – format

    Specifies the format of the data source file in a foreign table.

    Value range: **CSV**, **TEXT**, and **FIXED**. The default value is **TEXT**.

    ▪ In CSV files, escape sequences are processed as common strings. Therefore, newline characters are processed as data.

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- In TEXT files, escape sequences are processed as they are. Therefore, newline characters are not processed as data.
- In FIXED files, the column length of each record is the same and spaces are used for padding.

NOTE

- An escape sequence is a string starting with a backslash (\), including **\b** (backspace), **\f** (form feed), **\n** (new line), **\r** (carriage return), **\t** (horizontal tab), **\v** (vertical tab), *****digit* (octal number), and **\x***digit* (hexadecimal number). In TEXT files, strings are processed as they are. In files of other formats, strings are processed as data.
- **FIXED** is defined as follows (**POSITION** must be specified for each column when **FIXED** is used.):
  1. The column length of each record is the same.
  2. Spaces are used for column padding. Columns of the numeric type are left-aligned and columns of the string type are right-aligned.
  3. No delimiters are used between columns.

– header

Specifies whether a file contains a header with the names of each column in the file. **header** is available only for CSV and FIXED files.

When data is imported, if **header** is **on**, the first row of the data file will be identified as the header and ignored. If **header** is **off**, the first row will be identified as a data row.

When data is exported, if header is **on**, **fileheader** must be specified. **fileheader** is used to specify the export header file format. If **header** is **off**, an exported file does not contain a header.

Value range: **true/on** and **false/off** The default value is **false/off**.

– fileheader

Specifies a file that defines the content in the header for exported data. The file contains one row of data description of each column.

For example, to add a header in a file containing product information, define the file as follows:

The information of products.\n

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**NOTICE**

- This parameter is available only when **header** is **on** or **true**. The file must be prepared in advance.
- In **Remote** mode, the definition file must be put to the working directory of the GDS (the **-d** directory specified when the GDS is started).
- In **Local** mode, the definition file must be put to the same path of each node, and **fileheader** specifies the absolute path.
- The file can contain only one row of header information, and end with a newline character. Excess rows will be discarded. (Header information cannot contain newline characters).
- The length of the file including the newline character cannot exceed 1 MB.

– out_filename_prefix

Specifies the name prefix of the data file exported using GDS from a write-only foreign table.

**NOTICE**

- The file name prefix must be valid and compliant with the restrictions of the file system in the physical environment where the GDS is deployed. Otherwise, the file will fail to be created.
  - The prefix of the specified export file name does not contain invalid characters, including but not limited to: '/', '?', '*', ':', '|', '\\', '<', '>', '@', '#', '$', '&', '(', ')', '+', '-'. The allowed characters are [a-z]*[A-Z]*[0-9]* and '_'.
  - The file name prefix cannot contain feature columns reserved for the Windows and Linux OS, including but not limited to:

    "con", "aux", "nul", "prn", "com0", "com1", "com2", "com3", "com4", "com5", "com6", "com7", "com8", "com9", "lpt0", "lpt1", "lpt2", "lpt3", "lpt4", "lpt5", "lpt6", "lpt7", "lpt8", and "lpt9".
  - The total length of the absolute path consisting of the exported file prefix, the path specified by **gds –d**, and **.dat.x** should be as required by the file system where GDS is deployed.
  - It is required that the prefix can be correctly parsed and identified by the receiver (including but not limited to the original database where it was exported) of the data file. Identify and modify the option that causes the file name resolution problem (if any).
- To concurrently perform export jobs, do not use the same file name prefix for them. Otherwise, the exported files may overwrite each other or be lost in the OS or file system.

– delimiter

Specifies the column delimiter of data. Use the default delimiter if it is not set. The default delimiter in the TEXT format is a tab and that in the CSV format is a comma (,). No delimiter is used in the FIXED format.

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NOTE

- The value of **delimiter** cannot be **\r** or **\n**.
- A delimiter cannot be the same as the null value. The delimiter for the CSV format cannot be same as the **quote** value.
- The delimiter of TEXT data cannot contain any of the following characters: \.abcdefghijklmnopqrstuvwxyz0123456789.
- The data length of a single row should be less than 1 GB. A row that has many columns using long delimiters cannot contain much valid data.
- You are advised to use a multi-character, such as the combination of the dollar sign ($), caret (^), and ampersand (&), or invisible characters, such as 0x07, 0x08, and 0x1b as the delimiter.

Value range:

The value of **delimiter** can be a multi-character delimiter whose length is less than or equal to 10 bytes.

– quote

Specifies which characters in a CSV source data file will be quoted. The default value is single quotation marks ('').

NOTE

- The value of **quote** cannot be the same as that of the **delimiter** or **null** parameter.
- The value of **quote** must be a single-byte character.
- Invisible characters are recommended, such as 0x07, 0x08, and 0x1b.

– escape

Specifies which characters in a CSV source data file are escape characters. Escape characters can only be single-byte characters.

The default value is single quotation marks (''). If the value is the same as that of **quote**, it will be replaced by **\0**.

– null

Specifies the string that represents a null value.

NOTE

- A null value cannot be **\r** or **\n**. The maximum length is 100 characters.
- A null value cannot be the same as the **delimiter** or **quote** value.

Value range:

- The default value is **\n** for the TEXT format.
- The default value for the CSV format is an empty string without quotation marks.

– noescaping

Specifies, in the TEXT format, whether to escape the backslash (\) and its following characters.

NOTE

**noescaping** is available only for TEXT source data files.

Value range: **true/on** and **false/off** The default value is **false/off**.

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- encoding

  Specifies the encoding of a data file, that is, the encoding used to parse, check, and generate a data file. Its default value is the default **client_encoding** value of the current database.

  Before you import foreign tables, it is recommended that you set **client_encoding** to the file encoding format, or a format matching the character set of the file. Otherwise, parsing and check errors may occur, leading to import errors, rollback, or even invalid data import. In a foreign table used for export, you are also advised to set this parameter because the export result using the default character set may not be what you expected.

  If this parameter is not specified when you create a foreign table, a warning message will be displayed on the client.

  NOTE

  Currently, GDS foreign tables cannot parse data files using multiple encoding formats during data import and cannot write such data files during data export.

- fill_missing_fields

  Specifies how to handle the problem that the last column of a row in a source data file is lost during data import.

  Value range: **true/on** and **false/off** The default value is **false/off**.

  - **true/on**: If the last column in a row of a data source file is missing during data loading, the column is set to null and no import error message is reported.
  - **false/off**: If the last column in a row of a data source file is missing during data import, the following error message is reported:
    ```
    missing data for column "tt"
    ```

- ignore_extra_data

  Specifies whether to ignore excessive columns when the number of data source files exceeds the number of foreign table columns. This parameter is used only during data import.

  Value range: **true/on** and **false/off** The default value is **false/off**.

  - **true/on**: If the number of columns in a data source file is greater than that defined by the foreign table, the extra columns at the end of a row are ignored.
  - **false/off**: If the number of columns in a data source file is greater than that defined by the foreign table, the following error message is reported:
    ```
    extra data after last expected column
    ```

NOTICE

If a newline character at the end of a row is missing and the row and another row are integrated into one, data in another row is ignored after the parameter is set to **true**.

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- reject_limit

  Specifies the maximum number of data format errors allowed during a data import task. If the number of errors does not reach the maximum number, the data import task can still be executed.

  **NOTICE**

  You are advised to replace this syntax with **PER NODE REJECT LIMIT 'value'**.

  Data format errors include the following: a column is lost, an extra column exists, a data type is incorrect, and encoding is incorrect. Once a non-data-format error occurs, the whole data import process is stopped.

  Value range: a positive integer or **unlimited**

  The default value is **0**, indicating that error information is returned immediately.

  **NOTE**

  Enclose positive integer values with single quotation marks ('').

- mode

  Specifies the data import policy during a specific data import process.

  Value range:

  - **Normal** (default): supports all file types (CSV, TEXT, FIXED). Enable GDS to help data import.
  - **Shared**: supports the TEXT format. It does not need assistance from GDS, but requires that all the user data be mounted to the same path of the same nodes through NFS.
  - **Private**: User data has been stored in the same local directories of DNs.

- eol

  Specifies the newline character style of the imported or exported data file.

  Value range: multi-character newline characters within 10 bytes. Common newline characters include **\r** (0x0D), **\n** (0x0A), and **\r\n** (0x0D0A). Special newline characters include **$** and **#**.

  **NOTE**

  - The **eol** parameter supports only the TEXT format for data import and export and does not support the CSV or FIXED format for data import. For forward compatibility, the **EOL** parameter can be set to **0x0D** or **0x0D0A** for data export in the CSV or FIXED format.
  - The value of **EOL** cannot be the same as that of the **delimiter** or **null** parameter.
  - The **EOL** parameter value cannot contain the following characters: .abcdefghijklmnopqrstuvwxyz0123456789.

- fix

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Specifies the length of fixed-length data. The unit is byte. This syntax is available only for READ ONLY foreign tables.

Value range: less than 1 GB, and greater than or equal to the total length specified by **POSITION** (The total length is the sum of **offset** and **length** in the last column of the table definition.)

- out_fix_alignment

  Specifies how the columns of the types BYTEAOID, CHAROID, NAMEOID, TEXTOID, BPCHAROID, VARCHAROID, NVARCHAR2OID, and CSTRINGOID are aligned during fixed-length export.

  Value range: **align_left** and **align_right**

  Default value: **align_right**

**NOTICE**

The bytea data type must be in hexadecimal format (for example, \XXXX) or octal format (for example, \XXX\XXX\XXX). The data to be imported must be left-aligned (that is, the column data starts with either of the two formats instead of spaces). Therefore, if the exported file needs to be imported using a GDS foreign table and the file data length is less than that specified by the foreign table formatter, the exported file must be left aligned. Otherwise, an error is reported during the import.

- date_format

  Specifies the DATE format for data import. This syntax is available only for READ ONLY foreign tables.

  Value range: a valid DATE value For details, see **12.5.8 Date and Time Processing Functions and Operators**.

  NOTE

  If Oracle is specified as the compatible database, the DATE format is **TIMESTAMP**. For details, see **timestamp_format** below.

- time_format

  Specifies the TIME format for data import. This syntax is available only for READ ONLY foreign tables.

  Value range: a valid TIME value. Time zones are not supported. For details, see **12.5.8 Date and Time Processing Functions and Operators**.

- timestamp_format

  Specifies the TIMESTAMP format for data import. This syntax is available only for READ ONLY foreign tables.

  Value range: a valid TIMESTAMP value. Time zones cannot be used. For details, see **12.5.8 Date and Time Processing Functions and Operators**.

- smalldatetime_format

  Specifies the SMALLDATETIME format for data import. This syntax is available only for READ ONLY foreign tables.

  Value range: a valid SMALLDATETIME value For details, see **12.5.8 Date and Time Processing Functions and Operators**.

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– compatible_illegal_chars

Specifies whether to tolerate invalid characters during data import. This syntax is available only for READ ONLY foreign tables.

Value range: **true/on** and **false/off** The default value is **false/off**.

- **true/on**: No error message is reported and data import is not interrupted when there are invalid characters. Invalid characters are converted into valid ones, and then imported to the database.
- **false/off**: An error occurs when there are invalid characters, and the import stops.

NOTE

The rules for converting invalid characters are as follows:

1. **\0** is converted to a space.

2. Other invalid characters are converted to question marks.

3. When **compatible_illegal_chars** is set to **true/on**, after invalid characters such as **NULL**, **DELIMITER**, **QUOTE**, and **ESCAPE** are converted to spaces or question marks, an error message stating "illegal chars conversion may confuse COPY escape 0x20" will be displayed to remind you of possible parameter confusion caused by the conversion.

- **READ ONLY**

  Specifies whether a foreign table is read-only. This parameter is available only for data import.

- **WRITE ONLY**

  Specifies whether a foreign table is write-only. This parameter is available only for data import.

- **WITH error_table_name**

  Specifies the table where data format errors generated during parallel data import are recorded. You can query the error information table after data is imported to obtain error details. This parameter is available only after **reject_limit** is set.

  NOTE

  To be compatible with PostgreSQL open source interfaces, you are advised to replace this syntax with **LOG INTO**.

  Value range: a string. It must comply with the naming convention.

- **LOG INTO error_table_name**

  Specifies the table where data format errors generated during parallel data import are recorded. You can query the error information table after data is imported to obtain error details.

  NOTE

  This parameter is available only after **PER NODE REJECT LIMIT** is set.

  Value range: a string. It must comply with the naming convention.

- **REMOTE LOG 'name'**

  Specifies that the data format error information is saved as files in GDS. **name** is the prefix of the error data file.

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- **PER NODE REJECT LIMIT 'value'**

  Specifies the maximum number of data format errors allowed on each DN during data import. If the number of errors exceeds the specified value on any DN, data import fails, an error is reported, and the system exits data import.

  **NOTICE**

  This syntax specifies the error tolerance of a single node.

  Data format errors include the following: a column is lost, an extra column exists, a data type is incorrect, and encoding is incorrect. Once a non-data-format error occurs, the whole data import process is stopped.

  Value range: an integer or **unlimited**. The default value is 0, indicating that error information is returned immediately.

- **TO { GROUP groupname | NODE ( nodename [, ... ] ) }**

  Currently, **TO GROUP** is not supported. **TO NODE** is used for internal scale-out tools.

## Examples

```
-- Create a foreign table to import data from GDS servers 192.168.0.90 and 192.168.0.91 in text format. Record errors that occur during data import to the err_HR_staffS table.
openGauss=# CREATE FOREIGN TABLE foreign_HR_staffS
(
  staff_ID       NUMBER(6) ,
  FIRST_NAME     VARCHAR2(20),
  LAST_NAME      VARCHAR2(25),
  EMAIL          VARCHAR2(25),
  PHONE_NUMBER   VARCHAR2(20),
  HIRE_DATE      DATE,
  employment_ID  VARCHAR2(10),
  SALARY         NUMBER(8,2),
  COMMISSION_PCT NUMBER(2,2),
  MANAGER_ID     NUMBER(6),
  section_ID  NUMBER(4)
) SERVER gsmpp_server OPTIONS (location 'gsfs://192.168.0.90:5000/* | gsfs://192.168.0.91:5000/*', format 'TEXT', delimiter E'\x20',  null '') WITH err_HR_staffS;
-- Create a foreign table to import data from GDS servers 192.168.0.90 and 192.168.0.91 in text format and record error messages in the import process to the err_HR_staffS table. A maximum of two data format errors are allowed during the import.
CREATE FOREIGN TABLE foreign_HR_staffS_ft3
(
  staff_ID       NUMBER(6) ,
  FIRST_NAME     VARCHAR2(20),
  LAST_NAME      VARCHAR2(25),
  EMAIL          VARCHAR2(25),
  PHONE_NUMBER   VARCHAR2(20),
  HIRE_DATE      DATE,
  employment_ID  VARCHAR2(10),
  SALARY         NUMBER(8,2),
  COMMISSION_PCT NUMBER(2,2),
  MANAGER_ID     NUMBER(6),
  section_ID  NUMBER(4)
) SERVER gsmpp_server OPTIONS (location 'gsfs://192.168.0.90:5000/* | gsfs://192.168.0.91:5000/*', format 'TEXT', delimiter E'\x20',  null '',reject_limit '2') WITH err_HR_staffS_ft3;
-- Create a foreign table to import all files in the input_data directory in CSV format.
openGauss=# CREATE FOREIGN TABLE foreign_HR_staffS_ft1
(
  staff_ID       NUMBER(6) ,
  FIRST_NAME     VARCHAR2(20),
  LAST_NAME      VARCHAR2(25),
```

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```
  EMAIL          VARCHAR2(25),
  PHONE_NUMBER   VARCHAR2(20),
  HIRE_DATE      DATE,
  employment_ID  VARCHAR2(10),
  SALARY         NUMBER(8,2),
  COMMISSION_PCT NUMBER(2,2),
  MANAGER_ID     NUMBER(6),
  section_ID     NUMBER(4)
) SERVER gsmpp_server OPTIONS (location 'file:///input_data/*', format 'csv', mode 'private', delimiter ',')
WITH err_HR_staffS_ft1;
```

```
-- Create a foreign table to export data to the output_data directory in CSV format.
openGauss=# CREATE FOREIGN TABLE foreign_HR_staffS_ft2
(
  staff_ID       NUMBER(6) ,
  FIRST_NAME     VARCHAR2(20),
  LAST_NAME      VARCHAR2(25),
  EMAIL          VARCHAR2(25),
  PHONE_NUMBER   VARCHAR2(20),
  HIRE_DATE      DATE,
  employment_ID  VARCHAR2(10),
  SALARY         NUMBER(8,2),
  COMMISSION_PCT NUMBER(2,2),
  MANAGER_ID     NUMBER(6),
  section_ID  NUMBER(4)
) SERVER gsmpp_server OPTIONS (location 'file:///output_data/', format 'csv', delimiter '|', header 'on')
WRITE ONLY;
```

```
-- Delete the foreign table.
openGauss=# DROP FOREIGN TABLE foreign_HR_staffS;
openGauss=# DROP FOREIGN TABLE foreign_HR_staffS_ft1;
openGauss=# DROP FOREIGN TABLE foreign_HR_staffS_ft2;
openGauss=# DROP FOREIGN TABLE foreign_HR_staffS_ft3;
```

## Helpful Links

**12.14.9 ALTER FOREIGN TABLE (for Import and Export)** and **12.14.104 DROP FOREIGN TABLE**

## Suggestions

- delimiter
  - A delimiter cannot be **\r** or **\n**, or the same as the null value. The delimiter of CSV data cannot be same as the **quote** value.
  - The data length of a single row should be less than 1 GB. A row that has many columns using long delimiters cannot contain much valid data.
  - You are advised to use a multi-character, such as the combination of the dollar sign ($), caret (^), and ampersand (&), or invisible characters, such as 0x07, 0x08, and 0x1b as the delimiter.
- quote
  - The value of **quote** cannot be the same as that of the **delimiter** or null parameter. The value must be a single-byte character.
  - Invisible characters are recommended, such as 0x07, 0x08, and 0x1b.
- mode Normal
  - Supports all file types (including CSV, TEXT, and FIXED). To import data, you need to enable GDS on the data server.
- mode Shared

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  - Supports the TEXT format. It does not need assistance from GDS, but requires that all the user data be mounted to the same path of the same nodes through NFS.
- mode Private
  - This mode is used when user data has been stored in the same local directories of DNs.

# 12.14.61 CREATE FUNCTION

## Function

**CREATE FUNCTION** creates a function.

## Precautions

- If the parameters or return values of a function have precision, the precision is not checked.
- When creating a function, you are advised to explicitly specify the schemas of tables in the function definition. Otherwise, the function may fail to be executed.
- **current_schema** and **search_path** specified by **SET** during function creation are invalid. **search_path** and **current_schema** before and after function execution should be the same.
- If a function has output parameters, the **SELECT** statement uses the default values of the output parameters when calling the function. When the **CALL** statement calls the function, it requires that the output parameters must be specified. When the **CALL** statement calls an overloaded **PACKAGE** function, it can use the default values of the output parameters. For details, see examples in **12.14.42 CALL**.
- Only the functions compatible with PostgreSQL or those with the **PACKAGE** attribute can be overloaded. After **REPLACE** is specified, a new function is created instead of replacing a function if the number of parameters, parameter type, or return value is different.
- You can use the **SELECT** statement to specify different parameters using identical functions, but cannot use the **CALL** statement to call identical functions without the **PACKAGE** attribute.
- When you create a function, you cannot insert other agg functions out of the avg function or other functions.
- In non-logical cluster mode, return values, parameters, and variables cannot be set to the tables of the Node Groups that are not installed in the system by default. The internal statements of SQL functions cannot be executed on such tables.
- In logical cluster mode, if return values and parameters of the function are user tables, all the tables must be in the same logical cluster. If the function body involves operations on multiple logical cluster tables, the function cannot be set to **IMMUTABLE** or **SHIPPABLE**, preventing the function from being pushed down to a DN. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)
- In logical cluster mode, the parameters and return values of the function cannot use **%type** to reference a table column type. Otherwise, the function

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will fail to be created. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

- By default, the permissions to execute new functions are granted to **PUBLIC**. For details, see **12.14.140 GRANT**. By default, a user inherits the permissions of the **PUBLIC** role. Therefore, other users also have the permission to execute a function and view the definition of the function. In addition, to execute a function, other users must have the USAGE permission on the schema of the function. When creating a function, the user can revoke the default execution permissions from **PUBLIC** and grant them to other users as needed. To avoid the time window during which new functions can be accessed by all users, create functions and set function execution permissions in a transaction. After the database object isolation attribute is enabled, common users can view only the definitions of functions that they have the permission to execute. For details about how to enable the attribute, see *Security Hardening Guide*.
- If a function is defined as an IMMUTABLE or SHIPPABLE function, avoid INSERT, UPDATE, DELETE, MERGE, and DDL operations on the function because the CN needs to determine the execution node for these operations. Otherwise, an error may occur. If DDL operations are performed on a function of the IMMUTABLE or SHIPPABLE type, database objects on each node may be inconsistent. To resolve this problem, create the **VOLATILE plpgsql** function on the CN, run the **EXECUTE** statement in the function definition to dynamically execute the DDL operation for repairing system objects, and then use the EXECUTE DIRECT ON syntax to call the repair function on the specified DN.
- When calling functions without parameters inside another function, you can omit brackets and call functions using their names directly.
- When functions with output parameters are called inside another function which is an assignment expression, you can omit the output parameters of the called functions.
- Oracle-compatible functions support viewing, exporting, and importing parameter comments.
- Oracle-compatible functions support viewing, exporting, and importing comments between IS/AS and plsql_body.
- Users granted with the **CREATE ANY FUNCTION** permission can create or replace functions in the user schemas.
- The default permission on a function is **SECURITY INVOKER**. If you want to change the default permission to **SECURITY DEFINER**, you need to set the GUC parameter **behavior_compat_options** to **'plsql_security_definer'**. For details about the **SECURITY DEFINER** permission, see sections "Database Configuration > Permission Management" in *Security Hardening Guide*.

## Syntax

- Syntax (compatible with PostgreSQL) for creating a customized function:

```
CREATE [ OR REPLACE  ] FUNCTION function_name
    ( [  { argname [ argmode  ] argtype [  { DEFAULT  | :=  | =  } expression  ]}  [, ...]  ] )
    [ RETURNS rettype [ DETERMINISTIC  ]  | RETURNS TABLE (  { column_name column_type  }
[, ...] )]
    LANGUAGE lang_name
    [
      {IMMUTABLE  | STABLE  | VOLATILE }
       | {SHIPPABLE | NOT SHIPPABLE}
       | WINDOW
```

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```
      | [ NOT  ] LEAKPROOF
      | {CALLED ON NULL INPUT  | RETURNS NULL ON NULL INPUT | STRICT }
      | {[ EXTERNAL  ] SECURITY INVOKER | [ EXTERNAL  ] SECURITY DEFINER | AUTHID DEFINER  |
AUTHID CURRENT_USER}
      | {fenced | not fenced}
      | {PACKAGE}

      | COST execution_cost
      | ROWS result_rows
      | SET configuration_parameter { {TO | =} value | FROM CURRENT }}
   ][...]
  {
     AS 'definition'
     | AS 'obj_file', 'link_symbol'
  }
```

- Oracle syntax of creating a customized function:

```
CREATE [ OR REPLACE  ] FUNCTION function_name
   ( [  { argname [ argmode  ] argtype [  { DEFAULT | := | =  } expression  ] }  [, ...]  ] )
   RETURN rettype [ DETERMINISTIC  ]
   [
      {IMMUTABLE  | STABLE  | VOLATILE }
      | {SHIPPABLE | NOT SHIPPABLE}
      | {PACKAGE}
      | {FENCED | NOT FENCED}
      | [ NOT  ] LEAKPROOF
      | {CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT | STRICT }
      | {[ EXTERNAL  ] SECURITY INVOKER  | [ EXTERNAL  ] SECURITY DEFINER |
AUTHID DEFINER | AUTHID CURRENT_USER
}
      | COST execution_cost
      | ROWS result_rows
      | SET configuration_parameter { {TO | =} value  | FROM CURRENT
      | LANGUAGE lang_name
   ][...]

   {
     IS  | AS
} plsql_body
/
```

## Parameter Description

- **function_name**

  Specifies the name of the function to create (optionally schema-qualified).

  Value range: a string. It must comply with the identifier naming convention.

- **argname**

  Specifies the parameter name of the function.

  Value range: a string. It must comply with the identifier naming convention.

- **argmode**

  Specifies the parameter mode of the function.

  Value range: **IN**, **OUT**, **INOUT**, and **VARIADIC**. The default value is **IN**. Only the parameter of the **OUT** mode can be followed by **VARIADIC**. The parameters of **OUT** and **INOUT** cannot be used in the function definition of **RETURNS TABLE**.

  NOTE

  **VARIADIC** specifies parameters of the array type.

- **argtype**

Specifies the data type of a function parameter. You can use **%ROWTYPE** to indirectly reference the type of a table, or **%TYPE** to indirectly reference the type of a column in a table or composite type.

- **expression**

  Specifies the default expression of a parameter.

- **rettype**

  Specifies the return data type. Same as **argtype**, **%TYPE** or **%ROWTYPE** can also be used to indirectly reference types.

  When there is **OUT** or **IN OUT** parameter, the **RETURNS** clause can be omitted. If the clause exists, the result type of the clause must be the same as that of the output parameter. If there are multiple output parameters, the result type of the clause is **RECORD**. Otherwise, the result type of the clause is the same as that of a single output parameter.

  The **SETOF** modifier indicates that the function will return a set of items, rather than a single item.

- **column_name**

  Specifies the column name.

- **column_type**

  Specifies the column type.

- **definition**

  Specifies a string constant defining a function. Its meaning depends on the language. It can be an internal function name, a path pointing to a target file, a SQL query, or text in a procedural language.

- **LANGUAGE lang_name**

  Specifies the name of the language that is used to implement the function. It can be **SQL**, **C**, **internal**, or the name of a customized process language. To ensure downward compatibility, the name can use single quotation marks. Contents in single quotation marks must be capitalized.

  Due to compatibility issues, no matter which language is specified when an O-style database is created, the language used is plpgsql.

- **WINDOW**

  Specifies that the function is a window function. This is currently only useful for functions written in C. The **WINDOW** attribute cannot be changed when replacing an existing function definition.

  **NOTICE**

  For a customized window function, the value of **LANGUAGE** can only be **internal**, and the referenced internal function must be a window function.

- **IMMUTABLE**

  Specifies that the function always returns the same result if the parameter values are the same.

- **STABLE**

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Specifies that the function cannot modify the database, and that within a single table scan it will consistently return the same result for the same parameter value, but its result varies by SQL statements.

- **VOLATILE**

  Specifies that the function value can change in a single table scan and no optimization is performed.

- **SHIPPABLE**

  **NOT SHIPPABLE**

  Specifies whether the function can be pushed down to DNs for execution.

  - Functions of the **IMMUTABLE** type can always be pushed down to DNs.
  - Functions of the **STABLE** or **VOLATILE** type can be pushed down to DNs only if their attribute is **SHIPPABLE**.

---

**NOTICE**

If **SHIPPABLE**/**IMMUABLE** is specified for a function or stored procedure, the function or stored procedure cannot contain **EXCEPTION** or invoke functions or stored procedures that contain **EXCEPTION**.

---

- **PACKAGE**

  Specifies whether the function can be overloaded.

  - All PACKAGE and non-PACKAGE functions cannot be overloaded or replaced.
  - PACKAGE functions do not support parameters of the VARIADIC type.
  - The **PACKAGE** attribute of functions cannot be modified.

- **LEAKPROOF**

  Specifies that the function has no side effects. **LEAKPROOF** can be set only by the system administrator.

- **CALLED ON NULL INPUT**

  Declares that some parameters of the function can be invoked in normal mode if the parameter values are null. This parameter can be omitted.

- **RETURNS NULL ON NULL INPUT**

  **STRICT**

  Specifies that the function always returns null whenever any of its parameters is null. If this parameter is specified, the function is not executed when there are null parameters; instead a null result is returned automatically.

  **RETURNS NULL ON NULL INPUT** and **STRICT** have the same functions.

- **EXTERNAL**

  The keyword **EXTERNAL** is allowed for SQL conformance, but it is optional since, unlike in SQL, this feature applies to all functions not only external ones.

- **SECURITY INVOKER**

  **AUTHID CURRENT_USER**

  Specifies that the function will be executed with the permissions of the user who invokes it. This parameter can be omitted.

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**SECURITY INVOKER** and **AUTHID CURRENT_USER** have the same functions.

- **SECURITY DEFINER**

  **AUTHID DEFINER**

  Specifies that the function will be executed with the permissions of the user who created it.

  **AUTHID DEFINER** and **SECURITY DEFINER** have the same functions.

- **FENCED**

  **NOT FENCED**

  Indicates whether the function is executed in fenced mode or not fenced mode. In **NOT FENCED** mode, a function is executed in a CN or DN process. In **FENCED** mode, a function is executed in a new fork process, which does not affect CN or DN processes.

  Application scenarios:

  – Develop or debug a function in **FENCED** mode and execute it in **NOT FENCED** mode. This reduces the overhead of the fork process and communication.

  – Perform complex OS operations, such as opening a file, and processing signals and threads in FENCED mode; otherwise, the GaussDB database execution may be affected.

  – Customize C functions. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) If this parameter is not specified, the default value **FENCED** is used.

  – Customize PL/Java function. If this parameter is not specified, the default value **FENCED** is used and the **NOT FENCED** execution mode is not supported. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

  – Customize PL/pgSQL functions. If this parameter is not specified, the default value **NOT FENCED** is used and the **FENCED** execution mode is not supported.

- **COST execution_cost**

  Estimates the execution cost of a function.

  The unit of **execution_cost** is **cpu_operator_cost**.

  Value range: a positive integer

- **ROWS result_rows**

  Estimates the number of rows returned by the function. This is only allowed when the function is declared to return a set.

  Value range: a positive number. The default value is **1000**.

- **configuration_parameter**

  – **value**

    Sets a specified database session parameter to a specified value. If the value is **DEFAULT** or **RESET**, the default setting is used in the new session. **OFF** closes the setting.

    Value range: a string

    - DEFAULT

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  - OFF
  - RESET

  Specifies the default value.
- **from current**

  Uses the value of **configuration_parameter** of the current session.

- **obj_file, link_symbol**

  (Used for C functions) Specifies the absolute path of the dynamic library using *obj_file* and the link symbol (function name in C programming language) of the function using *link_symbol*. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

- **plsql_body**

  Specifies the PL/SQL stored procedure body.

**NOTICE**

When a user is created in the function body, the plaintext password is recorded in the log. You are not advised to do it.

## Examples

```
-- Define a function as SQL query.
openGauss=# CREATE FUNCTION func_add_sql(integer, integer) RETURNS integer
    AS 'select $1 + $2;'
    LANGUAGE SQL
    IMMUTABLE
    RETURNS NULL ON NULL INPUT;

-- Add an integer by parameter name using PL/pgSQL.
openGauss=# CREATE OR REPLACE FUNCTION func_increment_plsql(i integer) RETURNS integer AS $$
        BEGIN
                RETURN i + 1;
        END;
$$ LANGUAGE plpgsql;

-- Return the RECORD type.
CREATE OR REPLACE FUNCTION compute(i int, out result_1 bigint, out result_2 bigint)
returns SETOF RECORD
as $$
begin
    result_1 = i + 1;
    result_2 = i * 10;
return next;
end;
$$language plpgsql;

-- Return a record containing multiple output parameters.
openGauss=# CREATE FUNCTION func_dup_sql(in int, out f1 int, out f2 text)
    AS $$ SELECT $1, CAST($1 AS text) || ' is text' $$
    LANGUAGE SQL;

openGauss=# SELECT * FROM func_dup_sql(42);

-- Compute the sum of two integers and return the result (if the input is null, the returned result is null).
openGauss=# CREATE FUNCTION func_add_sql2(num1 integer, num2 integer) RETURN integer
AS
BEGIN
RETURN num1 + num2;
```

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```
END;
/
-- Create an overloaded function with the PACKAGE attribute:
openGauss=# create or replace function package_func_overload(col int, col2  int)
return integer package
as
declare
    col_type text;
begin
     col := 122;
         dbe_output.print_line('two int parameters ' || col2);
         return 0;
end;
/

openGauss=# create or replace function package_func_overload(col int, col2 smallint)
return integer package
as
declare
    col_type text;
begin
     col := 122;
         dbe_output.print_line('two smallint parameters ' || col2);
         return 0;
end;
/

-- Alter the execution rule of function add to IMMUTABLE (that is, the same result is returned if the
parameter remains unchanged).
openGauss=# ALTER FUNCTION func_add_sql2(INTEGER, INTEGER) IMMUTABLE;

-- Alter the name of function add to add_two_number.
openGauss=# ALTER FUNCTION func_add_sql2(INTEGER, INTEGER) RENAME TO add_two_number;

-- Change the owner of function add to omm.
openGauss=# ALTER FUNCTION add_two_number(INTEGER, INTEGER) OWNER TO omm;

-- Delete the function.
openGauss=# DROP FUNCTION add_two_number;
openGauss=# DROP FUNCTION func_increment_sql;
openGauss=# DROP FUNCTION func_dup_sql;
openGauss=# DROP FUNCTION func_increment_plsql;
openGauss=# DROP FUNCTION func_add_sql;
```

## Helpful Links

**12.14.10 ALTER FUNCTION** and **12.14.105 DROP FUNCTION**

## Suggestions

- analyse | analyze
  - Do not run **ANALYZE** in a transaction or anonymous block.
  - Do not run **ANALYZE** in a function or stored procedure.

# 12.14.62 CREATE GROUP

## Function

**CREATE GROUP** creates a user group.

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## Precautions

**CREATE GROUP** is an alias for **CREATE ROLE**, and it is not a standard SQL syntax and not recommended. Users can use **CREATE ROLE** directly.

## Syntax

```
CREATE GROUP group_name [ [ WITH ] option [ ... ] ]
    [ ENCRYPTED | UNENCRYPTED ] { PASSWORD | IDENTIFIED BY } { 'password' [ EXPIRED ] | DISABLE };
```

The syntax of the optional **action** clause is as follows:

```
where option can be:
{SYSADMIN | NOSYSADMIN}
    | {MONADMIN | NOMONADMIN}
    | {OPRADMIN | NOOPRADMIN}
    | {POLADMIN | NOPOLADMIN}
    | {AUDITADMIN | NOAUDITADMIN}
    | {CREATEDB | NOCREATEDB}
    | {USEFT | NOUSEFT}
    | {CREATEROLE | NOCREATEROLE}
    | {INHERIT | NOINHERIT}
    | {LOGIN | NOLOGIN}
    | {REPLICATION | NOREPLICATION}
    | {INDEPENDENT | NOINDEPENDENT}
    | {VCADMIN | NOVCADMIN}
    | {PERSISTENCE | NOPERSISTENCE}
    | CONNECTION LIMIT connlimit
    | VALID BEGIN 'timestamp'
    | VALID UNTIL 'timestamp'
    | RESOURCE POOL 'respool'
    | USER GROUP 'groupuser'
    | PERM SPACE 'spacelimit'
    | NODE GROUP logic_group_name
    | IN ROLE role_name [, ...]
    | IN GROUP role_name [, ...]
    | ROLE role_name [, ...]
    | ADMIN role_name [, ...]
    | USER role_name [, ...]
    | SYSID uid
    | DEFAULT TABLESPACE tablespace_name
    | PROFILE DEFAULT
    | PROFILE profile_name
    | PGUSER
```

## Parameter Description

See **Parameter Description** in **CREATE ROLE**.

## Helpful Links

**12.14.12 ALTER GROUP**, **12.14.107 DROP GROUP**, and **12.14.74 CREATE ROLE**

# 12.14.63 CREATE INCREMENTAL MATERIALIZED VIEW

## Function

**CREATE INCREMENTAL MATERIALIZED VIEW** creates an incremental materialized view, and you can refresh the data of the materialized view by using **REFRESH MATERIALIZED VIEW** (full refresh) and **REFRESH INCREMENTAL MATERIALIZED VIEW** (incremental refresh).

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**CREATE INCREMENTAL MATERIALIZED VIEW** is similar to **CREATE TABLE AS**, but it remembers the query used to initialize the view, so it can refresh data later. A materialized view has many attributes that are the same as those of a table, but does not support temporary materialized views.

## Precautions

- Incremental materialized views cannot be created on temporary tables or global temporary tables.
- Incremental materialized views support only simple filter queries and UNION ALL queries of base tables.
- The distribution column cannot be specified when an incremental materialized view is created.
- After an incremental materialized view is created, most DDL operations in the base table are no longer supported.
- The IUD operation cannot be performed on incremental materialized views.
- After an incremental materialized view is created, you need to run the **REFRESH** command to synchronize the materialized view with the base table when the base table data changes.

## Syntax

```
CREATE INCREMENTAL MATERIALIZED VIEW mv_name
   [ (column_name [, ...] ) ]
   [ TABLESPACE tablespace_name ]
   AS query;
```

## Parameter Description

- **mv_name**

  Name (optionally schema-qualified) of the materialized view to be created.

  Value range: a string. It must comply with the naming convention.

- **column_name**

  Column name in the new materialized view. The materialized view supports specified columns. The number of specified columns must be the same as the number of columns in the result of the subsequent query statement. If no column name is provided, the column name is obtained from the output column name of the query.

  Value range: a string. It must comply with the naming convention.

- **TABLESPACE tablespace_name**

  Tablespace to which the new materialized view belongs. If the tablespace is not specified, the default tablespace is used.

- **AS query**

  **SELECT** or **TABLE** command. This query will be run in a security-constrained operation.

## Examples

```
-- Create an ordinary table.
openGauss=# CREATE TABLE my_table (c1 int, c2 int);
-- Create an incremental materialized view.
openGauss=# CREATE INCREMENTAL MATERIALIZED VIEW my_imv AS SELECT * FROM my_table;
```

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```
-- Write data to the base table.
openGauss=# INSERT INTO my_table VALUES(1,1),(2,2);
-- Incrementally refresh the incremental materialized view my_imv.
openGauss=# REFRESH INCREMENTAL MATERIALIZED VIEW my_imv;
```

## Helpful Links

12.14.17 ALTER MATERIALIZED VIEW, 12.14.67 CREATE MATERIALIZED VIEW, 12.14.80 CREATE TABLE, 12.14.111 DROP MATERIALIZED VIEW, 12.14.150 REFRESH INCREMENTAL MATERIALIZED VIEW, and 12.14.151 REFRESH MATERIALIZED VIEW

# 12.14.64 CREATE INDEX

## Function

**CREATE INDEX-bak** defines a new index.

Indexes are primarily used to enhance database performance (though inappropriate use can result in database performance deterioration). You are advised to create indexes on:

- Columns that are often queried
- Join conditions. For a query on joined columns, you are advised to create a composite index on the columns, For example, for **select * from t1 join t2 on t1.a=t2.a and t1.b=t2.b**, you can create a composite index on columns **a** and **b** in table **t1**.
- Columns having filter criteria (especially scope criteria) of a **where** clause
- Columns that appear after **order by**, **group by**, and **distinct**

Partitioned tables do not support partial index creation (when indexes contain the GLOBAL or LOCAL keyword or the created index is a GLOBAL index).

## Precautions

- Indexes consume storage and computing resources. Creating too many indexes has negative impact on database performance (especially the performance of data import. Therefore, you are advised to import the data before creating indexes). Therefore, create indexes only when they are necessary.
- All functions and operators used in an index definition must be immutable, that is, their results must depend only on their parameters and never on any outside influence (such as the contents of another table or the current time). This restriction ensures that the behavior of the index is well-defined. To use a customized function in an index expression or **WHERE** clause, remember to mark the function **immutable** when you create it.
- When creating a unique index on a partitioned table, ensure that the index contains distribution columns. If an index does not contain a partition key, only global partition indexes can be created.
- Column-store tables support B-tree and psort indexes. If the two indexes are used, you cannot create expression, partial, and unique indexes.
- Column-store tables support GIN indexes, rather than partial indexes and unique indexes. If GIN indexes are used, you can create expression indexes.

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However, an expression in this situation cannot contain empty splitters, empty columns, or multiple columns.

- A user granted with the **CREATE ANY INDEX** permission can create indexes in both the public and user schemas.
- If a user-defined function is called in the expression index, the expression index function is executed based on the permission of the function creator.

## Syntax

- Create an index on a table.

```
CREATE [ UNIQUE ] INDEX [ CONCURRENTLY ] [ [schemaname.]index_name ] ON table_name
[ USING method ]
    ({ { column_name | ( expression ) } [ COLLATE collation ] [ opclass ] [ ASC | DESC ] [ NULLS
{ FIRST | LAST } ] }[, ...] )
    [ WITH ( {storage_parameter = value} [, ... ] ) ]
    [ TABLESPACE tablespace_name ]
    [ WHERE predicate ];
```

- Create an index on a partitioned table.

```
CREATE [ UNIQUE ] INDEX [ [schemaname.]index_name ] ON table_name [ USING method ]
    ( { { column_name | ( expression ) } [ COLLATE collation ] [ opclass ] [ ASC | DESC ] [ NULLS
LAST ] } [, ...] )
    [ LOCAL [ ( { PARTITION index_partition_name [ TABLESPACE index_partition_tablespace ] }
[, ...] ) ] | GLOBAL ]
    [ WITH ( { storage_parameter = value } [, ...] ) ]
    [ TABLESPACE tablespace_name ]
    [ WHERE predicate ];
```

## Parameter Description

- **UNIQUE**

  Creates a unique index. In this way, the system checks whether new values are unique in the index column. Attempts to insert or update data which would result in duplicate entries will generate an error.

  Currently, only B-tree indexes and UB-tree indexes in row-store tables support unique indexes.

- **CONCURRENTLY**

  Create an index (with ShareUpdateExclusiveLock) in a mode that does not block DML. When an index is created, other statements cannot access the table on which the index depends. If this keyword is specified, DML is not blocked during the creation.

  - This option can only specify a name of one index.
  - **CREATE INDEX** can be run within a transaction, but **CREATE INDEX CONCURRENTLY** cannot be run within a transaction.
  - Column-store tables and partitioned tables do not support index creation by using **CONCURRENTLY**. For temporary tables, you can use **CONCURRENTLY** to create indexes. However, indexes are created in blocking mode because no other sessions concurrently access the temporary tables and the blocking mode is more cost-effective.

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NOTE

- This keyword is specified when an index is created. The entire table needs to be scanned twice and built. When the table is scanned for the first time, an index is created and the read and write operations are not blocked. During the second scan, changes that have occurred since the first scan are merged and updated.
- The table needs to be scanned and built twice, and all existing transactions that may modify the table must be completed. This means that the creation of the index takes a longer time than normal. In addition, the CPU and I/O consumption also affects other services.
- If an index build fails, it leaves an "unusable" index. This index is ignored by the query, but it still consumes the update overhead. In this case, you are advised to run the **DROP INDEX IF EXISTS** statement to delete the index and run the **CONCURRENTLY** statement to create the index again.
- After the second scan, index creation must wait for any transaction that holds a snapshot earlier than the snapshot taken by the second scan to terminate. In addition, ShareUpdateExclusiveLock (level 4) added during index creation conflicts with a lock whose level is greater than or equal to 4. Therefore, when such an index is created, the system is prone to hang or deadlock. Example:
  - If two sessions create an index by using **CONCURRENTLY** for the same table, a deadlock occurs.
  - If a session creates an index by using **CONCURRENTLY** for a table and another session drops a table, a deadlock occurs.
  - There are three sessions. Session 1 locks table **a** and does not commit it. Session 2 creates an index by using **CONCURRENTLY** for table **b**. Session 3 writes data to table **a**. Before the transaction of session 1 is committed, session 2 is blocked.
  - When an index is created by using **CONCURRENTLY** for a table concurrently with the TRUNCATE operation on the same table, a deadlock occurs.
  - The transaction isolation level is set to repeatable read (read committed by default). Two sessions are started. Session 1 writes data to table **a** and does not commit it. Session 2 creates an index by using **CONCURRENTLY** for table **b**. Before the transaction of session 1 is committed, session 2 is blocked.
- When an index is being created or fails to be created, you need to check the index progress or status. You can query the **gs_get_index_status('schema_name', 'index_name')** function to check the index status on all nodes. The input parameters **schema_name** and **index_name** are used to specify the index schema name and index name, respectively. The return values are **node_name**, **indisready**, and **indisvalid**, indicating the node name, whether the index can be inserted on the node, and whether the index is available on the node. The index is available only when **indisready** and **indisvalid** on all nodes are set to **true**; otherwise, wait until the index creation is complete. If the index fails to be created, delete the index and create it again.

- **schema_name**

  Specifies the schema name.

  Value range: an existing schema name

- **index_name**

  Specifies the name of the index to create. No schema name can be included here; the index is always created in the same schema as its parent table.

  Value range: a string. It must comply with the naming convention.

- **table_name**

  Specifies the name of the table to be indexed (optionally schema-qualified).

  Value range: an existing table name

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- **USING method**

  Specifies the name of the index method to be used.

  Value range:

  - **btree**: B-tree indexes store key values of data in a B+ tree structure. This structure helps users to quickly search for indexes. B-tree supports comparison queries with a scope specified.
  - **gin**: GIN indexes are reverse indexes and can process values that contain multiple keys (for example, arrays).
  - **gist**: GiST indexes are suitable for the set data type and multidimensional data types, such as geometric and geographic data types.
  - **Psort**: psort index. It is used to perform partial sort on column-store tables.

  Row-store tables support the following index types: **btree** (default), **gin**, and **gist**. Column-store tables support the following index types: **Psort** (default), **btree**, and **gin**. Global temporary tables do not support GIN and GiST indexes.

- **column_name**

  Specifies the name of the column on which an index is to be created.

  Multiple columns can be specified if the index method supports multi-column indexes. A global index supports a maximum of 31 columns, and other indexes support a maximum of 32 columns.

- **expression**

  Specifies an expression based on one or more columns of the table. The expression usually must be written with surrounding parentheses, as shown in the syntax. However, the parentheses can be omitted if the expression has the form of a function call.

  Expression can be used to obtain fast access to data based on some transformation of the basic data. For example, an index computed on **upper(col)** would allow the clause **WHERE upper(col) = 'JIM'** to use an index.

  If an expression contains **IS NULL**, the index for this expression is invalid. In this case, you are advised to create a partial index.

- **COLLATE collation**

  Assigns a collation to the column (which must be of a collatable data type). If no collation is specified, the default collation is used. You can run the **select * from pg_collation** command to query collation rules from the **pg_collation** system catalog. The default collation rule is the row starting with **default** in the query result.

- **opclass**

  Specifies the name of an operator class. An operator class can be specified for each column of an index. The operator class identifies the operators to be used by the index for that column. For example, a B-tree index on the type int4 would use the **int4_ops** class; this operator class includes comparison functions for values of type int4. In practice, the default operator class for the column's data type is sufficient. The operator class applies to data with multiple sorts. For example, users might want to sort a complex-number data type either by absolute value or by real part. They could do this by defining two operator classes for the data type and then selecting the proper class when making an index.

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- **ASC**

  Specifies an ascending (default) sort order.

- **DESC**

  Specifies a descending sort order.

- **NULLS FIRST**

  Specifies that null values appear before non-null values in the sort ordering. This is the default when **DESC** is specified.

- **NULLS LAST**

  Specifies that null values appear after non-null values in the sort ordering. This is the default when **DESC** is not specified.

- **WITH ( {storage_parameter = value} [, ... ] )**

  Specifies the storage parameter used for an index.

  Value range:

  Only index GIN supports parameters **FASTUPDATE** and **GIN_PENDING_LIST_LIMIT**. Indexes other than GIN and psort support the **FILLFACTOR** parameter.

  – FILLFACTOR

    The fill factor of an index is a percentage from 10 to 100.

    Value range: 10–100

  – FASTUPDATE

    Specifies whether fast update is enabled for the GIN index.

    Value range: **ON** and **OFF**

    Default value: **ON**

  – GIN_PENDING_LIST_LIMIT

    Specifies the maximum capacity of the pending list of the GIN index when fast update is enabled for the GIN index.

    Value range: 64–2147483647. The unit is KB.

    Default value: The default value of **gin_pending_list_limit** depends on **gin_pending_list_limit** specified in GUC parameters. By default, the value is **4**.

  – CROSSBUCKET

    Specifies whether cross-hash bucket indexes are used. Only B-tree indexes are supported.

    Value range: **ON** and **OFF**

    Default: **ON**

- **TABLESPACE tablespace_name**

  Specifies the tablespace for an index. If no tablespace is specified, the default tablespace is used.

  Value range: an existing table name

- **WHERE predicate**

  Creates a partial index. A partial index is an index that contains entries for only a portion of a table, usually a portion that is more useful for indexing than the rest of the table. For example, if you have a table that contains both

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billed and unbilled orders where the unbilled orders take up a small fraction of the total table and yet that is an often used portion, you can improve performance by creating an index on just that portion. In addition, **WHERE** with **UNIQUE** can be used to enforce uniqueness over a subset for a table.

Value range: The predicate expression can only refer to columns of the underlying table, but it can use all columns, not just the ones being indexed. Currently, subqueries and aggregate expressions are forbidden in **WHERE**. You are not advised to use a predicate of numeric types such as int, because such types can be implicitly converted to bool values (non-zero values are implicitly converted to **true** and **0** is implicitly converted to **false**), which may cause unexpected results.

For a partitioned table index, if the created index contains the GLOBAL or LOCAL keyword or the created index is a GLOBAL index, the WHERE clause cannot be used to create an index.

- **PARTITION index_partition_name**

  Specifies the name of an index partition.

  Value range: a string. It must comply with the naming convention.

- **TABLESPACE index_partition_tablespace**

  Specifies the tablespace of an index partition.

  Value range: If this parameter is not specified, the value of **index_tablespace** is used.

## Examples

```
-- Create the tpcds. ship_mode_t1 table.
openGauss=# create schema tpcds;
openGauss=# CREATE TABLE tpcds.ship_mode_t1
(
    SM_SHIP_MODE_SK           INTEGER               NOT NULL,
    SM_SHIP_MODE_ID           CHAR(16)              NOT NULL,
    SM_TYPE                   CHAR(30)                      ,
    SM_CODE                   CHAR(10)                      ,
    SM_CARRIER                CHAR(20)                      ,
    SM_CONTRACT               CHAR(20)
)
DISTRIBUTE BY HASH(SM_SHIP_MODE_SK);

-- Create a common unique index on the SM_SHIP_MODE_SK column in the tpcds.ship_mode_t1 table.
openGauss=# CREATE UNIQUE INDEX ds_ship_mode_t1_index1 ON
tpcds.ship_mode_t1(SM_SHIP_MODE_SK);

-- Create a B-tree index on the SM_SHIP_MODE_SK column in the tpcds.ship_mode_t1 table.
openGauss=# CREATE INDEX ds_ship_mode_t1_index4 ON tpcds.ship_mode_t1 USING
btree(SM_SHIP_MODE_SK);

-- Create an expression index on the SM_CODE column in the tpcds. ship_mode_t1 table:
openGauss=# CREATE INDEX ds_ship_mode_t1_index2 ON tpcds.ship_mode_t1(SUBSTR(SM_CODE,1 ,4));

-- Create a partial index on the SM_SHIP_MODE_SK column where SM_SHIP_MODE_SK is greater than 10
in the tpcds. ship_mode_t1 table.
openGauss=# CREATE UNIQUE INDEX ds_ship_mode_t1_index3 ON
tpcds.ship_mode_t1(SM_SHIP_MODE_SK) WHERE SM_SHIP_MODE_SK>10;

-- Create an index on the SM_SHIP_MODE_SK column of table tpcds.ship_mode_t1 in a mode that does
not block DML.
openGauss=# CREATE INDEX CONCURRENTLY ds_ship_mode_t1_index4 ON
tpcds.ship_mode_t1(SM_SHIP_MODE_SK);

-- Rename an existing index.
```

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```
openGauss=# ALTER INDEX tpcds.ds_ship_mode_t1_index1 RENAME TO ds_ship_mode_t1_index5;

-- Set the index as unusable.
openGauss=# ALTER INDEX tpcds.ds_ship_mode_t1_index2 UNUSABLE;

-- Rebuild an index.
openGauss=# ALTER INDEX tpcds.ds_ship_mode_t1_index2 REBUILD;

-- Delete an existing index.
openGauss=# DROP INDEX tpcds.ds_ship_mode_t1_index2;

-- Delete the table.
openGauss=# DROP TABLE tpcds.ship_mode_t1;

-- Create a tablespace.
openGauss=# CREATE TABLESPACE example1 RELATIVE LOCATION 'tablespace1/tablespace_1';
openGauss=# CREATE TABLESPACE example2 RELATIVE LOCATION 'tablespace2/tablespace_2';
openGauss=# CREATE TABLESPACE example3 RELATIVE LOCATION 'tablespace3/tablespace_3';
openGauss=# CREATE TABLESPACE example4 RELATIVE LOCATION 'tablespace4/tablespace_4';
-- Create the tpcds. customer_address_p1 table.
openGauss=# CREATE TABLE tpcds.customer_address_p1
(
    CA_ADDRESS_SK             INTEGER               NOT NULL,
    CA_ADDRESS_ID             CHAR(16)              NOT NULL,
    CA_STREET_NUMBER          CHAR(10)                      ,
    CA_STREET_NAME            VARCHAR(60)                   ,
    CA_STREET_TYPE            CHAR(15)                      ,
    CA_SUITE_NUMBER           CHAR(10)                      ,
    CA_CITY                   VARCHAR(60)                   ,
    CA_COUNTY                 VARCHAR(30)                   ,
    CA_STATE                  CHAR(2)                       ,
    CA_ZIP                    CHAR(10)                      ,
    CA_COUNTRY                VARCHAR(20)                   ,
    CA_GMT_OFFSET             DECIMAL(5,2)                  ,
    CA_LOCATION_TYPE          CHAR(20)
)
TABLESPACE example1
DISTRIBUTE BY HASH(CA_ADDRESS_SK)
PARTITION BY RANGE(CA_ADDRESS_SK)
(
  PARTITION p1 VALUES LESS THAN (3000),
  PARTITION p2 VALUES LESS THAN (5000) TABLESPACE example1,
  PARTITION p3 VALUES LESS THAN (MAXVALUE) TABLESPACE example2
)
ENABLE ROW MOVEMENT;
-- Create the partitioned table index ds_customer_address_p1_index1 without specifying the index
partition name.
openGauss=# CREATE INDEX ds_customer_address_p1_index1 ON
tpcds.customer_address_p1(CA_ADDRESS_SK) LOCAL;
-- Create the partitioned table index ds_customer_address_p1_index2 with the name of the index partition
specified.
openGauss=# CREATE INDEX ds_customer_address_p1_index2 ON
tpcds.customer_address_p1(CA_ADDRESS_SK) LOCAL
(
    PARTITION CA_ADDRESS_SK_index1,
    PARTITION CA_ADDRESS_SK_index2 TABLESPACE example3,
    PARTITION CA_ADDRESS_SK_index3 TABLESPACE example4
)
TABLESPACE example2;

-- Change the tablespace of the partitioned table index CA_ADDRESS_SK_index2 to example1.
openGauss=# ALTER INDEX tpcds.ds_customer_address_p1_index2 MOVE PARTITION
CA_ADDRESS_SK_index2 TABLESPACE example1;

-- Change the tablespace of the partitioned table index CA_ADDRESS_SK_index3 to example2.
openGauss=# ALTER INDEX tpcds.ds_customer_address_p1_index2 MOVE PARTITION
CA_ADDRESS_SK_index3 TABLESPACE example2;

-- Rename a partitioned table index.
```

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```
openGauss=# ALTER INDEX tpcds.ds_customer_address_p1_index2 RENAME PARTITION
CA_ADDRESS_SK_index1 TO CA_ADDRESS_SK_index4;

-- Delete the created indexes and the partitioned table.
openGauss=# DROP INDEX tpcds.ds_customer_address_p1_index1;
openGauss=# DROP INDEX tpcds.ds_customer_address_p1_index2;
openGauss=# DROP TABLE tpcds.customer_address_p1;
-- Delete the tablespace.
openGauss=# DROP TABLESPACE example1;
openGauss=# DROP TABLESPACE example2;
openGauss=# DROP TABLESPACE example3;
openGauss=# DROP TABLESPACE example4;
```

### Helpful Links

**12.14.13 ALTER INDEX** and **12.14.108 DROP INDEX**

### Suggestions

- create index

  You are advised to create indexes on:

  - Columns that are often queried
  - Join conditions. For a query on joined columns, you are advised to create a composite index on the columns, For example, for **select * from t1 join t2 on t1.a=t2.a and t1.b=t2.b**, you can create a composite index on columns **a** and **b** in table **t1**.
  - Columns having filter criteria (especially scope criteria) of a **where** clause
  - Columns that appear after **order by**, **group by**, and **distinct**

  Constraints:

  - An index of an ordinary table supports a maximum of 32 columns. A GLOBAL index of a partitioned table supports a maximum of 31 columns.
  - The size of a single index cannot exceed the size of the index page (8 KB). The size of a B-tree, UB-tree, or GIN index cannot exceed one third of the page size.
  - Partial indexes cannot be created in a partitioned table.
  - When creating a unique index on a partitioned table, ensure that the index contains distribution columns. If an index does not contain a partition key, only global partition indexes can be created.

## 12.14.65 CREATE LANGUAGE

This version does not support this syntax.

## 12.14.66 CREATE MASKING POLICY

### Function

**CREATE MASKING POLICY** creates a masking policy.

### Precautions

Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.

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The masking policy takes effect only after the security policy is enabled, that is, **enable_security_policy** is set to **on**. For details, see "Database Configuration > Database Security Management Policies > Dynamic Data Masking" in the *Security Hardening Guide*.

For details about the execution effect and supported data types of preset masking functions, see "Database Security > Dynamic Data Masking" in *Feature Description*.

## Syntax

```
CREATE MASKING POLICY policy_name masking_clause[, ...]* policy_filter [ENABLE | DISABLE];
```

- masking_clause
  ```
  masking_function ON LABEL(label_name[, ...]*)
  ```
- masking_function

  **maskall** is not a preset function. It is hard-coded and cannot be displayed by running **\df**.

  Eight preset masking methods or user-defined functions
  ```
  maskall | randommasking | creditcardmasking | basicemailmasking | fullemailmasking |
  shufflemasking | alldigitsmasking | regexpmasking
  ```
- policy_filter:
  ```
  FILTER ON FILTER_TYPE(filter_value [,...]*)[,...]*
  ```
- FILTER_TYPE:
  ```
  IP | APP | ROLES
  ```

## Parameter Description

- **policy_name**

  Specifies the audit policy name, which must be unique.

  Value range: a string. It must comply with the naming convention.
- **label_name**

  Specifies the resource label name.
- **masking_clause**

  Specifies the masking function to be used to anonymize database resources labeled by **label_name**. **schema.function** can be used to specify the masking function.
- **policy_filter**

  Specifies the users for which the masking policy takes effect. If this parameter is left empty, the masking policy takes effect for all users.
- **FILTER_TYPE**

  Specifies the types of information to be filtered by the policy, including **IP**, **APP**, and **ROLES**.
- **filter_value**

  Indicates the detailed information to be filtered, such as the IP address, app name, and username.
- **ENABLE|DISABLE**

  Enables or disables the masking policy. If **ENABLE|DISABLE** is not specified, **ENABLE** is used by default.

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## Examples

```
-- Create users dev_mask and bob_mask.
openGauss=# CREATE USER dev_mask PASSWORD 'dev@1234';
openGauss=# CREATE USER bob_mask PASSWORD 'bob@1234';

-- Create table tb_for_masking.
openGauss=# CREATE TABLE tb_for_masking(col1 text, col2 text, col3 text);

-- Create a resource label for label sensitive column col1.
openGauss=# CREATE RESOURCE LABEL mask_lb1 ADD COLUMN(tb_for_masking.col1);

-- Create a resource label for label sensitive column col2.
openGauss=# CREATE RESOURCE LABEL mask_lb2 ADD COLUMN(tb_for_masking.col2);

-- Create a masking policy for the operation of accessing sensitive column col1.
openGauss=# CREATE MASKING POLICY maskpol1 maskall ON LABEL(mask_lb1);

-- Create a masking policy that takes effect only for scenarios where users are dev_mask and bob_mask,
client tools are psql and gsql, and IP addresses are 10.20.30.40, and 127.0.0.0/24.
openGauss=# CREATE MASKING POLICY maskpol2 randommasking ON LABEL(mask_lb2) FILTER ON
ROLES(dev_mask, bob_mask), APP(psql, gsql), IP('10.20.30.40', '127.0.0.0/24');
```

## Helpful Links

5.1.13.14.14-ALTER MASKING POLICY and 5.1.13.14.96-DROP MASKING POLICY

# 12.14.67 CREATE MATERIALIZED VIEW

**CREATE MATERIALIZED VIEW** creates a full materialized view, and you can use **REFRESH MATERIALIZED VIEW** (full refresh) to refresh the data in the materialized view.

**CREATE MATERIALIZED VIEW** is similar to **CREATE TABLE AS**, but it remembers the query used to initialize the view, so it can refresh data later. A materialized view has many attributes that are the same as those of a table, but does not support temporary materialized views.

## Precautions

- Full materialized views cannot be created in temporary tables or global temporary tables.
- Full materialized views do not support NodeGroups.
- After a full materialized view is created, most DDL operations in the base table are no longer supported.
- IUD operations cannot be performed on full materialized views.
- After a full materialized view is created, if the base table data changes, you need to run the refresh command to synchronize the materialized view with the base table.

## Syntax

```
CREATE MATERIALIZED VIEW mv_name
   [ (column_name [, ...] ) ]
   [ WITH ( {storage_parameter = value} [, ... ] ) ]
   [ TABLESPACE tablespace_name ]
   AS query;
```

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## Parameter Description

- **mv_name**

  Name (optionally schema-qualified) of the materialized view to be created.

  Value range: a string. It must comply with the naming convention.

- **column_name**

  Column name in the new materialized view. The materialized view supports specified columns. The number of specified columns must be the same as the number of columns in the result of the subsequent query statement. If no column name is provided, the column name is obtained from the output column name of the query.

  Value range: a string. It must comply with the naming convention.

- **WITH ( storage_parameter [= value] [, ... ] )**

  Specifies an optional storage parameter for a table or an index. For details, see **12.14.80 CREATE TABLE**.

- **TABLESPACE tablespace_name**

  Tablespace to which the new materialized view belongs. If the tablespace is not specified, the default tablespace is used.

- **AS query**

  **SELECT**, **TABLE**, or **VALUES** command This query will be run in a security-constrained operation.

## Examples

```
-- Create an ordinary table.
openGauss=# CREATE TABLE my_table (c1 int, c2 int);
-- Create a full materialized view.
openGauss=# CREATE MATERIALIZED VIEW my_mv AS SELECT * FROM my_table;
-- Write data to the base table.
openGauss=# INSERT INTO my_table VALUES(1,1),(2,2);
-- Fully refresh the full materialized view my_mv.
openGauss=# REFRESH MATERIALIZED VIEW my_mv;
```

## Helpful Links

**12.14.17 ALTER MATERIALIZED VIEW**, **12.14.63 CREATE INCREMENTAL MATERIALIZED VIEW**, **12.14.80 CREATE TABLE**, **12.14.111 DROP MATERIALIZED VIEW**, **12.14.150 REFRESH INCREMENTAL MATERIALIZED VIEW**, and **12.14.151 REFRESH MATERIALIZED VIEW**

# 12.14.68 CREATE MODEL

This syntax is not supported in distributed scenarios.

# 12.14.69 CREATE NODE

## Function

**CREATE NODE** creates a cluster node.

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## Precautions

**CREATE NODE GROUP** is an interface of the cluster management tool. You are not advised to use this interface, because doing so affects the cluster. Only the administrator has the permission to use this interface.

## Syntax

```
CREATE NODE nodename WITH
 (
   [ TYPE = nodetype,]
   [ HOST = hostname,]
   [ PORT = portnum,]
   [ HOST1 = 'hostname',]
   [ PORT1 = portnum,]
   [ HOSTPRIMARY [ = boolean ],]
   [ PRIMARY [ = boolean ],]
   [ PREFERRED [ = boolean ],]
   [ SCTP_PORT = portnum,]
   [ CONTROL_PORT = portnum,]
   [ SCTP_PORT1 = portnum,]
   [ CONTROL_PORT1 = portnum ]
 );
```

## Parameter Description

- **nodename**

  Specifies the node name.

  Value range: a string. It must comply with the naming convention.

- **TYPE = nodetype**

  Specifies the type of a node.

  Value range:

  – 'coordinator'

  – 'datanode'

- **HOST = hostname**

  Specifies the primary server name or IP address of a node.

- **PORT = portnum**

  Specifies the primary server port to which a node is bound.

- **HOST1 = hostname**

  Specifies the name or IP address of the standby server of a node.

- **PORT1 = portnum**

  Specifies the port number of the standby server to which a node is bound.

- **HOSTPRIMARY**

- **PRIMARY = boolean**

  Specifies whether the node is a primary node or not. A primary node allows read/write operations. A non-primary node allows only read operations.

  Value range:

  – **true**

  – **false** (default value)

- **PREFERRED = boolean**

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Specifies whether the node is a preferred node for read operations.

Value range:

- **true**
- **false** (default value)

- **SCTP_PORT = portnum**

  Specifies the port used by the TCP proxy communication library or SCTP communication library (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) of the primary node to listen on the data transmission channel. The TCP protocol is used to listen on connections.

- **CONTROL_PORT = portnum**

  Specifies the port used by the TCP proxy communication library of the primary node to listen on the control transmission channel. The TCP protocol is used to listen on connections.

- **SCTP_PORT1 = portnum**

  Specifies the port used by the TCP proxy communication library or SCTP communication library (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) of the standby node to listen on the data transmission channel. The TCP protocol is used to listen on connections.

- **CONTROL_PORT 1= portnum**

  Specifies the port used by the TCP proxy communication library of the standby node to listen on the control transmission channel. The TCP protocol is used to listen on connections.

## Helpful Links

**12.14.18 ALTER NODE** and **12.14.113 DROP NODE**

# 12.14.70 CREATE NODE GROUP

## Function

**CREATE NODE GROUP** creates a cluster node group.

## Precautions

- **CREATE NODE GROUP** is an interface of the cluster management tool.
- Only a system administrator has the permission.

## Syntax

```
CREATE NODE GROUP groupname
   [WITH ( nodename [, ... ] )] [bucketcnt bucket_cnt]
   [ BUCKETS [ ( bucketnumber [, ... ] ) ] ] [VCGROUP] [DISTRIBUTE FROM src_group_name] [groupparent parent_group_name];
```

## Parameter Description

- **groupname**

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Specifies the name of a node group.

Value range: a string. It must comply with the naming convention. A value can contain a maximum of 63 characters.

NOTE

A node group name supports all ASCII characters, but you are advised to name a node group according to the naming convention.

- **nodename**

  Specifies the node name.

  Value range: a string. It must comply with the naming convention. A value can contain a maximum of 63 characters.

  If this parameter is not specified, the value of **bucketcnt** must be specified, indicating that child node groups belonging to the installation node group will be created.

- bucketcnt bucket_cnt

  **bucket_cnt** indicates the number of buckets.

  The value range is [32,16384) and the value must be a power of 2.

  If this parameter is not specified, the value of **WITH** must be specified.

- **BUCKETS [ ( bucketnumber [, ... ] ) ]**

  Designed for internal use of the cluster management tool. You are not advised to use it directly. Otherwise, the cluster may be affected.

- **VCGROUP**

  Creates a node group used as a logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

- **DISTRIBUTE FROM src_group_name**

  Creates a node group to redistribute data in the node group specified by **src_group_name**. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) You are not advised to use this clause, because it may lead to data distribution errors or node group unavailability.

- groupparent parent_group_name

  **parent_group_name** indicates the name of the parent node group to which the current child node group belongs.

## Helpful Links

12.14.114 DROP NODE GROUP

# 12.14.71 CREATE PROCEDURE

## Function

**CREATE PROCEDURE** creates a stored procedure.

## Precautions

- If the parameters or return values of a stored procedure have precision, the precision is not checked.

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- When creating a stored procedure, you are advised to explicitly specify the schemas of all operations on table objects in the stored procedure definition. Otherwise, the stored procedure may fail to be executed.
- **current_schema** and **search_path** specified by **SET** during stored procedure creation are invalid. **search_path** and **current_schema** before and after function execution should be the same.
- If a stored procedure has output parameters, the **SELECT** statement uses the default values of the output parameters when calling the procedure. When the **CALL** statement calls the stored procedure or a non-overloaded function, output parameters must be specified. When the **CALL** statement calls an overloaded **PACKAGE** function, it can use the default values of the output parameters. For details, see examples in **12.14.42 CALL**.
- A stored procedure with the **PACKAGE** attribute can use overloaded functions.
- When you create a procedure, you cannot insert aggregate functions or other functions out of the average function.
- If a function is defined as **IMMUTABLE** or **SHIPPABLE**, avoid **INSERT**, **UPDATE**, **DELETE**, **MERGE**, and **DDL** operations in the function because the CN needs to determine the execution node for these operations. Otherwise, an error may occur.
- The stored procedure does not support operations that will return a set.
- When stored procedures without parameters are called in another stored procedure, you can omit brackets and call stored procedures using their names directly.
- When functions with output parameters are called in a stored procedure which is an assignment expression, you can omit the output parameters of the called functions.
- The stored procedure supports viewing, exporting, and importing parameter comments.
- The stored procedure supports viewing, exporting, and importing parameter comments between IS/AS and plsql_body.
- Users granted with the **CREATE ANY FUNCTION** permission can create or replace stored procedures in the user schemas.
- The default permission on a stored procedure is **SECURITY INVOKER**. If you want to change the default permission to **SECURITY DEFINER**, you need to set the GUC parameter **behavior_compat_options** to **'plsql_security_definer'**. For details about the **SECURITY DEFINER** permission, see sections "Database Configuration > Permission Management" in *Security Hardening Guide*.

## Syntax

```
openGauss=# CREATE [ OR REPLACE ] PROCEDURE procedure_name
   [ ( {[ argname ] [ argmode ] argtype [ { DEFAULT | := | = } expression ]}[,...]) ]
   [
     { IMMUTABLE | STABLE | VOLATILE }
     | { SHIPPABLE | NOT SHIPPABLE }
     | {PACKAGE}
     | [ NOT ] LEAKPROOF
     | { CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT | STRICT }
     | {[ EXTERNAL ] SECURITY INVOKER | [ EXTERNAL ] SECURITY DEFINER | AUTHID DEFINER | AUTHID
CURRENT_USER}
     | COST execution_cost
     | SET configuration_parameter { [ TO | = ] value | FROM CURRENT }
```

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```
   ][ ... ]
 { IS | AS }
plsql_body
/
```

## Parameter Description

- **OR REPLACE**

  Replaces the original definition when two stored procedures are with the same name.

- **procedure_name**

  Specifies the name of the stored procedure that is created (optionally with schema names).

  Value range: a string. It must comply with the naming convention.

- **argmode**

  Specifies the mode of an argument.

  NOTICE

  **VARIADIC** specifies parameters of the array type.

  Value range: **IN**, **OUT**, **INOUT**, and **VARIADIC**. The default value is **IN**. Only the parameter of the **OUT** mode can be followed by **VARIADIC**. The parameters of **OUT** and **INOUT** cannot be used in procedure definition of **RETURNS TABLE**.

- **argname**

  Specifies the argument name.

  Value range: a string. It must comply with the identifier naming convention.

- **argtype**

  Specifies the data type of the parameter. You can use **%ROWTYPE** to indirectly reference the type of a table, or **%TYPE** to indirectly reference the type of a column in a table or composite type.

  Value range: a valid data type

- **IMMUTABLE, STABLE,**...

  Specifies a constraint. The function of each parameter is similar to that of **CREATE FUNCTION**. For details, see **12.14.61 CREATE FUNCTION**.

- **plsql_body**

  Specifies the PL/SQL stored procedure body.

  NOTICE

  When you create a user, or perform other operations requiring password input in a stored procedure, the system catalog and CSV log record the password in plaintext. Therefore, you are advised not to perform such operations in the stored procedure.

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> **NOTE**
>
> No specific order is applied to **argname** and **argname**. The following order is advised: **argname**, **argmode**, and **argtype**.

## Examples

```
-- Create a stored procedure.
openGauss=# CREATE OR REPLACE PROCEDURE prc_add
(
    param1    IN   INTEGER,
    param2    IN OUT  INTEGER
)
AS
BEGIN
   param2:= param1 + param2;
   dbe_output.print_line('result is: '||to_char(param2));
END;
/

-- Call the stored procedure.
openGauss=# SELECT prc_add(2,3);

-- Create a stored procedure whose parameter type is VARIADIC.
openGauss=# CREATE OR REPLACE PROCEDURE pro_variadic (var1 VARCHAR2(10) DEFAULT 'hello!',var4
VARIADIC int4[])
AS
BEGIN
    dbe_output.print_line(var1);
END;
/

-- Execute the stored procedure.
openGauss=# SELECT pro_variadic(var1=>'hello', VARIADIC var4=> array[1,2,3,4]);

-- Create a stored procedure with the permission of the user who calls it.
openGauss=# CREATE TABLE tb1(a integer);
openGauss=#  CREATE PROCEDURE insert_data(v integer)
SECURITY INVOKER
AS
BEGIN
    INSERT INTO tb1 VALUES(v);
END;
/

-- Call the stored procedure.
openGauss=#  CALL insert_data(1);

-- Create a stored procedure with the PACKAGE attribute.
openGauss=# create or replace procedure package_func_overload(col int, col2 out varchar)
package
as
declare
    col_type text;
begin
     col2 := '122';
        dbe_output.print_line('two varchar parameters ' || col2);
end;
/
-- Delete the stored procedure.
openGauss=# DROP PROCEDURE prc_add;
openGauss=# DROP PROCEDURE pro_variadic;
openGauss=# DROP PROCEDURE insert_data;
openGauss=# DROP PROCEDURE package_func_overload;
```

## Helpful Links

**12.14.116 DROP PROCEDURE**

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## Suggestions

- analyse | analyze
  - Do not run **ANALYZE** in a transaction or anonymous block.
  - Do not run **ANALYZE** in a function or stored procedure.

# 12.14.72 CREATE RESOURCE LABEL

## Function

**CREATE RESOURCE LABEL** creates a resource label.

## Precautions

Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.

## Syntax

```
CREATE RESOURCE LABEL [IF NOT EXISTS] label_name ADD label_item_list[, ...]*;
```

- label_item_list
  ```
  resource_type(resource_path[, ...]*)
  ```
- resource_type
  ```
  TABLE | COLUMN | SCHEMA | VIEW | FUNCTION
  ```

## Parameter Description

- **label_name**

  Specifies the resource label name, which must be unique.

  Value range: a string. It must comply with the naming convention.
- **resource_type**

  Specifies the type of database resources to be labeled.
- **resource_path**

  Specifies the path of database resources.

## Examples

```
-- Create table tb_for_label.
openGauss=# CREATE TABLE tb_for_label(col1 text, col2 text, col3 text);

-- Create schema schema_for_label.
openGauss=# CREATE SCHEMA schema_for_label;

-- Create view view_for_label.
openGauss=# CREATE VIEW view_for_label AS SELECT 1;

-- Create function func_for_label.
openGauss=# CREATE FUNCTION func_for_label RETURNS TEXT AS $$ SELECT col1 FROM tb_for_label; $$
LANGUAGE SQL;

-- Create a resource label based on the table.
openGauss=# CREATE RESOURCE LABEL IF NOT EXISTS table_label add TABLE(public.tb_for_label);

-- Create a resource label based on the columns.
openGauss=# CREATE RESOURCE LABEL IF NOT EXISTS column_label add
COLUMN(public.tb_for_label.col1);

-- Create a resource label based on the schema.
```

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```
openGauss=# CREATE RESOURCE LABEL IF NOT EXISTS schema_label add SCHEMA(schema_for_label);

-- Create a resource label based on the view.
openGauss=# CREATE RESOURCE LABEL IF NOT EXISTS view_label add VIEW(view_for_label);

-- Create a resource label based on the function.
openGauss=# CREATE RESOURCE LABEL IF NOT EXISTS func_label add FUNCTION(func_for_label);
```

## Helpful Links

**5.1.13.14.17-ALTER RESOURCE LABEL** and **5.1.13.14.102-DROP RESOURCE LABEL**

# 12.14.73 CREATE RESOURCE POOL

The current feature is a lab feature. Contact Huawei technical support before using it.

## Function

**CREATE RESOURCE POOL** creates a resource pool and specifies the Cgroup of the resource pool.

## Precautions

Only a user with the **CREATE** permission on the current database can perform this operation.

## Syntax

```
CREATE RESOURCE POOL pool_name
    [WITH ({MEM_PERCENT=pct | CONTROL_GROUP="group_name" | ACTIVE_STATEMENTS=stmt |
MAX_DOP = dop | MEMORY_LIMIT='memory_size' | io_limits=io_limits | io_priority='io_priority' |
nodegroup="nodegroupname" | is_foreign=boolean }[, ... ])];
```

## Parameter Description

- **pool_name**

  Specifies the name of a resource pool.

  The name of the resource pool cannot be same as that of an existing resource pool.

  Value range: a string. It must comply with the naming convention.

- **group_name**

  Specifies the name of a Cgroup.

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NOTE

- You can use either double quotation marks ("") or single quotation marks (') in the syntax when setting the name of a Cgroup.
- The value of **group_name** is case-sensitive.
- If **group_name** is not specified, the string "Medium" will be used by default in the syntax, indicating the **Medium** Timeshare Cgroup under **DefaultClass**.
- If an administrator specifies a Workload Cgroup under Class, for example, **control_group** set to **class1:workload1**, the resource pool will be associated with the **workload1** Cgroup under **class1**. The level of **Workload** can also be specified. For example, **control_group** is set to **class1:workload1:1**.
- If a database user specifies the Timeshare string (**Rush**, **High**, **Medium**, or **Low**) in the syntax, for example, **control_group** is set to **High**, the resource pool will be associated with the **High** Timeshare Cgroup under **DefaultClass**.
- In multi-tenant scenarios, the Cgroup associated with a group resource pool is a Class Cgroup, and that associated with a service resource pool is a Workload Cgroup. Additionally, switching Cgroups between different resource pools is not allowed.

Value range: a string. It must comply with the rule in the description, which specifies the created Cgroup.

- **stmt**

  Specifies the maximum number of statements that can be concurrently executed in a resource pool.

  Value range: numeric data ranging from –1 to 2147483647

- **dop**

  Specifies the maximum statement concurrency degree for a resource pool, equivalent to the number of threads that can be created for executing a statement.

  Value range: numeric data ranging from 1 to 2147483647

- **memory_size**

  Specifies the maximum memory size of a resource pool.

  Value range: a string from 1 KB to 2047 GB

- **mem_percent**

  Specifies the proportion of available resource pool memory to the total memory or group user memory.

  In multi-tenant scenarios, **mem_percent** of group users or service users ranges from 1 to 100. The default value is **20**.

  In common scenarios, **mem_percent** of common users ranges from 0 to 100. The default value is **0**.

  NOTE

  When both of **mem_percent** and **memory_limit** are specified, only **mem_percent** takes effect.

- **io_limits**

  Specifies the upper limit of IOPS in a resource pool.

  Row-store is measured by 10,000 IOPS, while column-store is measured by IOPS.

- **io_priority**

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Specifies the I/O priority for jobs that consume many I/O resources. It takes effect when the I/O usage reaches 90%.

There are three priorities: **Low**, **Medium**, and **High**. If you do not want to control I/O resources, use the default value **None**.

NOTE

The settings of **io_limits** and **io_priority** are valid only for complex jobs, such as batch import (using **INSERT INTO SELECT**, **COPY FROM**, or **CREATE TABLE AS**), complex queries involving over 500 MB data on each DN, and **VACUUM FULL**.

- **nodegroup**

  Specifies the name of a logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The logical cluster must already exist.

  If the logical cluster name contains uppercase letters or special characters or begins with a digit, enclose the name with double quotation marks ("") in SQL statements.

- **is_foreign**

  Specifies that the current resource pool is used to control the resources of common users who are not associated with the logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The logical cluster is specified by the **nodegroup** column of the resource pool.

  NOTE

  - **nodegroup** must specify an existing logical cluster, and cannot be **elastic_group** or the default node group (**group_version1**), which is generated during cluster installation.
  - If **is_foreign** is set to **true**, the resource pool cannot be associated with users. That is, **CREATE USER... RESOURCE POOL** cannot be used to configure resource pools for users. The resource pool automatically checks whether the users are associated with its logical cluster. If they are not, they will be controlled by the resource pool when performing operations on DNs in the logical cluster.

## Examples

This example assumes that Cgroups have been created by users in advance.

```
-- Create a default resource pool, and associate it with the Medium Timeshare Cgroup under Workload under DefaultClass.
openGauss=# CREATE RESOURCE POOL pool1;

-- Create a resource pool and specify the High Timeshare Workload Cgroup under the DefaultClass Cgroup.
openGauss=# CREATE RESOURCE POOL pool2 WITH (CONTROL_GROUP="High");

-- Create a resource pool, and associate it with the Low Timeshare Cgroup under Workload under class1.
openGauss=# CREATE RESOURCE POOL pool3 WITH (CONTROL_GROUP="class1:Low");

-- Create a resource pool, and associate it with the wg1 Workload Cgroup under class1.
openGauss=# CREATE RESOURCE POOL pool4 WITH (CONTROL_GROUP="class1:wg1");

-- Create a resource pool, and associate it with the wg2 Workload Cgroup under class1.
openGauss=# CREATE RESOURCE POOL pool5 WITH (CONTROL_GROUP="class1:wg2:3");

-- Delete the resource pool.
openGauss=# DROP RESOURCE POOL pool1;
openGauss=# DROP RESOURCE POOL pool2;
openGauss=# DROP RESOURCE POOL pool3;
```

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```
openGauss=# DROP RESOURCE POOL pool4;
openGauss=# DROP RESOURCE POOL pool5;
```

## Helpful Links

12.14.21 ALTER RESOURCE POOL and 12.14.118 DROP RESOURCE POOL

# 12.14.74 CREATE ROLE

## Function

**CREATE ROLE** creates a role.

A role is an entity that owns database objects and permissions. In different environments, a role can be considered a user, a group, or both.

## Precautions

- **CREATE ROLE** adds a role to a database. The role does not have the **LOGIN** permission.
- Only the user who has the **CREATE ROLE** permission or a system administrator is allowed to create roles.

## Syntax

```
CREATE ROLE role_name [ [ WITH ] option [ ... ] ] [ ENCRYPTED | UNENCRYPTED ] { PASSWORD |
IDENTIFIED BY } { 'password' [EXPIRED] | DISABLE };
```

The syntax of role information configuration clause **option** is as follows:

```
{SYSADMIN | NOSYSADMIN}
  | {MONADMIN | NOMONADMIN}
  | {OPRADMIN | NOOPRADMIN}
  | {POLADMIN | NOPOLADMIN}
  | {AUDITADMIN | NOAUDITADMIN}
  | {CREATEDB | NOCREATEDB}
  | {USEFT | NOUSEFT}
  | {CREATEROLE | NOCREATEROLE}
  | {INHERIT | NOINHERIT}
  | {LOGIN | NOLOGIN}
  | {REPLICATION | NOREPLICATION}
  | {INDEPENDENT | NOINDEPENDENT}
  | {VCADMIN | NOVCADMIN}
  | {PERSISTENCE | NOPERSISTENCE}
  | CONNECTION LIMIT connlimit
  | VALID BEGIN 'timestamp'
  | VALID UNTIL 'timestamp'
  | RESOURCE POOL 'respool'
  | USER GROUP 'groupuser'
  | PERM SPACE 'spacelimit'
  | TEMP SPACE 'tmpspacelimit'
  | SPILL SPACE 'spillspacelimit'
  | NODE GROUP logic_cluster_name
  | IN ROLE role_name [, ...]
  | IN GROUP role_name [, ...]
  | ROLE role_name [, ...]
  | ADMIN rol e_name [, ...]
  | USER role_name [, ...]
  | SYSID uid
  | DEFAULT TABLESPACE tablespace_name
  | PROFILE DEFAULT
  | PROFILE profile_name
  | PGUSER
```

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## Parameter Description

- **role_name**

  Specifies the name of a role.

  Value range: a string. It must comply with the identifier naming convention and can contain a maximum of 63 characters. If the value contains more than 63 characters, the database truncates it and retains the first 63 characters as the role name. If a role name contains uppercase letters, the database automatically converts the uppercase letters into lowercase letters. To create a role name that contains uppercase letters, enclose the role name with double quotation marks ("").

- **password**

  Specifies the login password.

  The new password must:

  – Contain at least eight characters. This is the default length.

  – Differ from the role name or the role name spelled backward.

  – Contain at least three of the following character types: uppercase characters, lowercase characters, digits, and special characters (limited to ~!@#$ %^&*()-_=+\|[{}];:,<.>/?). If the password contains characters other than the preceding characters, an error will be reported during statement execution.

  – The password can also be a ciphertext character string that meets the format requirements. This mode is mainly used to import user data. You are not advised to use it directly. If a ciphertext password is used, the user must know the plaintext corresponding to the ciphertext password and ensure that the plaintext password meets the complexity requirements. The database does not verify the complexity of the ciphertext password. Instead, the security of the ciphertext password is ensured by the user.

  – Be enclosed by single quotation marks when a role is created.

  Value range: a character string that cannot be empty.

- **EXPIRED**

  When creating a user, you can select **EXPIRED**. That is, you can create a user whose password is invalid. The user cannot perform simple query or extended query. The statement can be executed only after the password is changed.

- **DISABLE**

  By default, you can change your password unless it is disabled. To disable the password of a user, use this parameter. After the password of a user is disabled, the password will be deleted from the system. The user can connect to the database only through external authentication, for example, Kerberos authentication. Only administrators can enable or disable a password. Common users cannot disable the password of an initial user. To enable a password, run **ALTER USER** and specify the password.

- **ENCRYPTED | UNENCRYPTED**

  Controls whether the password is stored encrypted in the system catalogs. According to product security requirement, the password must be stored encrypted. Therefore, **UNENCRYPTED** is forbidden in GaussDB. If the password string has already been encrypted in the SHA256 format, it is stored encrypted as it was, regardless of whether **ENCRYPTED** or **UNENCRYPTED** is

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specified (since the system cannot decrypt the specified encrypted password string). This allows reloading of encrypted passwords during dump/restore.

- **SYSADMIN | NOSYSADMIN**

  Determines whether a new role is a system administrator. Roles having the **SYSADMIN** attribute have the highest permission.

  Value range: If not specified, **NOSYSADMIN** is the default.

  When separation of duties is enabled, users with the SYSADMIN permission do not have the permission to create users.

- **MONADMIN | NOMONADMIN**

  Determines whether a role is a monitoring administrator.

  Value range: If not specified, **NOMONADMIN** is the default.

- **OPRADMIN | NOOPRADMIN**

  Determines whether a role is an O&M administrator.

  Value range: If not specified, **NOOPRADMIN** is the default.

- **POLADMIN | NOPOLADMIN**

  Determines whether a role is a security policy administrator.

  Value range: If not specified, **NOPOLADMIN** is the default.

- **AUDITADMIN | NOAUDITADMIN**

  Determines whether a role has the audit and management attributes.

  If not specified, **NOAUDITADMIN** is the default.

- **CREATEDB | NOCREATEDB**

  Determines a role's permission to create databases.

  A new role does not have the permission to create databases.

  Value range: If not specified, **NOCREATEDB** is the default.

- **USEFT | NOUSEFT**

  This parameter is reserved and not used in this version.

- **CREATEROLE | NOCREATEROLE**

  Determines whether a role will be permitted to create new roles (that is, execute **CREATE ROLE** and **CREATE USER**). A role with the **CREATEROLE** permission can also modify and delete other roles.

  Value range: If not specified, **NOCREATEROLE** is the default.

  - When separation of duties is disabled, users with the CREATEROLE permission can create users with the CREATEROLE, AUDITADMIN, MONADMIN, POLADMIN, or CREATEDB permission and common users.
  - When separation of duties is enabled, users with the CREATEROLE permission can create users with the CREATEROLE, MONADMIN, POLADMIN, or CREATEDB permission and common users.

- **INHERIT | NOINHERIT**

  Determines whether a role "inherits" the permissions of roles in the same group. It is not recommended.

- **LOGIN | NOLOGIN**

  Determines whether a role is allowed to log in to a database. A role having the **LOGIN** attribute can be considered as a user.

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Value range: If not specified, **NOLOGIN** is the default.

- **REPLICATION | NOREPLICATION**

  Determines whether a role is allowed to initiate streaming replication or put the system in and out of backup mode. A role having the **REPLICATION** attribute is specific to replication.

  If not specified, **NOREPLICATION** is the default.

- **INDEPENDENT | NOINDEPENDENT**

  Defines private, independent roles. For a role with the **INDEPENDENT** attribute, administrators' permissions to control and access this role are separated. The rules are as follows:

  – Administrators have no permission to add, delete, query, modify, copy, or authorize the corresponding table objects without the authorization from the **INDEPENDENT** role.

  – If permissions related to private user tables are granted to non-private users, the system administrator will obtain the same permissions.

  – System administrators and security administrators with the **CREATEROLE** attribute have no permission to modify the inheritance relationship of the **INDEPENDENT** role without the authorization of the **INDEPENDENT** role.

  – System administrators have no permission to modify the owner of the table objects for the **INDEPENDENT** role.

  – System administrators and security administrators with the **CREATEROLE** attribute have no permission to remove the **INDEPENDENT** attribute of the **INDEPENDENT** role.

  – System administrators and security administrators with the **CREATEROLE** attribute have no permission to change the database password of the **INDEPENDENT** role. The **INDEPENDENT** role must manage its own password. If the password is lost, it cannot be reset.

  – The **SYSADMIN** attribute of a user cannot be changed to the **INDEPENDENT** attribute.

  – Operations performed by users in the **INDEPENDENT** role are recorded in audit logs based on the audit policy.

- **VCADMIN | NOVCADMIN**

  Defines the role of a logical cluster administrator. A logical cluster administrator has the following permissions other than permissions of common users:

  – Create, modify, and delete resource pools in the associated logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

  – Grant the access permission on the associated logical cluster to other users or roles, or revoke the access permission from those users or roles.

- **PERSISTENCE | NOPERSISTENCE**

  Defines a permanent user. Only the initial user is allowed to create, modify, and delete permanent users with the **PERSISTENCE** attribute.

- **CONNECTION LIMIT**

  Specifies how many concurrent connections the role can make.

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NOTICE

- The system administrator is not restricted by this parameter.
- **connlimit** is calculated for each CN. The number of connections in a cluster is calculated using the following formula: Number of connections in a cluster = **connlimit** x Number of normal CNs.

Value range: an integer greater than or equal to -1. The default value is **-1**, which means unlimited.

- **VALID BEGIN**

  Sets a date and time when the role's password takes effect. If this clause is omitted, the password takes effect immediately.

- **VALID UNTIL**

  Sets a date and time after which the role's password is no longer valid. If this clause is omitted, the password will be valid for all time.

- **RESOURCE POOL**

  Sets the name of resource pool used by the role. The name belongs to the system catalog **pg_resource_pool**.

- **USER GROUP 'groupuser'**

  Creates a sub-user.

- **PERM SPACE**

  Sets the space available for a user.

- **TEMP SPACE**

  Sets the space allocated to the temporary table of a user.

- **SPILL SPACE**

  Sets the operator disk flushing space of a user.

- **NODE GROUP**

  Specifies the name of the logical cluster associated with a user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) If the name of the logical cluster contains uppercase characters or special characters, enclose the name with double quotation marks ("").

- **IN ROLE**

  Lists one or more existing roles to which the new role will be immediately added as a new member. It is not recommended.

- **IN GROUP**

  Specifies an obsolete spelling of **IN ROLE**. It is not recommended.

- **ROLE**

  Lists one or more existing roles which are automatically added as members of the new role.

- **ADMIN**

  Similar to **ROLE**. However, **ADMIN** grants permissions of new roles to other roles.

- **USER**

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Specifies an obsolete spelling of the **ROLE** clause.

- **SYSID**

  The **SYSID** clause is ignored.

- **DEFAULT TABLESPACE**

  The **DEFAULT TABLESPACE** clause is ignored.

- **PROFILE**

  The **PROFILE** clause is ignored.

- **PGUSER**

  In the current version, this attribute is reserved only for forward compatibility.

## Examples

```
-- Create role manager whose password is xxxxxxxxxx:
openGauss=# CREATE ROLE manager IDENTIFIED BY 'xxxxxxxxxx';

-- Create a role with its validity from January 1, 2015 to January 1, 2026.
openGauss=# CREATE ROLE miriam WITH LOGIN PASSWORD 'xxxxxxxxxxx' VALID BEGIN '2015-01-01'
VALID UNTIL '2026-01-01';

-- Change the password of role manager to abcd@123.
openGauss=# ALTER ROLE manager IDENTIFIED BY 'abcd@123' REPLACE 'xxxxxxxxxx';

-- Change role manager to the system administrator.
openGauss=# ALTER ROLE manager SYSADMIN;

-- Delete role manager.
openGauss=# DROP ROLE manager;

-- Delete role miriam.
openGauss=# DROP ROLE miriam;
```

## Helpful Links

12.14.163 SET ROLE, 12.14.22 ALTER ROLE, 12.14.119 DROP ROLE, 12.14.140 GRANT, and 12.14.154 REVOKE

# 12.14.75 CREATE ROW LEVEL SECURITY POLICY

## Function

**CREATE ROW LEVEL SECURITY POLICY** creates a row-level access control policy for a table.

The policy takes effect only after row-level access control is enabled (by running **ALTER TABLE... ENABLE ROW LEVEL SECURITY**). Otherwise, this statement does not take effect.

Currently, row-level access control affects the read (**SELECT**, **UPDATE**, **DELETE**) of data tables and does not affect the write (**INSERT** and **MERGE INTO**) of data tables. The table owner or system administrators can create an expression in the **USING** clause. When the client reads the data table, the database server combines the expressions that meet the condition and applies it to the execution plan in the statement rewriting phase of a query. For each tuple in a data table, if the expression returns **TRUE**, the tuple is visible to the current user; if the expression returns **FALSE** or **NULL**, the tuple is invisible to the current user.

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A row-level access control policy name is specific to a table. A data table cannot have row-level access control policies with the same name. Different data tables can have the same row-level access control policy.

Row-level access control policies can be applied to specified operations (**SELECT**, **UPDATE**, **DELETE**, and **ALL**). **ALL** indicates that **SELECT**, **UPDATE**, and **DELETE** will be affected. For a new row-level access control policy, the default value **ALL** will be used if you do not specify the operations that will be affected.

Row-level access control policies can be applied to a specified user (role) or to all users (**PUBLIC**). For a new row-level access control policy, the default value **PUBLIC** will be used if you do not specify the user that will be affected.

## Precautions

- Row-level access control policies can be defined for row-store tables, row-store partitioned tables, column-store tables, column-store partitioned tables, replication tables, unlogged tables, and hash tables.
- Row-level access control policies cannot be defined for foreign tables and temporary tables.
- Row-level access control policies cannot be defined for views.
- A maximum of 100 row-level access control policies can be defined for a table.
- System administrators are not affected by row-level access control policies and can view all data in a table.
- Tables queried by using SQL statements, views, functions, and stored procedures are affected by row-level access control policies.

## Syntax

```
CREATE [ ROW LEVEL SECURITY ] POLICY policy_name ON table_name
    [ AS { PERMISSIVE | RESTRICTIVE } ]
    [ FOR { ALL | SELECT | UPDATE | DELETE } ]
    [ TO { role_name | PUBLIC | CURRENT_USER | SESSION_USER } [, ...] ]
    USING ( using_expression )
```

## Parameter Description

- **policy_name**

  Specifies the name of a row-level access control policy to be created. The names of row-level access control policies for a table must be unique.

- **table_name**

  Specifies the name of a table to which a row-level access control policy is applied.

- PERMISSIVE | RESTRICTIVE

  **PERMISSIVE** enables the permissive policy for row-level access control. The conditions of the permissive policy are joined through the OR expression. **RESTRICTIVE** enables the restrictive policy for row-level access control. The conditions of the restrictive policy are joined through the AND expression. The join methods are as follows:

  (using_expression_permissive_1 OR using_expression_permissive_2 ...) AND (using_expression_restrictive_1 AND using_expression_restrictive_2 ...)

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The default value is **PERMISSIVE**.

- **command**

  Specifies the SQL operations affected by a row-level access control policy, including **ALL**, **SELECT**, **UPDATE**, and **DELETE**. If this parameter is not specified, the default value **ALL** will be used, covering **SELECT**, **UPDATE**, and **DELETE**.

  If *command* is set to **SELECT**, only tuple data that meets the condition (the return value of *using_expression* is **TRUE**) can be queried. The operations that are affected include **SELECT**, **UPDATE.... RETURNING**, and **DELETE... RETURNING**.

  If *command* is set to **UPDATE**, only tuple data that meets the condition (the return value of *using_expression* is **TRUE**) can be updated. The operations that are affected include **UPDATE**, **UPDATE ... RETURNING**, and **SELECT ... FOR UPDATE/SHARE**.

  If *command* is set to **DELETE**, only tuple data that meets the condition (the return value of *using_expression* is **TRUE**) can be deleted. The operations that are affected include **DELETE** and **DELETE ... RETURNING**.

  The following table describes the relationship between row-level access control policies and SQL statements.

  **Table 12-120** Relationship between row-level access control policies and SQL statements.

| Command | SELECT/ALL policy | UPDATE/ALL policy | DELETE/ALL policy |
| --- | --- | --- | --- |
| **SELECT** | Existing row | No | No |
| **SELECT FOR UPDATE/SHARE** | Existing row | Existing row | No |
| **UPDATE** | No | Existing row | No |
| **UPDATE RETURNING** | Existing row | Existing row | No |
| **DELETE** | No | No | Existing row |
| **DELETE RETURNING** | Existing row | No | Existing row |

- **role_name**

  Specifies database users affected by a row-level access control policy.

  If this parameter is not specified, the default value **PUBLIC** will be used, indicating that all database users will be affected. You can specify multiple affected database users.

  **NOTICE**

  System administrators are not affected by row access control.

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- **using_expression**

  Specifies an expression defined for a row-level access control policy (return type: Boolean).

  The expression cannot contain aggregate functions or window functions. In the statement rewriting phase of a query, if row-level access control for a data table is enabled, the expressions that meet the specified conditions will be added to the plan tree. The expression is calculated for each tuple in the data table. For **SELECT**, **UPDATE**, and **DELETE**, row data is visible to the current user only when the return value of the expression is **TRUE**. If the expression returns **FALSE**, the tuple is invisible to the current user. In this case, the user cannot view the tuple through the **SELECT** statement, update the tuple through the **UPDATE** statement, or delete the tuple through the **DELETE** statement.

## Examples

```
-- Create user alice.
postgres=# CREATE USER alice PASSWORD 'xxxxxxxxx';

-- Create user bob.
postgres=# CREATE USER bob PASSWORD 'xxxxxxxxx';

-- Create the data table all_data.
openGauss=# CREATE TABLE public.all_data(id int, role varchar(100), data varchar(100));

-- Insert data into the data table.
openGauss=# INSERT INTO all_data VALUES(1, 'alice', 'alice data');
openGauss=# INSERT INTO all_data VALUES(2, 'bob', 'bob data');
openGauss=# INSERT INTO all_data VALUES(3, 'peter', 'peter data');

-- Grant the read permission on the all_data table to users alice and bob.
openGauss=# GRANT SELECT ON all_data TO alice, bob;

-- Enable row-level access control.
openGauss=# ALTER TABLE all_data ENABLE ROW LEVEL SECURITY;

-- Create a row-level access control policy to specify that the current user can view only their own data.
openGauss=# CREATE ROW LEVEL SECURITY POLICY all_data_rls ON all_data USING(role =
CURRENT_USER);

-- View information about the all_data table.
openGauss=# \d+ all_data
                        Table "public.all_data"
 Column |          Type          | Modifiers | Storage  | Stats target | Description
--------+------------------------+-----------+----------+--------------+-------------
 id     | integer                |           | plain    |              |
 role   | character varying(100) |           | extended |              |
 data   | character varying(100) |           | extended |              |
Row Level Security Policies:
    POLICY "all_data_rls"
      USING (((role)::name = "current_user"()))
Has OIDs: no
Distribute By: HASH(id)
Location Nodes: ALL DATANODES
Options: orientation=row, compression=no, enable_rowsecurity=true

-- Run SELECT.
openGauss=# SELECT * FROM all_data;
 id | role  |    data
----+-------+------------
  1 | alice | alice data
  2 | bob   | bob data
  3 | peter | peter data
(3 rows)
```

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```
-- Grant the login permission to the user.
openGauss=# ALTER USER alice LOGIN;

openGauss=# EXPLAIN(COSTS OFF) SELECT * FROM all_data;
         QUERY PLAN
----------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Seq Scan on all_data
(3 rows)

-- Switch to user alice and run SELECT.
openGauss=# SELECT * FROM all_data;
 id | role  |    data
----+-------+------------
  1 | alice | alice data
(1 row)

openGauss=# EXPLAIN(COSTS OFF) SELECT * FROM all_data;
                        QUERY PLAN
-----------------------------------------------------------------
 Streaming (type: GATHER)
   Node/s: All datanodes
   ->  Seq Scan on all_data
         Filter: ((role)::name = 'alice'::name)
 Notice: This query is influenced by row level security feature
(5 rows)
```

## Helpful Links

12.14.120 DROP ROW LEVEL SECURITY POLICY

# 12.14.76 CREATE SCHEMA

## Function

**CREATE SCHEMA** creates a schema.

Named objects are accessed either by "qualifying" their names with the schema name as a prefix, or by setting a search path that includes the desired schema. When creating named objects, you can also use the schema name as a prefix.

Optionally, **CREATE SCHEMA** can include sub-commands to create objects within the new schema. The sub-commands are treated essentially the same as separate commands issued after creating the schema. If the **AUTHORIZATION** clause is used, all the created objects are owned by this user.

## Precautions

- Only a user with the **CREATE** permission on the current database can perform this operation.
- The owner of an object created by a system administrator in a schema with the same name as a common user is the common user, not the system administrator.

## Syntax

- Create a schema based on a specified name.

```
CREATE SCHEMA schema_name
    [ AUTHORIZATION user_name ] [WITH BLOCKCHAIN] [ schema_element [ ... ] ];
```

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- Create a schema based on a username.
  ```
  CREATE SCHEMA AUTHORIZATION user_name [ schema_element [ ... ] ];
  ```

## Parameter Description

- **schema_name**

  Specifies the schema name.

  **NOTICE**

  The name must be unique.

  The schema name cannot start with **pg_**.

  Value range: a string. It must comply with the naming convention.

- **AUTHORIZATION user_name**

  Specifies the owner of a schema. If **schema_name** is not specified, **user_name** will be used as the schema name. In this case, **user_name** can only be a role name.

  Value range: an existing username or role name

- **WITH BLOCKCHAIN**

  Specifies the tamper-proof attribute of a schema. A common row-store table in tamper-proof mode is a tamper-proof user table.

- **schema_element**

  Specifies an SQL statement defining an object to be created within the schema. Currently, only **CREATE TABLE**, **CREATE VIEW**, **CREATE INDEX**, **CREATE PARTITION**, and **GRANT** are accepted as clauses within **CREATE SCHEMA**.

  Objects created by sub-commands are owned by the user specified by **AUTHORIZATION**.

**NOTE**

If objects in the schema on the current search path are with the same name, specify the schemas for different objects. You can run **SHOW SEARCH_PATH** to check the schemas on the current search path.

## Examples

```
-- Create the role1 role.
openGauss=# CREATE ROLE role1 IDENTIFIED BY 'xxxxxxxxxx';

-- Create a schema named role1 for the role1 role. The owner of the films and winners tables created by the clause is role1.
openGauss=# CREATE SCHEMA AUTHORIZATION role1
    CREATE TABLE films (title text, release date, awards text[])
    CREATE VIEW winners AS
    SELECT title, release FROM films WHERE awards IS NOT NULL;

-- Delete the schema.
openGauss=# DROP SCHEMA role1 CASCADE;
-- Delete the user.
openGauss=# DROP USER role1 CASCADE;
```

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## Helpful Links

12.14.24 ALTER SCHEMA and 12.14.121 DROP SCHEMA

# 12.14.77 CREATE SEQUENCE

## Function

**CREATE SEQUENCE** adds a sequence to the current database. The owner of a sequence is the user who creates the sequence.

## Precautions

- A sequence is a special table that stores arithmetic columns. Such a table is controlled by DBMS. It has no actual meaning and is usually used to generate unique identifiers for rows or tables.
- If a schema name is given, the sequence is created in the specified schema; otherwise, it is created in the current schema. The sequence name must be different from the names of other sequences, tables, indexes, views in the same schema.
- After the sequence is created, functions **nextval()** and **generate_series(1,N)** insert data to the table. Make sure that the number of times for invoking **nextval** is greater than or equal to N+1. Otherwise, errors will be reported because the number of times for invoking function **generate_series()** is N+1.
- A user granted with the CREATE ANY SEQUENCE permission can create sequences in the public and user schemas.

## Syntax

```
CREATE SEQUENCE name [ INCREMENT [ BY ] increment ]
    [ MINVALUE minvalue | NO MINVALUE | NOMINVALUE ] [ MAXVALUE maxvalue | NO MAXVALUE |
NOMAXVALUE]
    [ START [ WITH ] start ] [ CACHE cache ] [ [ NO ] CYCLE | NOCYCLE ]
    [ OWNED BY { table_name.column_name | NONE } ];
```

## Parameter Description

- **name**

  Specifies the name of a sequence to be created.

  Value range: a sting containing only lowercase letters, uppercase letters, special characters #_$, and digits

- **increment**

  Specifies the step for a sequence. A positive number generates an ascending sequence, and a negative number generates a decreasing sequence.

  The default value is **1**.

- **MINVALUE minvalue | NO MINVALUE| NOMINVALUE**

  Specifies the minimum value of the sequence. If **MINVALUE** is not declared, or **NO MINVALUE** is declared, the default value of the ascending sequence is **1**, and that of the descending sequence is **$-2^{63}$-1**. **NOMINVALUE** is equivalent to **NO MINVALUE**.

- **MAXVALUE maxvalue | NO MAXVALUE| NOMAXVALUE**

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Specifies the maximum value of the sequence. If **MAXVALUE** is not declared, or **NO MAXVALUE** is declared, the default value of the ascending sequence is $2^{63}$**-1**, and that of the descending sequence is **-1**. **NOMAXVALUE** is equivalent to **NO MAXVALUE**.

- **start**

  Specifies the start value of the sequence. The default value for an ascending sequence is **minvalue** and that for a descending sequence is **maxvalue**.

- **cache**

  Specifies the number of sequences stored in the memory for quick access purposes.

  Default value **1** indicates that one sequence can be generated each time.

  NOTE

  - It is not recommended that you define **cache** and **maxvalue** or **minvalue** at the same time. The continuity of sequences cannot be ensured after **cache** is defined because unacknowledged sequences may be generated, causing waste of sequences. If there are requirements on the concurrency performance, see the **session_sequence_cache** parameter.
  - cache specifies the value that a single CN/DN applies for from the GTM at a time. **session_sequence_cache** specifies the value of the cache that a single session applies for from the CN/DN at a time. The value is automatically discarded after the session ends.

- **CYCLE**

  Recycles sequences after the number of sequences reaches **maxvalue** or **minvalue**.

  If **NO CYCLE** is specified, any invocation of **nextval** would return an error after the number of sequences reaches **maxvalue** or **minvalue**.

  **NOCYCLE** is equivalent to **NO CYCLE**.

  The default value is **NO CYCLE**.

  If **CYCLE** is specified, the sequence uniqueness cannot be ensured.

- **OWNED BY**-

  Associates a sequence with a specified column included in a table. In this way, the sequence will be deleted when you delete its associated column or the table where the column belongs to. The associated table and sequence must be owned by the same user and in the same schema. **OWNED BY** only establishes the association between a table column and the sequence. Sequences on the column do not increase automatically when data is inserted.

  The default value **OWNED BY NONE** indicates that such association does not exist.

NOTICE

You are not advised to use the sequence created using **OWNED BY** in other tables. If multiple tables need to share a sequence, the sequence must not belong to a specific table.

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## Examples

Create an ascending sequence named **serial**, which starts from 101.

```
openGauss=# CREATE SEQUENCE serial
 START 101
 CACHE 20;
```

Select the next number from the sequence.

```
openGauss=# SELECT nextval('serial');
 nextval
---------
     101
```

Select the next number from the sequence.

```
openGauss=# SELECT nextval('serial');
 nextval
---------
     102
```

Create a sequence associated with the table.

```
openGauss=# CREATE TABLE customer_address
(
    ca_address_sk             integer               not null,
    ca_address_id             char(16)              not null,
    ca_street_number          char(10)                      ,
    ca_street_name            varchar(60)                   ,
    ca_street_type            char(15)                      ,
    ca_suite_number           char(10)                      ,
    ca_city                   varchar(60)                   ,
    ca_county                 varchar(30)                   ,
    ca_state                  char(2)                       ,
    ca_zip                    char(10)                      ,
    ca_country                varchar(20)                   ,
    ca_gmt_offset             decimal(5,2)                  ,
    ca_location_type          char(20)
);

openGauss=# CREATE SEQUENCE serial1
 START 101
 CACHE 20
OWNED BY customer_address.ca_address_sk;
-- Delete the sequence.
openGauss=# DROP TABLE customer_address;
openGauss=# DROP SEQUENCE serial cascade;
openGauss=# DROP SEQUENCE serial1 cascade;
```

## Helpful Links

**12.14.122 DROP SEQUENCE** and **12.14.25 ALTER SEQUENCE**

# 12.14.78 CREATE SERVER

## Function

**CREATE SERVER** creates a foreign server.

A foreign server stores OBS server information or other homogeneous cluster information.

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## Precautions

Only a system administrator and users with permission to use a specified **FOREIGN DATA WRAPPER** can create a foreign server. The authorization syntax is as follows:

```
GRANT USAGE ON FOREIGN DATA WRAPPER fdw_name TO username
```

**fdw_name** is the name of the **FOREIGN DATA WRAPPER**, and **username** is the name of the user creating a foreign server.

When multi-layer quotation marks are used for sensitive columns (such as **password** and **secret_access_key**) in OPTIONS, the semantics is different from that in the scenario where quotation marks are not used. Therefore, sensitive columns are not identified for anonymization.

## Syntax

```
CREATE SERVER server_name
    FOREIGN DATA WRAPPER fdw_name
    OPTIONS ( { option_name ' value ' } [, ...] ) ;
```

## Parameter Description

- **server_name**

  Specifies the server name.

  Value range: a string containing no more than 63 characters

- **FOREIGN DATA WRAPPER fdw_name**

  Specifies the name of the foreign data wrapper.

  Value range: **fdw_name** is the data wrapper created by the system during database initialization. Currently, **fdw_name** can only be **gc_fdw** for other homogeneous clusters. You can also create **dist_fdw**, **file_fdw**, and **log_fdw**.

- **OPTIONS ( { option_name ' value ' } [, ...] )**

  Specifies the parameters for the foreign server. The detailed parameter description is as follows:

  – encrypt

    Specifies whether data is encrypted. This parameter is available only when **type** is **OBS**. The default value is **on**.

    Value range:

    - **on** indicates that data is encrypted and HTTPS is used for communication.
    - **off** indicates that data is not encrypted and HTTP is used for communication.

  – access_key

    Specifies the access key (AK) (obtained by users from the OBS console) used for the OBS access protocol. When you create a foreign table, the AK value is encrypted and saved to the metadata table of the database. This parameter is available only when **type** is set to **OBS**.

  – secret_access_key

    Specifies the secret key (SK) value (obtained by users from the OBS console) used for the OBS access protocol. When you create a foreign

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table, the SK value is encrypted and saved to the metadata table of the database. This parameter is available only when **type** is set to **OBS**.

## Examples

Create the **obs_server** server, in which **dfs_fdw** is the built-in foreign data wrapper.

```
-- Create obs_server.
openGauss=# CREATE SERVER obs_server FOREIGN DATA WRAPPER DFS_FDW OPTIONS (
  address 'obs.abc.com',
   access_key 'xxxxxxxxx',
  secret_access_key 'yyyyyyyyyyyyy',
  type 'obs'
);

-- Delete obs_server.
openGauss=# DROP SERVER obs_server;
```

You are advised to create another server in the homogeneous cluster, where **gc_fdw** is the foreign data wrapper in the database.

```
-- Create a server.
openGauss=# CREATE SERVER server_remote FOREIGN DATA WRAPPER GC_FDW OPTIONS
   (address '10.146.187.231:8000,10.180.157.130:8000' ,
  dbname 'test',
  username 'test',
  password 'xxxxxxxx'
);

-- Delete the server.
openGauss=# DROP SERVER server_remote;
```

Helpful Links

**12.14.26 ALTER SERVER** and **12.14.123 DROP SERVER**

# 12.14.79 CREATE SYNONYM

## Function

**CREATE SYNONYM** creates a synonym object. A synonym is an alias of a database object and is used to record the mapping between database object names. You can use synonyms to access associated database objects.

## Precautions

- The user of a synonym should be its owner.
- If the schema name is specified, create a synonym in the specified schema. Otherwise create a synonym in the current schema.
- Database objects that can be accessed using synonyms include tables, views, functions, and stored procedures.
- To use synonyms, you must have the required permissions on associated objects.
- The following DML statements support synonyms: **SELECT**, **INSERT**, **UPDATE**, **DELETE**, **EXPLAIN**, and **CALL**.
- The **CREATE SYNONYM** statement of an associated function or stored procedure cannot be used in a stored procedure. You are advised to use synonyms existing in the **pg_synonym** system catalog in the stored procedure.

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- You are not advised to create synonyms for temporary tables. To create a synonym, you need to specify the schema name of the target temporary table. Otherwise, the synonym cannot be used normally. In addition, you need to run the **DROP SYNONYM** command before the current session ends.
- After an original object is deleted, the synonym associated with the object will not be deleted in cascading mode. If you continue to access the synonym, an error message is displayed, indicating that the synonym has expired.
- Synonyms cannot be created for encrypted tables that contain encrypted columns and views, functions, and stored procedures based on encrypted tables.

## Syntax

```
CREATE [ OR REPLACE ] SYNONYM synonym_name
    FOR object_name;
```

## Parameter Description

- **synonym**

  Specifies the name of the synonym to be created, which can contain the schema name.

  Value range: a string. It must comply with the naming convention.

- **object_name**

  Specifies the name of an object that is associated (optionally with schema names).

  Value range: a string. It must comply with the naming convention.

  NOTE

  **object_name** can be the name of an object that does not exist.

CAUTION

Do not create aliases for functions that contain passwords and other sensitive information, such as the encryption function gs_encrypt and the decryption function gs_decrypt or use aliases to call the functions to prevent sensitive information leakage.

## Examples

```
-- Create schema ot.
openGauss=# CREATE SCHEMA ot;

-- Create table ot.t1 and its synonym t1.
openGauss=# CREATE TABLE ot.t1(id int, name varchar2(10)) DISTRIBUTE BY hash(id);
openGauss=# CREATE OR REPLACE SYNONYM t1 FOR ot.t1;

-- Use synonym t1.
openGauss=# SELECT * FROM t1;
openGauss=# INSERT INTO t1 VALUES (1, 'ada'), (2, 'bob');
openGauss=# UPDATE t1 SET t1.name = 'cici' WHERE t1.id = 2;

-- Create synonym v1 and its associated view ot.v_t1.
openGauss=# CREATE SYNONYM v1 FOR ot.v_t1;
openGauss=# CREATE VIEW ot.v_t1 AS SELECT * FROM ot.t1;
```

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```
-- Use synonym v1.
openGauss=# SELECT * FROM v1;

-- Create overloaded function ot.add and its synonym add.
openGauss=# CREATE OR REPLACE FUNCTION ot.add(a integer, b integer) RETURNS integer AS
$$
SELECT $1 + $2
$$
LANGUAGE sql;

openGauss=# CREATE OR REPLACE FUNCTION ot.add(a decimal(5,2), b decimal(5,2)) RETURNS
decimal(5,2) AS
$$
SELECT $1 + $2
$$
LANGUAGE sql;

openGauss=# CREATE OR REPLACE SYNONYM add FOR ot.add;

-- Use synonym add.
openGauss=# SELECT add(1,2);
openGauss=# SELECT add(1.2,2.3);

-- Create stored procedure ot.register and its synonym register.
openGauss=# CREATE PROCEDURE ot.register(n_id integer, n_name varchar2(10))
SECURITY INVOKER
AS
BEGIN
    INSERT INTO ot.t1 VALUES(n_id, n_name);
END;
/

openGauss=# CREATE OR REPLACE SYNONYM register FOR ot.register;

-- Use synonym register to invoke the stored procedure.
openGauss=# CALL register(3,'mia');

-- Delete the synonym.
openGauss=# DROP SYNONYM t1;
openGauss=# DROP SYNONYM IF EXISTS v1;
openGauss=# DROP SYNONYM IF EXISTS add;
openGauss=# DROP SYNONYM register;
openGauss=# DROP SCHEMA ot CASCADE;
```

## Helpful Links

12.14.28 ALTER SYNONYM and 12.14.124 DROP SYNONYM

# 12.14.80 CREATE TABLE

## Function

**CREATE TABLE** creates an initially empty table in the current database. The table will be owned by the creator.

## Precautions

- For details about the data types supported by column-store tables, see 12.3.17 Data Types Supported by Column-store Tables.
- It is recommended that the number of column-store tables do not exceed 1000.

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- The primary key constraint and unique constraint in the table must contain distribution keys.
- Distribution columns do not support the UPDATE operation.
- If an error occurs during table creation, after it is fixed, the system may fail to delete the empty disk files created before the last automatic clearance. This problem seldom occurs and does not affect system running of the database.
- Column-store tables support only **PARTIAL CLUSTER KEY** table-level constraints, but do not support primary and foreign key table-level constraints.
- Only the **NULL**, **NOT NULL**, and **DEFAULT** constant values can be used as column-store table constraints.
- Whether column-store tables support a delta table is specified by the **enable_delta_store** parameter. The threshold for storing data into a delta table is specified by the **deltarow_threshold** parameter.
- When JDBC is used, the **DEFAULT** value can be set through **PrepareStatement**.
- Row-store tables do not support table-level **PRIMARY KEY** constraints.
- According to the concurrency control policy, if the **DROP TABLE IF EXIST** and **CREATE IF EXIST** statements are performed on the same table concurrently, one of the two will be rolled back. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)
- A user granted with the **CREATE ANY TABLE** permission can create tables in the public and user schemas. To create a table that contains serial columns, you must also be granted with the **CREATE ANY SEQUENCE** permission to create sequences.

## Syntax

- Create a table.

```
CREATE [ [ GLOBAL | LOCAL ] [ TEMPORARY | TEMP ] | UNLOGGED ] TABLE [ IF NOT EXISTS ]
table_name
    ({ column_name data_type [ compress_mode ] [ COLLATE collation ] [ column_constraint [ ... ] ]
        | table_constraint
        | LIKE source_table [ like_option [...] ] }
        [, ... ])
    [ WITH ( {storage_parameter = value} [, ... ] ) ]
    [ ON COMMIT { PRESERVE ROWS | DELETE ROWS } ]
    [ COMPRESS | NOCOMPRESS ]
    [ TABLESPACE tablespace_name ]
    [ DISTRIBUTE BY { REPLICATION | HASH ( column_name [, ...] )
    | RANGE ( column_name [, ...] ) { SLICE REFERENCES tablename | ( slice_less_than_item [, ...] )
    | ( slice_start_end_item [, ...] ) }
    | LIST ( column_name [, ...] ) { SLICE REFERENCES tablename | ( slice_values_item [, ...] ) }
    } ]
    [ TO { GROUP groupname | NODE ( nodename [, ... ] ) } ];
```

  - **column_constraint** is as follows:

```
[ CONSTRAINT constraint_name ]
{ NOT NULL |
  NULL |
  CHECK ( expression ) |
  DEFAULT default_expr |
  UNIQUE [ index_parameters ] |
  PRIMARY KEY [ index_parameters ] |
  ENCRYPTED WITH ( COLUMN_ENCRYPTION_KEY = column_encryption_key,
ENCRYPTION_TYPE = encryption_type_value ) }
  REFERENCES reftable [ ( refcolumn ) ] [ MATCH FULL | MATCH PARTIAL | MATCH SIMPLE ]
```

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```
    [ ON DELETE action ] [ ON UPDATE action ] }
[ DEFERRABLE | NOT DEFERRABLE ] [ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]
```

- **compress_mode** of a column is as follows:

```
{ DELTA | PREFIX | DICTIONARY | NUMSTR | NOCOMPRESS }
```

- **table_constraint** is as follows:

```
[ CONSTRAINT constraint_name ]
{ CHECK ( expression ) |
  UNIQUE ( column_name [, ... ] ) [ index_parameters ] |
  PRIMARY KEY ( column_name [, ... ] ) [ index_parameters ] |
  PARTIAL CLUSTER KEY ( column_name [, ... ] ) }
[ DEFERRABLE | NOT DEFERRABLE ][ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]
```

- **like_option** is as follows:

```
{ INCLUDING | EXCLUDING } { DEFAULTS | CONSTRAINTS | INDEXES | STORAGE | COMMENTS |
PARTITION | RELOPTIONS | DISTRIBUTION | ALL }
```

- Range distribution rules

  **slice_less_than_item** is as follows:

  ```
  SLICE slice_name VALUES LESS THAN ({ literal | MAXVALUE } [, ...])
  [ DATANODE dn_name ]
  ```

  **slice_start_end_item** is as follows:

  ```
  SLICE slice_name_prefix {
  { START ( literal ) END ( literal ) EVERY ( literal ) } |
  { START ( literal ) END ( { literal | MAXVALUE } ) } |
  { START ( literal ) } |
  { END ( { literal | MAXVALUE } ) }
  }
  ```

- The LIST distribution rule **slice_values_item** is as follows:

  ```
  SLICE slice_name VALUES (list_values_item) [DATANODE dn_name]
  ```

  **list_values_item** is as follows:

  ```
  { DEFAULT | { partition_values_list [, ...] } }
  ```

  **partition_values_list** is as follows:

  ```
  { (literal [, ...]) }
  ```

**index_parameters** is as follows:

```
[ WITH ( {storage_parameter = value} [, ... ] ) ]
[ USING INDEX TABLESPACE tablespace_name ]
```

## Parameter Description

- **UNLOGGED**

  If this keyword is specified, the created table is an unlogged table. Data written to unlogged tables is not written to the WALs, which makes them considerably faster than ordinary tables. However, an unlogged table is automatically truncated after conflicts, operating system restart, database restart, primary/standby switchover, power-off, or abnormal shutdown, incurring data loss risks. The contents of an unlogged table are also not replicated to standby servers. Any indexes created on an unlogged table are not automatically logged as well.

  Usage scenario: Unlogged tables do not ensure data security. Users can back up data before using unlogged tables; for example, users should back up the data before a system upgrade.

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Troubleshooting: If data is missing in the indexes of unlogged tables due to some unexpected operations such as an unclean shutdown, users should re-create the indexes with errors.

- **GLOBAL | LOCAL**

  When creating a temporary table, you can specify the **GLOBAL** or **LOCAL** keyword before **TEMP** or **TEMPORARY**. Currently, the two keywords are used to be compatible with the SQL standard. A local temporary table will be created by GaussDB regardless of whether **GLOBAL** or **LOCAL** is specified.

- **TEMPORARY | TEMP**

  If **TEMP** or **TEMPORARY** is specified, the created table is a temporary table. A temporary table is automatically dropped at the end of the current session. Therefore, you can create and use temporary tables in the current session as long as the connected CN in the session is normal. Temporary tables are created only in the current session. If a DDL statement involves operations on temporary tables, a DDL error will be generated. Therefore, you are not advised to perform operations on temporary tables in DDL statements. **TEMP** is equivalent to **TEMPORARY**.

  **NOTICE**

  - Temporary tables are visible to the current session through the schema starting with **pg_temp** start. Users should not delete schema started with **pg_temp** or **pg_toast_temp**.
  - If **TEMPORARY** or **TEMP** is not specified when you create a table but its schema is set to that starting with **pg_temp_** in the current session, the table will be created as a temporary table.
  - A temporary table is visible only to the current session. Therefore, it cannot be used together with **\parallel on**.
  - Temporary tables do not support DN faults or primary/standby switchovers.

- **IF NOT EXISTS**

  Sends a notice, but does not throw an error, if a table with the same name exists.

- **table_name**

  Specifies the name of the table to be created.

  **NOTICE**

  Some processing logic of materialized views determines whether a table is the log table of a materialized view or a table associated with a materialized view based on the table name prefix. Therefore, do not create a table whose name prefix is **mlog_** or **matviewmap_**. Otherwise, some functions of the table are affected.

- **column_name**

  Specifies the name of a column to be created in the new table.

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- **data_type**

  Specifies the data type of the column.

- **compress_mode**

  Specifies whether to compress a table column. The option specifies the algorithm preferentially used by table columns. Row-store tables do not support compression.

  Value range: **DELTA**, **PREFIX**, **DICTIONARY**, **NUMSTR**, and **NOCOMPRESS**

- **COLLATE collation**

  Assigns a collation to the column (which must be of a collatable data type). If no collation is specified, the default collation is used. You can run the **select * from pg_collation** command to query collation rules from the **pg_collation** system catalog. The default collation rule is the row starting with **default** in the query result.

- **LIKE source_table [ like_option ... ]**

  Specifies a table from which the new table automatically inherits all column names, their data types, and their not-null constraints, as well as the default expression declared as serial.

  The new table and the original table are decoupled after creation is complete. Changes to the original table will not be applied to the new table, and it is not possible to include data of the new table in scans of the original table.

  Columns and constraints copied by **LIKE** are not merged with the same name. If the same name is specified explicitly or in another **LIKE** clause, an error is reported.

  - The default expressions are copied from the original table to the new table only if **INCLUDING DEFAULTS** is specified. The default behavior is to exclude default expressions, resulting in the copied columns in the new table having default values null.
  - The **CHECK** constraints are copied from the original table to the new table only when **INCLUDING CONSTRAINTS** is specified. Other types of constraints are never copied to the new table. Not-null constraints are always copied to the new table. These rules also apply to column constraints and table constraints.
  - Any indexes on the original table will not be created on the new table, unless the **INCLUDING INDEXES** clause is specified.
  - **STORAGE** settings for the copied column definitions are copied only if **INCLUDING STORAGE** is specified. The default behavior is to exclude **STORAGE** settings.
  - If **INCLUDING COMMENTS** is specified, comments for the copied columns, constraints, and indexes are copied. The default behavior is to exclude comments.
  - If **INCLUDING PARTITION** is specified, the partition definitions of the source table are copied to the new table, and the new table no longer uses the **PARTITION BY** clause. The default behavior is to exclude partition definition of the original table.
  - If **INCLUDING RELOPTIONS** is specified, the new table will copy the storage parameter (that is, **WITH** clause) of the source table. The default behavior is to exclude partition definition of the storage parameter of the original table.

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  - If **INCLUDING DISTRIBUTION** is specified, the distribution information of the original table is copied to the new table, including distribution type and key, and the new table no longer use the **DISTRIBUTE BY** clause. The default behavior is to exclude distribution information of the original table.
  - **INCLUDING ALL** contains the meaning of **INCLUDING DEFAULTS**, **INCLUDING CONSTRAINTS**, **INCLUDING INDEXES**, **INCLUDING STORAGE**, **INCLUDING COMMENTS**, **INCLUDING PARTITION**, **INCLUDING RELOPTIONS**, and **INCLUDING DISTRIBUTION**.

**NOTICE**

- If the source table contains a sequence with the **SERIAL**, **BIGSERIAL**, or **SMALLSERIRAL** data type, or a column in the source table is a sequence by default and the sequence is created for this table by using **CREATE SEQUENCE... OWNED BY**, these sequences will not be copied to the new table, and another sequence specific to the new table will be created. This is different from earlier versions. To share a sequence between the source table and new table, create a shared sequence (do not use **OWNED BY**) and set a column in the source table to this sequence.
- You are not advised to set a column in the source table to the sequence specific to another table especially when the table is distributed in specific node groups, because doing so may result in **CREATE TABLE ... LIKE** execution failures. In addition, doing so may cause the sequence to become invalid in the source sequence because the sequence will also be deleted from the source table when it is deleted from the table that the sequence is specific to. To share a sequence among multiple tables, you are advised to create a shared sequence for them.

- **WITH ( { storage_parameter = value } [, ... ] )**

  Specifies an optional storage parameter for a table or an index. The WITH clause for a table can contain **OIDS=TRUE** or **OIDS** to specify that each row in the new table is assigned an OID. If **OIDS=FALSE** is specified, no OID is assigned.

  **NOTE**

  When using **Numeric** of any precision to define a column, specifies precision **p** and scale **s**. When precision and scale are not specified, the input will be displayed.

  The description of parameters is as follows:

  - FILLFACTOR

    The fill factor of a table is a percentage from 10 to 100. **100** (complete filling) is the default value. When a smaller fill factor is specified, **INSERT** operations pack table pages only to the indicated percentage. The remaining space on each page is reserved for updating rows on that page. This gives **UPDATE** a chance to place the updated copy of a row on the same page, which is more efficient than placing it on a different page. For a table whose entries are never updated, setting the fill factor to **100** (complete filling) is the best choice, but in heavily updated tables a smaller fill factor would be appropriate. The parameter has no meaning for column–store tables.

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Value range: 10 to 100

- ORIENTATION

  Storage mode (row store or column store) of table data. This parameter cannot be modified once it is set.

  Value range:

  - **ROW** indicates that table data is stored in rows.

    **ROW** applies to the OLTP service, which has many interactive transactions. An interaction involves many columns in the table. Using ROW can improve the efficiency.

  - **COLUMN** indicates that the data is stored in columns.

    **COLUMN** applies to the data warehouse service, which has a large amount of aggregation computing, and involves a few column operations.

  Default value:

  If an ordinary tablespace is specified, the default is **ROW**.

- COMPRESSION

  Specifies the compression level of table data. It determines the compression ratio and time. Generally, the higher the level of compression, the higher the ratio, the longer the time; and the lower the level of compression, the lower the ratio, the shorter the time. The actual compression ratio depends on the distribution mode of table data loaded. Row-store tables do not support compression.

  Value range:

  The valid values for column-store tables are **YES**, **NO**, **LOW**, **MIDDLE**, and **HIGH**, and the default value is **LOW**.

- COMPRESSLEVEL

  Specifies the table data compression ratio and duration at the same compression level. This divides a compression level into sublevels, providing more choices for compression ratio and duration. As the value becomes greater, the compression ratio becomes higher and duration longer at the same compression level.

  Value range: 0 to 3. The default value is **0**.

- MAX_BATCHROW

  Specifies the maximum number of rows in a storage unit during data loading. The parameter is only valid for column-store tables.

  Value range: 10000 to 60000

- PARTIAL_CLUSTER_ROWS

  Specifies the number of records to be partially clustered for storage during data loading. The parameter is only valid for column-store tables.

  Value range: 600000 to 2147483647

- DELTAROW_THRESHOLD

  Specifies the upper limit of to-be-imported rows for triggering the data import to a delta table when data of a column-store table is to be imported. This parameter takes effect only if **enable_delta_store** is set to **on**. The parameter is only valid for column-store tables.

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Value range: 0 to 9999. The default value is **100**.

- segment

  The table data is stored in segmented paging mode. This parameter supports only row-store tables. Column-store tables, temporary tables, and unlogged tables are not supported. The ustore storage engine is not supported.

  Value range: **on** and **off**

  Default value: **off**

- hashbucket

  Creates a hash table that uses buckets. This parameter supports only row-store tables, including row-store range tables.

  Value range: **on** and **off**

  Default value: **off**

**NOTICE**

- In current version, DDL operations on hash bucket tables are affected. Therefore, you are not advised to frequently perform DDL operations on hash bucket tables.
- Hash bucket tables are bound to segmented paging storage, that is, when **hashbucket** is set to **on**, **segment** is set to **on**.

- bucketcnt

  Specifies the number of buckets of a bucket table when the table is created. The value of this parameter must correspond to a child node group.

  The value ranges from 32 to 16384 and must be an integer power of 2.

  Default value: **16384**.

- enable_tde

  Creates a transparent encryption table. Before enabling this function, ensure that **enable_tde** in "GUC Parameter" has been enabled, the KMS service has been enabled, and the cluster master key ID in **tde_cmk_id** in "GUC Parameter" has been correctly configured. This parameter supports only row-store tables. Column-store tables and temporary tables are not supported. The ustore storage engine is not supported.

  Value range: **on** and **off** If this parameter is set to **on**, transparent data encryption is enabled. If this parameter is set to **off**, transparent data encryption is disabled but the encryption function will be enabled later. When a table is created, a data encryption key will be applied from KMS.

  Default value: **off**

- encrypt_algo

  Specifies the transparent data encryption algorithm. Before enabling this function, ensure that **enable_tde** must be set for a table. The encryption algorithm can be specified only when a table is created. Different tables support different encryption algorithms. After the table is created, the encryption algorithm cannot be changed.

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Value range: a string. The value can be **AES_128_CTR** or **SM4_CTR**.

If **enable_tde** is not set, the default value is null. If **enable_tde** is set to **on** or **off** and **encrypt_algo** is not set, the value is **AES_128_CTR**.

- parallel_workers

  Number of bgworker threads started when an index is created. For example, value **2** indicates that two bgworker threads are started to create indexes concurrently.

  Value range: [0,32], int type. The value **0** indicates that this function is disabled.

  Default value: If this parameter is not set, the concurrent index creation function is disabled.

- dek_cipher

  Ciphertext of the key used for transparent data encryption. When **enable_tde** is enabled, the system automatically applies for ciphertext creation. You cannot specify the ciphertext. The key rotation function can be used to update the key.

  Value range: a string.

  If encryption is disabled, the default value is null by default.

- cmk_id

  ID of the cluster master key used for transparent data encryption. When **enable_tde** is enabled, the value is obtained from **tde_cmk_id** in "GUC Parameter" and cannot be specified or modified by users.

  Value range: a string.

  If encryption is disabled, the default value is null by default.

- hasuids

  If this parameter is set to **on**, a unique table-level ID is allocated to a tuple when the tuple is updated.

  Value range: **on** and **off**

  Default value: **off**

- **WITHOUT OIDS**

  It is equivalent to **WITH (OIDS=FALSE)**.

- **ON COMMIT { PRESERVE ROWS | DELETE ROWS }**

  **ON COMMIT** determines what to do when you commit a temporary table creation operation. Currently, the **PRESERVE ROWS** and **DELETE ROWS** options are supported.

  - **PRESERVE ROWS** (default): No special action is taken at the ends of transactions. The temporary table and its table data are unchanged.
  - **DELETE ROWS**: All rows in the temporary table will be deleted at the end of each transaction block.

- **COMPRESS | NOCOMPRESS**

  If you specify **COMPRESS** in the **CREATE TABLE** statement, the compression feature is triggered in case of a bulk **INSERT** operation. If this feature is enabled, a scan is performed for all tuple data within the page to generate a dictionary and then the tuple data is compressed and stored. If **NOCOMPRESS** is specified, the table is not compressed. Row-store tables do not support compression.

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Default value: **NOCOMPRESS**, that is, tuple data is not compressed before storage.

- **TABLESPACE tablespace_name**

  Specifies the tablespace where the new table is created. If not specified, the default tablespace is used.

- **DISTRIBUTE BY**

  Specifies how the table is distributed or replicated between DNs.

  Value range:

  – **REPLICATION**: Each row in the table exists on all DNs, that is, each DN has complete table data.

  – **HASH (column_name)**: Each row of the table will be placed into specified DNs based on the hash value of the specified column.

  – **RANGE(column_name)**: maps a specified column based on the range and distributes data to the corresponding DNs.

  – **LIST(column_name)**: maps a specified column based on a specific value and distributes data to the corresponding DNs.

  NOTE

  - When **DISTRIBUTE BY { HASH | RANGE | LIST } (column_name)** is specified, the primary key and its unique index must contain the **column_name** column.
  - When **DISTRIBUTE BY { HASH | RANGE | LIST } (column_name)** is specified for a referenced table, the foreign key of the referencing table must contain the **column_name** column.
  - For a RANGE distribution policy using the VALUE LESS THAN clause, a maximum of four distribution key columns are supported. The distribution rules are as follows:

    1. The comparison starts from the first column of values to be inserted.

    2. If the value of the first column is smaller than the boundary value of the current column in the local shard, values are directly inserted.

    3. If the value of the first column is equal to the boundary value of the current column in the local shard, compare the value of the second column with the boundary value of the next column in the local shard. If the value of the second column is smaller than the boundary value of the next column in the local shard, values are directly inserted. If they are still equal, continue to the comparison until the value of the column is smaller than the boundary value of the column in the local shard, and then insert the values.

    4. If the values of the all columns are greater than the boundary value of the current column in the local shard, compare the value with that in the next shard.

  Default value: **HASH(column_name)**. Set **column_name** to the primary key (if any) of the table or the column whose first data type supports distribution keys.

  **column_name** supports the following data types:

  – Integer types: **TINYINT**, **SMALLINT**, **INT**, **BIGINT**, and **NUMERIC/DECIMAL**

  – Character types: **CHAR**, **BPCHAR**, **VARCHAR**, **VARCHAR2**, **NVARCHAR2**, and **TEXT**

  – Date/time types: **DATE**, **TIME**, **TIMETZ**, **TIMESTAMP**, **TIMESTAMPTZ**, **INTERVAL**, and **SMALLDATETIME**

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**NOTE**

When you create a table, the choices of distribution keys and partition keys have major impact on SQL query performance. Therefore, select appropriate distribution keys and partition keys with strategies.

- Select appropriate distribution keys.

  A hash table's distribution key should evenly distribute data on each DN to prevent skewing the data or distributing it unevenly across DNs. Determine appropriate distribution keys based on the following principles:

  1. Determine whether data is skewed.

     Connect to the database and run the following statement to check the number of tuples on each each DN. Replace *tablename* with the actual name of the table to be analyzed.

     ```
     openGauss=# SELECT a.count,b.node_name FROM (SELECT count(*) AS count,xc_node_id FROM tablename GROUP BY xc_node_id) a, pgxc_node b WHERE a.xc_node_id=b.node_id ORDER BY a.count DESC;
     ```

     If tuple numbers vary greatly (several times or tenfold) in each each DN, a data skew occurs. Change the data distribution key based on the following principle:

  2. Recreate a table to change its distribution keys. **ALTER TABLE** cannot change distribution keys. Therefore, you need to recreate a table when changing its distribution keys.

     Principles for selecting distribution keys are as follows:

     The value of the distribution key should be discrete so that data can be evenly distributed on each DN. You can select the primary key of the table as the distribution key. For example, for a person information table, choose the ID card number column as the distribution key.

     With the above principle met, you can select join conditions as distribution keys so that join tasks can be pushed down to DNs, reducing the amount of data transferred between the DNs.

- Select appropriate partition keys.

  In range partitioning, a table is partitioned based on ranges defined by one or more columns, with no overlap between the ranges of values assigned to different partitions. Each range has a dedicated partition for data storage.

  Modify partition keys to make the query result stored in the same or least partitions (partition pruning). Obtain consecutive I/O to improve the query performance.

  In actual services, time is used to filter query objects. Therefore, you can use time as a partition key, and change the key value based on the total data volume and data volume of a single query.

- RANGE/LIST distribution

  If no DN is specified for the shards of a RANGE/LIST distribution table, the database uses the Round Robin algorithm to allocate DNs to the shards. In addition, if RANGE/LIST distribution is used, you are advised to define as many shards as possible when creating a table for future capacity expansion. If the defined number of shards is less than the number of DNs before scale-out, data redistribution cannot be performed on new DNs. Note that the sharding rules are designed by users. In some extreme cases, scale-out may not solve the problem of insufficient storage space.

- **TO { GROUP groupname | NODE ( nodename [, ... ] ) }**

  **TO GROUP** specifies the node group to which the table to be created belongs. **TO NODE** is used for internal scale-out tools.

- **CONSTRAINT constraint_name**

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Specifies the name of a column or table constraint. The optional constraint clauses specify constraints that new or updated rows must satisfy for an INSERT or UPDATE operation to succeed.

There are two ways to define constraints:

- A column constraint is defined as part of a column definition, and it is bound to a particular column.
- A table constraint is not bound to a particular column but can apply to more than one column.

- **NOT NULL**

  The column is not allowed to contain null values.

- **NULL**

  The column is allowed to contain null values. This is the default setting.

  This clause is only provided for compatibility with non-standard SQL databases. It is not recommended.

- **CHECK ( expression )**

  Specifies an expression producing a Boolean result where the INSERT or UPDATE operation of new or updated rows can succeed only when the expression result is **TRUE** or **UNKNOWN**; otherwise, an error is thrown and the database is not altered.

  A check constraint specified as a column constraint should reference only the column's values, while an expression appearing in a table constraint can reference multiple columns.

  NOTE

  **<>NULL** and **!=NULL** are invalid in an expression. Change them to **is NOT NULL**.

- **DEFAULT default_expr**

  Assigns a default data value for a column. The value can be any variable-free expressions. (Subqueries and cross-references to other columns in the current table are not allowed.) The data type of the default expression must match the data type of the column.

  The default expression will be used in any insert operation that does not specify a value for the column. If there is no default value for a column, then the default value is null.

- **UNIQUE index_parameters**

  **UNIQUE ( column_name [, ... ] ) index_parameters**

  Specifies that a group of one or more columns of a table can contain only unique values.

  For the purpose of a unique constraint, null is not considered equal.

  NOTE

  If **DISTRIBUTE BY REPLICATION** is not specified, the column table that contains only unique values must contain distribution keys.

- **PRIMARY KEY index_parameters**

  **PRIMARY KEY ( column_name [, ... ] ) index_parameters**

  Specifies that a column or columns of a table can contain only unique (non-duplicate) and non-null values.

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Only one primary key can be specified for a table.

NOTE

If **DISTRIBUTE BY REPLICATION** is not specified, the column set with a primary key constraint must contain distribution keys.

- **DEFERRABLE | NOT DEFERRABLE**

  Controls whether the constraint can be deferred. A constraint that is not deferrable will be checked immediately after every command. Checking of constraints that are deferrable can be postponed until the end of the transaction using the **SET CONSTRAINTS** command. **NOT DEFERRABLE** is the default value. Currently, only **UNIQUE** and **PRIMARY KEY** constraints accept this clause. All the other constraints are not deferrable.

- **PARTIAL CLUSTER KEY**

  Specifies a partial cluster key for storage. When importing data to a column-store table, you can perform local data sorting by specified columns (single or multiple).

- **INITIALLY IMMEDIATE | INITIALLY DEFERRED**

  If a constraint is deferrable, this clause specifies the default time to check the constraint.

  – If the constraint is **INITIALLY IMMEDIATE** (default value), it is checked after each statement.
  – If the constraint is **INITIALLY DEFERRED**, it is checked only at the end of the transaction.

  The constraint check time can be altered using the **SET CONSTRAINTS** statement.

- **USING INDEX TABLESPACE tablespace_name**

  Allows selection of the tablespace in which the index associated with a **UNIQUE** or **PRIMARY KEY** constraint will be created. If not specified, **default_tablespace** is consulted, or the default tablespace in the database if **default_tablespace** is empty.

- **ENCRYPTION_TYPE = encryption_type_value**

  For the encryption type in the ENCRYPTED WITH constraint, the value of **encryption_type_value** is **DETERMINISTIC** or **RANDOMIZED**.

## Examples

```
-- Create a simple table.
openGauss=# CREATE TABLE tpcds.warehouse_t1
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
);
```

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```
openGauss=# CREATE TABLE tpcds.warehouse_t2
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)         DICTIONARY,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
);
-- Create a table and set the default value of the W_STATE column to GA.
openGauss=# CREATE TABLE tpcds.warehouse_t3
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)           DEFAULT 'GA',
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
);

-- Create a table and check whether the W_WAREHOUSE_NAME column is unique at the end of its
creation.
openGauss=# CREATE TABLE tpcds.warehouse_t4
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)    UNIQUE DEFERRABLE,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
);
-- Create a table with its fill factor set to 70%.
openGauss=# CREATE TABLE tpcds.warehouse_t5
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
```

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```
    W_STATE                 CHAR(2)                 ,
    W_ZIP                   CHAR(10)                ,
    W_COUNTRY               VARCHAR(20)             ,
    W_GMT_OFFSET            DECIMAL(5,2),
    UNIQUE(W_WAREHOUSE_NAME) WITH(fillfactor=70)
);

-- Alternatively, user the following syntax:
openGauss=# CREATE TABLE tpcds.warehouse_t6
(
    W_WAREHOUSE_SK          INTEGER               NOT NULL,
    W_WAREHOUSE_ID          CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME        VARCHAR(20)           UNIQUE,
    W_WAREHOUSE_SQ_FT       INTEGER               ,
    W_STREET_NUMBER         CHAR(10)              ,
    W_STREET_NAME           VARCHAR(60)           ,
    W_STREET_TYPE           CHAR(15)              ,
    W_SUITE_NUMBER          CHAR(10)              ,
    W_CITY                  VARCHAR(60)           ,
    W_COUNTY                VARCHAR(30)           ,
    W_STATE                 CHAR(2)               ,
    W_ZIP                   CHAR(10)              ,
    W_COUNTRY               VARCHAR(20)           ,
    W_GMT_OFFSET            DECIMAL(5,2)
) WITH(fillfactor=70);

-- Create a table and specify that its data is not written to WALs.
openGauss=# CREATE UNLOGGED TABLE tpcds.warehouse_t7
(
    W_WAREHOUSE_SK          INTEGER               NOT NULL,
    W_WAREHOUSE_ID          CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME        VARCHAR(20)           ,
    W_WAREHOUSE_SQ_FT       INTEGER               ,
    W_STREET_NUMBER         CHAR(10)              ,
    W_STREET_NAME           VARCHAR(60)           ,
    W_STREET_TYPE           CHAR(15)              ,
    W_SUITE_NUMBER          CHAR(10)              ,
    W_CITY                  VARCHAR(60)           ,
    W_COUNTY                VARCHAR(30)           ,
    W_STATE                 CHAR(2)               ,
    W_ZIP                   CHAR(10)              ,
    W_COUNTRY               VARCHAR(20)           ,
    W_GMT_OFFSET            DECIMAL(5,2)
);

-- Create a temporary table.
openGauss=# CREATE TEMPORARY TABLE warehouse_t24
(
    W_WAREHOUSE_SK          INTEGER               NOT NULL,
    W_WAREHOUSE_ID          CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME        VARCHAR(20)           ,
    W_WAREHOUSE_SQ_FT       INTEGER               ,
    W_STREET_NUMBER         CHAR(10)              ,
    W_STREET_NAME           VARCHAR(60)           ,
    W_STREET_TYPE           CHAR(15)              ,
    W_SUITE_NUMBER          CHAR(10)              ,
    W_CITY                  VARCHAR(60)           ,
    W_COUNTY                VARCHAR(30)           ,
    W_STATE                 CHAR(2)               ,
    W_ZIP                   CHAR(10)              ,
    W_COUNTRY               VARCHAR(20)           ,
    W_GMT_OFFSET            DECIMAL(5,2)
);

-- Create a temporary table in a transaction and specify that this table is deleted when the transaction is
committed.
openGauss=# CREATE TEMPORARY TABLE warehouse_t25
(
    W_WAREHOUSE_SK          INTEGER               NOT NULL,
```

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```
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
) ON COMMIT DELETE ROWS;

-- Create a table and specify that no error is reported for duplicate tables (if any).
openGauss=# CREATE TABLE IF NOT EXISTS tpcds.warehouse_t8
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
);

-- Create a general tablespace.
openGauss=# CREATE TABLESPACE DS_TABLESPACE1 RELATIVE LOCATION 'tablespace/tablespace_1';
-- Specify a tablespace when creating a table.
openGauss=# CREATE TABLE tpcds.warehouse_t9
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
) TABLESPACE DS_TABLESPACE1;

-- Separately specify the index tablespace for W_WAREHOUSE_NAME when creating the table.
openGauss=# CREATE TABLE tpcds.warehouse_t10
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)           UNIQUE USING INDEX TABLESPACE
DS_TABLESPACE1,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
```

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```
    W_STATE                 CHAR(2)                 ,
    W_ZIP                   CHAR(10)                ,
    W_COUNTRY               VARCHAR(20)             ,
    W_GMT_OFFSET            DECIMAL(5,2)
);
-- Create a table with a primary key constraint.
openGauss=# CREATE TABLE tpcds.warehouse_t11
(
    W_WAREHOUSE_SK          INTEGER         PRIMARY KEY,
    W_WAREHOUSE_ID          CHAR(16)        NOT NULL,
    W_WAREHOUSE_NAME        VARCHAR(20)             ,
    W_WAREHOUSE_SQ_FT       INTEGER                 ,
    W_STREET_NUMBER         CHAR(10)                ,
    W_STREET_NAME           VARCHAR(60)             ,
    W_STREET_TYPE           CHAR(15)                ,
    W_SUITE_NUMBER          CHAR(10)                ,
    W_CITY                  VARCHAR(60)             ,
    W_COUNTY                VARCHAR(30)             ,
    W_STATE                 CHAR(2)                 ,
    W_ZIP                   CHAR(10)                ,
    W_COUNTRY               VARCHAR(20)             ,
    W_GMT_OFFSET            DECIMAL(5,2)
);

-- An alternative for the preceding syntax is as follows:
openGauss=# CREATE TABLE tpcds.warehouse_t12
(
    W_WAREHOUSE_SK          INTEGER             NOT NULL,
    W_WAREHOUSE_ID          CHAR(16)            NOT NULL,
    W_WAREHOUSE_NAME        VARCHAR(20)             ,
    W_WAREHOUSE_SQ_FT       INTEGER                 ,
    W_STREET_NUMBER         CHAR(10)                ,
    W_STREET_NAME           VARCHAR(60)             ,
    W_STREET_TYPE           CHAR(15)                ,
    W_SUITE_NUMBER          CHAR(10)                ,
    W_CITY                  VARCHAR(60)             ,
    W_COUNTY                VARCHAR(30)             ,
    W_STATE                 CHAR(2)                 ,
    W_ZIP                   CHAR(10)                ,
    W_COUNTRY               VARCHAR(20)             ,
    W_GMT_OFFSET            DECIMAL(5,2),
    PRIMARY KEY(W_WAREHOUSE_SK)
);

-- Or use the following statement to specify the name of the constraint:
openGauss=# CREATE TABLE tpcds.warehouse_t13
(
    W_WAREHOUSE_SK          INTEGER             NOT NULL,
    W_WAREHOUSE_ID          CHAR(16)            NOT NULL,
    W_WAREHOUSE_NAME        VARCHAR(20)             ,
    W_WAREHOUSE_SQ_FT       INTEGER                 ,
    W_STREET_NUMBER         CHAR(10)                ,
    W_STREET_NAME           VARCHAR(60)             ,
    W_STREET_TYPE           CHAR(15)                ,
    W_SUITE_NUMBER          CHAR(10)                ,
    W_CITY                  VARCHAR(60)             ,
    W_COUNTY                VARCHAR(30)             ,
    W_STATE                 CHAR(2)                 ,
    W_ZIP                   CHAR(10)                ,
    W_COUNTRY               VARCHAR(20)             ,
    W_GMT_OFFSET            DECIMAL(5,2),
    CONSTRAINT W_CSTR_KEY1 PRIMARY KEY(W_WAREHOUSE_SK)
);

-- Create a table with a compound primary key constraint.
openGauss=# CREATE TABLE tpcds.warehouse_t14
(
    W_WAREHOUSE_SK          INTEGER             NOT NULL,
    W_WAREHOUSE_ID          CHAR(16)            NOT NULL,
```

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```
    W_WAREHOUSE_NAME          VARCHAR(20)                ,
    W_WAREHOUSE_SQ_FT         INTEGER                    ,
    W_STREET_NUMBER           CHAR(10)                   ,
    W_STREET_NAME             VARCHAR(60)                ,
    W_STREET_TYPE             CHAR(15)                   ,
    W_SUITE_NUMBER            CHAR(10)                   ,
    W_CITY                    VARCHAR(60)                ,
    W_COUNTY                  VARCHAR(30)                ,
    W_STATE                   CHAR(2)                    ,
    W_ZIP                     CHAR(10)                   ,
    W_COUNTRY                 VARCHAR(20)                ,
    W_GMT_OFFSET              DECIMAL(5,2),
    CONSTRAINT W_CSTR_KEY2 PRIMARY KEY(W_WAREHOUSE_SK, W_WAREHOUSE_ID)
);

-- Create a column-store table.
openGauss=# CREATE TABLE tpcds.warehouse_t15
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                ,
    W_WAREHOUSE_SQ_FT         INTEGER                    ,
    W_STREET_NUMBER           CHAR(10)                   ,
    W_STREET_NAME             VARCHAR(60)                ,
    W_STREET_TYPE             CHAR(15)                   ,
    W_SUITE_NUMBER            CHAR(10)                   ,
    W_CITY                    VARCHAR(60)                ,
    W_COUNTY                  VARCHAR(30)                ,
    W_STATE                   CHAR(2)                    ,
    W_ZIP                     CHAR(10)                   ,
    W_COUNTRY                 VARCHAR(20)                ,
    W_GMT_OFFSET              DECIMAL(5,2)
) WITH (ORIENTATION = COLUMN);

-- Create a column-store table using partial clustered storage.
openGauss=# CREATE TABLE tpcds.warehouse_t16
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                ,
    W_WAREHOUSE_SQ_FT         INTEGER                    ,
    W_STREET_NUMBER           CHAR(10)                   ,
    W_STREET_NAME             VARCHAR(60)                ,
    W_STREET_TYPE             CHAR(15)                   ,
    W_SUITE_NUMBER            CHAR(10)                   ,
    W_CITY                    VARCHAR(60)                ,
    W_COUNTY                  VARCHAR(30)                ,
    W_STATE                   CHAR(2)                    ,
    W_ZIP                     CHAR(10)                   ,
    W_COUNTRY                 VARCHAR(20)                ,
    W_GMT_OFFSET              DECIMAL(5,2),
    PARTIAL CLUSTER KEY(W_WAREHOUSE_SK, W_WAREHOUSE_ID)
) WITH (ORIENTATION = COLUMN);

-- Define a column-store table with compression enabled.
openGauss=# CREATE TABLE tpcds.warehouse_t17
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                ,
    W_WAREHOUSE_SQ_FT         INTEGER                    ,
    W_STREET_NUMBER           CHAR(10)                   ,
    W_STREET_NAME             VARCHAR(60)                ,
    W_STREET_TYPE             CHAR(15)                   ,
    W_SUITE_NUMBER            CHAR(10)                   ,
    W_CITY                    VARCHAR(60)                ,
    W_COUNTY                  VARCHAR(30)                ,
    W_STATE                   CHAR(2)                    ,
    W_ZIP                     CHAR(10)                   ,
```

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```
    W_COUNTRY               VARCHAR(20)                 ,
    W_GMT_OFFSET            DECIMAL(5,2)
) WITH (ORIENTATION = COLUMN, COMPRESSION=HIGH);

-- Define a table with compression enabled.
openGauss=# CREATE TABLE tpcds.warehouse_t18
(
    W_WAREHOUSE_SK          INTEGER               NOT NULL,
    W_WAREHOUSE_ID          CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                 ,
    W_WAREHOUSE_SQ_FT         INTEGER                     ,
    W_STREET_NUMBER         CHAR(10)                    ,
    W_STREET_NAME           VARCHAR(60)                 ,
    W_STREET_TYPE           CHAR(15)                    ,
    W_SUITE_NUMBER            CHAR(10)                  ,
    W_CITY                  VARCHAR(60)                 ,
    W_COUNTY                  VARCHAR(30)               ,
    W_STATE                 CHAR(2)                     ,
    W_ZIP                   CHAR(10)                    ,
    W_COUNTRY               VARCHAR(20)                 ,
    W_GMT_OFFSET            DECIMAL(5,2)
) COMPRESS;

-- Define a column check constraint.
openGauss=# CREATE TABLE tpcds.warehouse_t19
(
    W_WAREHOUSE_SK          INTEGER               PRIMARY KEY CHECK (W_WAREHOUSE_SK > 0),
    W_WAREHOUSE_ID          CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)           CHECK (W_WAREHOUSE_NAME IS NOT NULL),
    W_WAREHOUSE_SQ_FT         INTEGER                     ,
    W_STREET_NUMBER         CHAR(10)                    ,
    W_STREET_NAME           VARCHAR(60)                 ,
    W_STREET_TYPE           CHAR(15)                    ,
    W_SUITE_NUMBER            CHAR(10)                  ,
    W_CITY                  VARCHAR(60)                 ,
    W_COUNTY                  VARCHAR(30)               ,
    W_STATE                 CHAR(2)                     ,
    W_ZIP                   CHAR(10)                    ,
    W_COUNTRY               VARCHAR(20)                 ,
    W_GMT_OFFSET            DECIMAL(5,2)
);

openGauss=# CREATE TABLE tpcds.warehouse_t20
(
    W_WAREHOUSE_SK          INTEGER               PRIMARY KEY,
    W_WAREHOUSE_ID          CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)           CHECK (W_WAREHOUSE_NAME IS NOT NULL),
    W_WAREHOUSE_SQ_FT         INTEGER                     ,
    W_STREET_NUMBER         CHAR(10)                    ,
    W_STREET_NAME           VARCHAR(60)                 ,
    W_STREET_TYPE           CHAR(15)                    ,
    W_SUITE_NUMBER            CHAR(10)                  ,
    W_CITY                  VARCHAR(60)                 ,
    W_COUNTY                  VARCHAR(30)               ,
    W_STATE                 CHAR(2)                     ,
    W_ZIP                   CHAR(10)                    ,
    W_COUNTRY               VARCHAR(20)                 ,
    W_GMT_OFFSET            DECIMAL(5,2),
    CONSTRAINT W_CONSTR_KEY2 CHECK(W_WAREHOUSE_SK > 0 AND W_WAREHOUSE_NAME IS NOT
NULL)
);

-- Define a table with each row stored in all DNs.
openGauss=# CREATE TABLE tpcds.warehouse_t21
(
    W_WAREHOUSE_SK          INTEGER               NOT NULL,
    W_WAREHOUSE_ID          CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                 ,
    W_WAREHOUSE_SQ_FT         INTEGER                     ,
```

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```
    W_STREET_NUMBER           CHAR(10)                    ,
    W_STREET_NAME             VARCHAR(60)                 ,
    W_STREET_TYPE             CHAR(15)                    ,
    W_SUITE_NUMBER            CHAR(10)                    ,
    W_CITY                    VARCHAR(60)                 ,
    W_COUNTY                  VARCHAR(30)                 ,
    W_STATE                   CHAR(2)                     ,
    W_ZIP                     CHAR(10)                    ,
    W_COUNTRY                 VARCHAR(20)                 ,
    W_GMT_OFFSET              DECIMAL(5,2)
)DISTRIBUTE BY REPLICATION;
Enable the primarynode option of the replication table.
openGauss=# ALTER TABLE tpcds.warehouse_t21 SET (primarynode=on);

Check whether the option is enabled. (The content displayed in Options varies according to the version.)
openGauss=# \d+ tpcds.warehouse_t21
                        Table "tpcds.warehouse_t21"
     Column       |         Type          | Modifiers | Storage  | Stats target | Description
------------------+-----------------------+-----------+----------+--------------+-------------
 w_warehouse_sk    | integer               | not null  | plain    |              |
 w_warehouse_id    | character(16)         | not null  | extended |              |
 w_warehouse_name  | character varying(20) |           | extended |              |
 w_warehouse_sq_ft | integer               |           | plain    |              |
 w_street_number   | character(10)         |           | extended |              |
 w_street_name     | character varying(60) |           | extended |              |
 w_street_type     | character(15)         |           | extended |              |
 w_suite_number    | character(10)         |           | extended |              |
 w_city            | character varying(60) |           | extended |              |
 w_county          | character varying(30) |           | extended |              |
 w_state           | character(2)          |           | extended |              |
 w_zip             | character(10)         |           | extended |              |
 w_country         | character varying(20) |           | extended |              |
 w_gmt_offset      | numeric(5,2)          |           | main     |              |
Has OIDs: no
Distribute By: REPLICATION
Location Nodes: ALL DATANODES
Options: compression=no, primarynode=on
-- Define a hash table.
openGauss=# CREATE TABLE tpcds.warehouse_t22
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2),
    CONSTRAINT W_CONSTR_KEY3 UNIQUE(W_WAREHOUSE_SK)
)DISTRIBUTE BY HASH(W_WAREHOUSE_SK);
-- View DN information.
gaussdb=# select node_name from pgxc_node;
  node_name
--------------
 coordinator1
 datanode1
 datanode2
 datanode3
 datanode4
 datanode5
 datanode6
(7 rows)
```

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```
-- Define a table using RANGE distribution.
openGauss=# CREATE TABLE tpcds.warehouse_t26
(
W_WAREHOUSE_SK            INTEGER               NOT NULL,
W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
W_WAREHOUSE_NAME          VARCHAR(20)                   ,
W_WAREHOUSE_SQ_FT         INTEGER                       ,
W_STREET_NUMBER           CHAR(10)                      ,
W_STREET_NAME             VARCHAR(60)                   ,
W_STREET_TYPE             CHAR(15)                      ,
W_SUITE_NUMBER            CHAR(10)                      ,
W_CITY                    VARCHAR(60)                   ,
W_COUNTY                  VARCHAR(30)                   ,
W_STATE                   CHAR(2)                       ,
W_ZIP                     CHAR(10)                      ,
W_COUNTRY                 VARCHAR(20)                   ,
W_GMT_OFFSET              DECIMAL(5,2)
)DISTRIBUTE BY RANGE(W_WAREHOUSE_ID)
(
   SLICE s1 VALUES LESS THAN (10) DATANODE datanode1,
   SLICE s2 VALUES LESS THAN (20) DATANODE datanode2,
   SLICE s3 VALUES LESS THAN (30) DATANODE datanode3,
   SLICE s4 VALUES LESS THAN (MAXVALUE) DATANODE datanode4
);

-- Example of a multi-column range partitioning policy
openGauss=# create table t_ran1(c1 int, c2 int, c3 int, c4 int, c5 int)
distribute by range(c1,c2)
(
SLICE s1 VALUES LESS THAN (10,10) DATANODE datanode1,
SLICE s2 VALUES LESS THAN (10,20) DATANODE datanode2,
SLICE s3 VALUES LESS THAN (20,10) DATANODE datanode3
);
openGauss=# insert into t_ran1 values(9,5,'a');
openGauss=# insert into t_ran1 values(9,20,'a');
openGauss=# insert into t_ran1 values(9,21,'a');
openGauss=# insert into t_ran1 values(10,5,'a');
openGauss=# insert into t_ran1 values(10,15,'a');
openGauss=# insert into t_ran1 values(10,20,'a');
openGauss=# insert into t_ran1 values(10,21,'a');
openGauss=# insert into t_ran1 values(11,5,'a');
openGauss=# insert into t_ran1 values(11,20,'a');
openGauss=# insert into t_ran1 values(11,21,'a');
openGauss=# select node_name,node_type,node_id from pgxc_node;
  node_name   | node_type |   node_id
--------------+-----------+-------------
 coordinator1 | C         |  1938253334
 datanode1    | D         |   888802358
 datanode2    | D         |  -905831925
 datanode3    | D         | -1894792127
(4 rows)
openGauss=# select xc_node_id,* from t_ran1;
 xc_node_id  | c1 | c2 | c3 | c4 | c5
-------------+----+----+----+----+----
   888802358 |  9 |  5 |  0 |    |
   888802358 |  9 | 20 |  0 |    |
   888802358 |  9 | 21 |  0 |    |
   888802358 | 10 |  5 |  0 |    |
  -905831925 | 10 | 15 |  0 |    |
 -1894792127 | 10 | 20 |  0 |    |
 -1894792127 | 10 | 21 |  0 |    |
 -1894792127 | 11 |  5 |  0 |    |
 -1894792127 | 11 | 20 |  0 |    |
 -1894792127 | 11 | 21 |  0 |    |
(10 rows)

-- Create a table using SLICE REFERENCES.
openGauss=# CREATE TABLE tpcds.warehouse_t27
(
```

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```
W_WAREHOUSE_SK            INTEGER               NOT NULL,
W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
W_WAREHOUSE_NAME          VARCHAR(20)                   ,
W_WAREHOUSE_SQ_FT         INTEGER                       ,
W_STREET_NUMBER           CHAR(10)                      ,
W_STREET_NAME             VARCHAR(60)                   ,
W_STREET_TYPE             CHAR(15)                      ,
W_SUITE_NUMBER            CHAR(10)                      ,
W_CITY                    VARCHAR(60)                   ,
W_COUNTY                  VARCHAR(30)                   ,
W_STATE                   CHAR(2)                       ,
W_ZIP                     CHAR(10)                      ,
W_COUNTRY                 VARCHAR(20)                   ,
W_GMT_OFFSET              DECIMAL(5,2)
)DISTRIBUTE BY RANGE(W_WAREHOUSE_ID) SLICE REFERENCES warehouse_t26;

-- Define a table using LIST distribution.
openGauss=# CREATE TABLE tpcds.warehouse_t28
(
W_WAREHOUSE_SK            INTEGER               NOT NULL,
W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
W_WAREHOUSE_NAME          VARCHAR(20)                   ,
W_WAREHOUSE_SQ_FT         INTEGER                       ,
W_STREET_NUMBER           CHAR(10)                      ,
W_STREET_NAME             VARCHAR(60)                   ,
W_STREET_TYPE             CHAR(15)                      ,
W_SUITE_NUMBER            CHAR(10)                      ,
W_CITY                    VARCHAR(60)                   ,
W_COUNTY                  VARCHAR(30)                   ,
W_STATE                   CHAR(2)                       ,
W_ZIP                     CHAR(10)                      ,
W_COUNTRY                 VARCHAR(20)                   ,
W_GMT_OFFSET              DECIMAL(5,2)
)DISTRIBUTE BY LIST(W_COUNTRY)
(
    SLICE s1 VALUES ('USA') DATANODE datanode1,
    SLICE s2 VALUES ('CANADA') DATANODE datanode2,
    SLICE s3 VALUES ('UK') DATANODE datanode3,
    SLICE s4 VALUES (DEFAULT) DATANODE datanode4
);
-- Add a varchar column to the tpcds.warehouse_t19 table.
openGauss=# ALTER TABLE tpcds.warehouse_t19 ADD W_GOODS_CATEGORY varchar(30);

-- Add a check constraint to the tpcds.warehouse_t19 table.
openGauss=# ALTER TABLE tpcds.warehouse_t19 ADD CONSTRAINT W_CONSTR_KEY4 CHECK (W_STATE IS
NOT NULL);

-- Use one statement to alter the types of two existing columns.
openGauss=# ALTER TABLE tpcds.warehouse_t19
    ALTER COLUMN W_GOODS_CATEGORY TYPE varchar(80),
    ALTER COLUMN W_STREET_NAME TYPE varchar(100);

-- This statement is equivalent to the preceding statement.
openGauss=# ALTER TABLE tpcds.warehouse_t19 MODIFY (W_GOODS_CATEGORY varchar(30),
W_STREET_NAME varchar(60));

-- Add a not-null constraint to an existing column.
openGauss=# ALTER TABLE tpcds.warehouse_t19 ALTER COLUMN W_GOODS_CATEGORY SET NOT NULL;

-- Remove not-null constraints from an existing column.
openGauss=# ALTER TABLE tpcds.warehouse_t19 ALTER COLUMN W_GOODS_CATEGORY DROP NOT NULL;

-- If no partial cluster is specified in a column-store table, add a partial cluster to the table.
openGauss=# ALTER TABLE tpcds.warehouse_t17 ADD PARTIAL CLUSTER KEY(W_WAREHOUSE_SK);

-- View the constraint name and delete the partial cluster column of a column-store table.
openGauss=# \d+ tpcds.warehouse_t17
                        Table "tpcds.warehouse_t17"
    Column      |         Type          | Modifiers | Storage  | Stats target | Description
```

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```
-------------------+-----------------------+-----------+----------+--------------+-------------
 w_warehouse_sk    | integer               | not null  | plain    |              |
 w_warehouse_id    | character(16)         | not null  | extended |              |
 w_warehouse_name  | character varying(20) |           | extended |              |
 w_warehouse_sq_ft | integer               |           | plain    |              |
 w_street_number   | character(10)         |           | extended |              |
 w_street_name     | character varying(60) |           | extended |              |
 w_street_type     | character(15)         |           | extended |              |
 w_suite_number    | character(10)         |           | extended |              |
 w_city            | character varying(60) |           | extended |              |
 w_county          | character varying(30) |           | extended |              |
 w_state           | character(2)          |           | extended |              |
 w_zip             | character(10)         |           | extended |              |
 w_country         | character varying(20) |           | extended |              |
 w_gmt_offset      | numeric(5,2)          |           | main     |              |
Partial Cluster :
    "warehouse_t17_cluster" PARTIAL CLUSTER KEY (w_warehouse_sk)
Has OIDs: no
Distribute By: HASH(w_warehouse_sk)
Location Nodes: ALL DATANODES
Options: compression=no, version=0.12
openGauss=# ALTER TABLE tpcds.warehouse_t17 DROP CONSTRAINT warehouse_t17_cluster;

-- Move a table to another tablespace.
openGauss=# ALTER TABLE tpcds.warehouse_t19 SET TABLESPACE PG_DEFAULT;
-- Create the joe schema.
openGauss=# CREATE SCHEMA joe;

-- Move a table to another schema.
openGauss=# ALTER TABLE tpcds.warehouse_t19 SET SCHEMA joe;

-- Rename an existing table.
openGauss=# ALTER TABLE joe.warehouse_t19 RENAME TO warehouse_t23;

-- Delete a column from the warehouse_t23 table.
openGauss=# ALTER TABLE joe.warehouse_t23 DROP COLUMN W_STREET_NAME;

-- Create an encryption table.
openGauss=# CREATE TABLE creditcard_info (id_number    int, name text encrypted with
(column_encryption_key = ImgCEK, encryption_type = DETERMINISTIC), credit_card  varchar(19) encrypted
with (column_encryption_key = ImgCEK1, encryption_type = DETERMINISTIC));
NOTICE:  The 'DISTRIBUTE BY' clause is not specified. Using 'id_number' as the distribution column by
default.
HINT:  Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
CREATE TABLE

-- Delete the tablespace, schema joe, and schema tables warehouse.
openGauss=# DROP TABLE tpcds.warehouse_t1;
openGauss=# DROP TABLE tpcds.warehouse_t2;
openGauss=# DROP TABLE tpcds.warehouse_t3;
openGauss=# DROP TABLE tpcds.warehouse_t4;
openGauss=# DROP TABLE tpcds.warehouse_t5;
openGauss=# DROP TABLE tpcds.warehouse_t6;
openGauss=# DROP TABLE tpcds.warehouse_t7;
openGauss=# DROP TABLE tpcds.warehouse_t8;
openGauss=# DROP TABLE tpcds.warehouse_t9;
openGauss=# DROP TABLE tpcds.warehouse_t10;
openGauss=# DROP TABLE tpcds.warehouse_t11;
openGauss=# DROP TABLE tpcds.warehouse_t12;
openGauss=# DROP TABLE tpcds.warehouse_t13;
openGauss=# DROP TABLE tpcds.warehouse_t14;
openGauss=# DROP TABLE tpcds.warehouse_t15;
openGauss=# DROP TABLE tpcds.warehouse_t16;
openGauss=# DROP TABLE tpcds.warehouse_t17;
openGauss=# DROP TABLE tpcds.warehouse_t18;
openGauss=# DROP TABLE tpcds.warehouse_t20;
openGauss=# DROP TABLE tpcds.warehouse_t21;
openGauss=# DROP TABLE tpcds.warehouse_t22;
openGauss=# DROP TABLE joe.warehouse_t23;
```

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```
openGauss=# DROP TABLE tpcds.warehouse_t24;
openGauss=# DROP TABLE tpcds.warehouse_t25;
openGauss=# DROP TABLE tpcds.warehouse_t26;
openGauss=# DROP TABLE tpcds.warehouse_t27;
openGauss=# DROP TABLE tpcds.warehouse_t28;
openGauss=# DROP TABLE creditcard_info;
openGauss=# DROP TABLESPACE DS_TABLESPACE1;
openGauss=# DROP SCHEMA IF EXISTS joe CASCADE;
```

## Helpful Links

**12.14.30 ALTER TABLE**, **12.14.125 DROP TABLE**, and **12.14.81 CREATE TABLESPACE**

## Suggestions

- UNLOGGED
  - The unlogged table and its indexes do not use the WAL log mechanism during data writing. Their write speed is much higher than that of ordinary tables. Therefore, they can be used for storing intermediate result sets of complex queries to improve query performance.
  - The unlogged table has no primary/standby mechanism. In case of system faults or abnormal breakpoints, data loss may occur. Therefore, the unlogged table cannot be used to store basic data.
- TEMPORARY | TEMP
  - A temporary table is automatically dropped at the end of a session.
  - The temporary table is visible only to the current CN.
- LIKE
  - The new table automatically inherits all column names, data types, and not-null constraints from this table. The new table is irrelevant to the original table after the creation.
- LIKE INCLUDING DEFAULTS
  - The default expressions are copied from the original table to the new table only if **INCLUDING DEFAULTS** is specified. The default behavior is to exclude default expressions, resulting in the copied columns in the new table having default values null.
- LIKE INCLUDING CONSTRAINTS
  - The **CHECK** constraints are copied from the original table to the new table only when **INCLUDING CONSTRAINTS** is specified. Other types of constraints are never copied to the new table. Not-null constraints are always copied to the new table. These rules also apply to column constraints and table constraints.
- LIKE INCLUDING INDEXES
  - Any indexes on the original table will not be created on the new table, unless the **INCLUDING INDEXES** clause is specified.
- LIKE INCLUDING STORAGE
  - **STORAGE** settings for the copied column definitions are copied only if **INCLUDING STORAGE** is specified. The default behavior is to exclude **STORAGE** settings.
- LIKE INCLUDING COMMENTS

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  - If **INCLUDING COMMENTS** is specified, comments for the copied columns, constraints, and indexes are copied. The default behavior is to exclude comments.
- LIKE INCLUDING PARTITION
  - If **INCLUDING PARTITION** is specified, the partition definitions of the source table are copied to the new table, and the new table no longer uses the **PARTITION BY** clause. The default behavior is to exclude partition definition of the original table.
- LIKE INCLUDING RELOPTIONS
  - If **INCLUDING RELOPTIONS** is specified, the new table will copy the storage parameter (that is, **WITH** clause) of the source table. The default behavior is to exclude partition definition of the storage parameter of the original table.
- LIKE INCLUDING DISTRIBUTION
  - If **INCLUDING DISTRIBUTION** is specified, the distribution information of the original table is copied to the new table, including distribution type and key, and the new table no longer use the **DISTRIBUTE BY** clause. The default behavior is to exclude distribution information of the original table.
- LIKE INCLUDING ALL
  - **INCLUDING ALL** contains the meaning of **INCLUDING DEFAULTS**, **INCLUDING CONSTRAINTS**, **INCLUDING INDEXES**, **INCLUDING STORAGE**, **INCLUDING COMMENTS**, **INCLUDING PARTITION**, **INCLUDING RELOPTIONS**, and **INCLUDING DISTRIBUTION**.
- ORIENTATION ROW
  - Creates a row-store table. Row-store applies to the OLTP service, which has many interactive transactions. An interaction involves many columns in the table. Using row-store can improve the efficiency.
- ORIENTATION COLUMN
  - Creates a column-store table. Column store applies to the data warehouse service, which has a large amount of aggregation computing, and involves a few column operations.
- DISTRIBUTE BY
  - It is recommended that a fact table or dimension table containing a large amount of data be created as a distribution table. Each row of the table will be placed into specified DNs based on the hash value of the specified column. The syntax is **distribute by hash (column_name)**.
  - It is recommended that a dimension table containing a small amount of data be created as a replication table. Each row in the table exists on all DNs. That is, each DN has complete table data. The syntax is **distribute by replication**.

# 12.14.81 CREATE TABLESPACE

## Function

**CREATE TABLESPACE** creates a tablespace in a database.

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## Precautions

- The system administrator or a user who inherits the **gs_role_tablespace** permission of the built-in role can create a tablespace.
- Do not run **CREATE TABLESPACE** in a transaction block.
- If executing **CREATE TABLESPACE** fails but the internal directory (or file) has been created, the directory (or file) will remain. You need to manually clear it before creating the tablespace again. If there are residual files of soft links for the tablespace in the data directory, delete the residual files, and then perform O&M operations.
- **CREATE TABLESPACE** cannot be used for two-phase transactions. If it fails on some nodes, the execution cannot be rolled back.
- For details about how to prepare for creating tablespaces, see the description of parameters below.
- You are not advised to use user-defined tablespaces in scenarios such as Huawei Cloud.

  This is because user-defined tablespaces are usually used with storage media other than the main storage (storage device where the default tablespace is located, such as a disk) to isolate I/O resources that can be used by different services. Storage devices use standard configurations and do not have other available storage media in scenarios such as Huawei Cloud. If the user-defined tablespace is not properly used, the system cannot run stably for a long time and the overall performance is affected. Therefore, you are advised to use the default tablespace.

## Syntax

```
CREATE TABLESPACE tablespace_name
    [ OWNER user_name ] [ RELATIVE ] LOCATION 'directory' [ MAXSIZE 'space_size' ]
    [with_option_clause];
```

The **with_option_clause** syntax for creating a general tablespace is as follows:

```
WITH ( {filesystem= { 'general'| "general" | general} |
    random_page_cost = { 'value ' | value } |
    seq_page_cost = { 'value ' | value }}[,...])
```

## Parameter Description

- **tablespace_name**

  Specifies name of the tablespace to be created.

  The tablespace name must be distinct from the name of any existing tablespace in the cluster and cannot start with "pg", which are reserved for system catalog spaces.

  Value range: a string. It must comply with the naming convention.

- **OWNER user_name**

  Specifies the name of the user who will own the tablespace. If omitted, the default owner is the current user.

  Only system administrators can create tablespaces, but they can use the **OWNER** clause to assign ownership of tablespaces to other users.

  Value range: a string. It must be an existing user.

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- **RELATIVE**

  Specifies a relative path. The location directory is relative to each CN/DN data directory.

  Directory hierarchy: the relative path of the CN or DN directory **/pg_location/** A relative path contains a maximum of two levels.

  If this parameter is not specified, the absolute tablespace path is used. The **LOCATION** directory must be an absolute path.

- **LOCATION directory**

  Specifies the directory for the table space. When creating an absolute tablespace path, ensure that the directory meets the following requirements:

  – The GaussDB system user must have the read and write permissions on the directory, and the directory must be empty. If the directory does not exist, the system automatically creates it.

  – The directory must be an absolute path, and does not contain special characters, such as dollar sign ($) and greater-than sign (>).

  – The directory cannot be specified under the database data directory.

  – The directory must be a local path.

  Value range: a string. It must be a valid directory.

- **MAXSIZE 'space_size'**

  Specifies the maximum size of a tablespace on a single DN.

  Value range: a string consisting of a positive integer and unit. The unit can be KB, MB, GB, TB, or PB currently. The unit of parsed value is KB and cannot exceed the range that can be expressed in 64 bits, which is 1 KB to 9007199254740991 KB.

- **random_page_cost**

  Specifies the cost of randomly reading the page overhead.

  Value range: 0 to 1.79769e+308

  Default value: value of the GUC parameter **random_page_cost**

- **seq_page_cost**

  Specifies the cost of reading the page overhead in specified order.

  Value range: 0 to 1.79769e+308

  Default value: value of GUC parameter **seq_page_cost**

## Examples

```
-- Create a tablespace.
openGauss=# CREATE TABLESPACE ds_location1 RELATIVE LOCATION 'test_tablespace/test_tablespace_1';

-- Create user joe.
openGauss=# CREATE ROLE joe IDENTIFIED BY 'xxxxxxxxxxxx';

-- Create user jay.
openGauss=# CREATE ROLE jay IDENTIFIED BY 'xxxxxxxxxxx';

-- Create a tablespace and set its owner to user joe.
openGauss=# CREATE TABLESPACE ds_location2 OWNER joe RELATIVE LOCATION 'test_tablespace/
test_tablespace_2';

-- Rename the ds_location1 tablespace to ds_location3.
openGauss=# ALTER TABLESPACE ds_location1 RENAME TO ds_location3;
```

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```
-- Change the owner of the ds_location2 tablespace.
openGauss=# ALTER TABLESPACE ds_location2 OWNER TO jay;

-- Delete the tablespace.
openGauss=# DROP TABLESPACE ds_location2;
openGauss=# DROP TABLESPACE ds_location3;

-- Delete the user.
openGauss=# DROP ROLE joe;
openGauss=# DROP ROLE jay;
```

## Helpful Links

12.14.57 CREATE DATABASE, 12.14.80 CREATE TABLE, 12.14.64 CREATE INDEX, 12.14.126 DROP TABLESPACE, and 12.14.32 ALTER TABLESPACE

## Suggestions

- create tablespace

  You are not advised to create tablespaces in a transaction.

# 12.14.82 CREATE TABLE AS

## Function

**CREATE TABLE AS** creates a table from the results of a query.

It creates a table and fills it with data obtained using **SELECT**. The table columns have the names and data types associated with the output columns of **SELECT** (except that you can override the **SELECT** output column names by giving an explicit list of new column names).

**CREATE TABLE AS** queries a source table once and writes the data in a new table. The result in the query view changes with the source table. In contrast, the view re-computes and defines its **SELECT** statement at each query.

## Precautions

- This statement cannot be used to create a partitioned table.
- If an error occurs during table creation, after it is fixed, the system may fail to delete the disk files that are created before the last automatic clearance and whose size is not 0. This problem seldom occurs and does not affect system running of the database.

## Syntax

```
CREATE [ [ GLOBAL | LOCAL ] [ TEMPORARY | TEMP ] | UNLOGGED ] TABLE table_name
    [ (column_name [, ...] ) ]
    [ WITH ( {storage_parameter = value} [, ... ] ) ]
    [ COMPRESS | NOCOMPRESS ]
    [ TABLESPACE tablespace_name ]
    [ DISTRIBUTE BY { REPLICATION | { [HASH ] ( column_name ) } } ]
    [ TO { GROUP groupname | NODE ( nodename [, ... ] ) } ]
    AS query
    [ WITH [ NO ] DATA ];
```

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## Parameter Description

- **UNLOGGED**

  Specifies that the table is created as an unlogged table. Data written to unlogged tables is not written to the WALs, which makes them considerably faster than ordinary tables. However, they are not crash-safe: an unlogged table is automatically truncated after a crash or unclean shutdown. The contents of an unlogged table are also not replicated to standby servers. Any indexes created on an unlogged table are automatically unlogged as well.

  – Usage scenario: Unlogged tables do not ensure data security. Users can back up data before using unlogged tables; for example, users should back up the data before a system upgrade.

  – Troubleshooting: If data is missing in the indexes of unlogged tables due to some unexpected operations such as an unclean shutdown, users should re-create the indexes with errors.

- **GLOBAL | LOCAL**

  When creating a temporary table, you can specify the **GLOBAL** or **LOCAL** keyword before **TEMP** or **TEMPORARY**. Currently, the two keywords are used to be compatible with the SQL standard. A local temporary table will be created by the GaussDB regardless of whether **GLOBAL** or **LOCAL** is specified.

- **TEMPORARY | TEMP**

  If **TEMP** or **TEMPORARY** is specified, the created table is a temporary table. Temporary tables are classified into global temporary tables and local temporary tables. If the keyword **GLOBAL** is specified when a temporary table is created, the table is a global temporary table. Otherwise, the table is a local temporary table.

  The metadata of the global temporary table is visible to all sessions. After the sessions end, the metadata still exists. The user data, indexes, and statistics of a session are isolated from those of another session. Each session can only view and modify the data submitted by itself. Global temporary tables have two schemas: **ON COMMIT PRESERVE ROWS** and **ON COMMIT PRESERVE ROWS**. In session-based **ON COMMIT PRESERVE ROWS** schema, user data is automatically cleared when a session ends. In transaction-based **ON COMMIT DELETE ROWS** schema, user data is automatically cleared when the commit or rollback operation is performed. If the **ON COMMIT** option is not specified during table creation, the session level is used by default. Different from local temporary tables, you can specify a schema that does not start with **pg_temp_** when creating a global temporary table.

  A local temporary table is automatically dropped at the end of the current session. Therefore, temporary tables can still be created and used in the current session when the database node connected to the current session is faulty. Temporary tables are created only in the current session. If a DDL statement involves operations on temporary tables, a DDL error will be generated. Therefore, you are not advised to perform operations on temporary tables in DDL statements. **TEMP** is equivalent to **TEMPORARY**.

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**NOTICE**

- Local temporary tables are visible to the current session through the schema starting with **pg_temp**. Users should not delete schema started with **pg_temp** or **pg_toast_temp**.
- If **TEMPORARY** or **TEMP** is not specified when you create a table and its schema is set to the schema of the **pg_temp_** start in the current session, the table will be created as a temporary table.
- If global temporary tables and indexes are being used by other sessions, do not perform **ALTER** or **DROP**.
- The DDL of a global temporary table affects only the user data and indexes of the current session. For example, **TRUNCATE**, **REINDEX**, and **ANALYZE** are valid only for the current session.

- **table_name**

  Specifies the name of the table to be created.

  Value range: a string. It must comply with the naming convention.

- **column_name**

  Specifies the name of a column to be created in the new table.

  Value range: a string. It must comply with the naming convention.

- **WITH ( storage_parameter [= value] [, ... ] )**

  Specifies an optional storage parameter for a table or an index. See details of parameters below.

  – FILLFACTOR

    The fill factor of a table is a percentage from 10 to 100. **100** (complete filling) is the default value. When a smaller fill factor is specified, **INSERT** operations pack table pages only to the indicated percentage. The remaining space on each page is reserved for updating rows on that page. This gives **UPDATE** a chance to place the updated copy of a row on the same page, which is more efficient than placing it on a different page. For a table whose entries are never updated, setting the fill factor to **100** (complete filling) is the best choice, but in heavily updated tables a smaller fill factor would be appropriate. The parameter is only valid for row–store tables.

    Value range: 10–100

  – ORIENTATION

    Value range:

    **COLUMN**: The data will be stored in columns.

    **ROW** (default value): The data will be stored in rows.

  – COMPRESSION

    Specifies the compression level of table data. It determines the compression ratio and time. Generally, the higher the level of compression, the higher the ratio, the longer the time; and the lower the level of compression, the lower the ratio, the shorter the time. The actual compression ratio depends on the distribution mode of table data loaded.

    Value range:

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The valid values for column-store tables are **YES**, **NO**, **LOW**, **MIDDLE**, and **HIGH**, and the default value is **LOW**.

Row-store tables do not support compression.

- MAX_BATCHROW

  Specifies the maximum number of rows in a storage unit during data loading. The parameter is only valid for column-store tables.

  Value range: 10000 to 60000

- hashbucket

  Creates a hash table that uses buckets. This parameter supports only row-store tables, including row-store range tables.

  Value range: **on** and **off**

  Default value: **off**

**NOTICE**

In current version, DDL operations on hash bucket tables are affected. Therefore, you are not advised to frequently perform DDL operations on hash bucket tables.

- **COMPRESS / NOCOMPRESS**

  Specifies keyword **COMPRESS** during the creation of a table, so that the compression feature is triggered in case of bulk **INSERT** operations. If this feature is enabled, a scan is performed for all tuple data within the page to generate a dictionary and then the tuple data is compressed and stored. If **NOCOMPRESS** is specified, the table is not compressed. Row-store tables do not support compression.

  Default value: **NOCOMPRESS**, that is, tuple data is not compressed before storage.

- **TABLESPACE tablespace_name**

  Specifies that the new table will be created in the **tablespace_name** tablespace. If not specified, the default tablespace is used.

- **DISTRIBUTE BY**

  Specifies how the table is distributed or replicated between DNs.

  - **REPLICATION**: Each row in the table exists on all DNs, that is, each DN has complete table data.
  - **HASH (column_name)**: Each row of the table will be placed into specified DNs based on the hash value of the specified column.

**NOTICE**

- When **DISTRIBUTE BY HASH (column_name)** is specified, the primary key and its unique index must contain the **column_name** column.
- When **DISTRIBUTE BY HASH (column_name)** is specified for a referenced table, the foreign key of the referencing table must contain the **column_name** column.

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Default value: **HASH(column_name)**, primary key column of **column_name** (if any) or column of the first data type that can be used as a distribution key.

**column_name** supports the following data types:

- Integer types: **TINYINT**, **SMALLINT**, **INT**, **BIGINT**, and **NUMERIC/DECIMAL**
- Character types: **CHAR**, **BPCHAR**, **VARCHAR**, **VARCHAR2**, and **NVARCHAR2**
- Date/time types: **DATE**, **TIME**, **TIMETZ**, **TIMESTAMP**, **TIMESTAMPTZ**, **INTERVAL**, and **SMALLDATETIME**

- **TO { GROUP groupname | NODE ( nodename [, ... ] ) }**

  **TO GROUP** specifies the node group to which the table to be created belongs. **TO NODE** is used for internal scale-out tools.

- **AS query**

  Specifies a **SELECT** or **VALUES** command, or an **EXECUTE** command that runs a prepared **SELECT** or **VALUES** query.

- **[ WITH [ NO ] DATA ]**

  Specifies whether the data produced by the query should be copied to the new table. By default, the data will be copied. If the value **NO** is used, only the table structure will be copied.

## Examples

```
-- Create the tpcds.store_returns table.
openGauss=# CREATE TABLE tpcds.store_returns
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    sr_item_sk                VARCHAR(20)                ,
    W_WAREHOUSE_SQ_FT         INTEGER
);
-- Create the tpcds.store_returns_t1 table and insert numbers that are greater than 16 in the sr_item_sk column of the tpcds.store_returns table.
openGauss=# CREATE TABLE tpcds.store_returns_t1 AS SELECT * FROM tpcds.store_returns WHERE sr_item_sk > '4795';

-- Copy tpcds.store_returns to create the tpcds.store_returns_t2 table.
openGauss=# CREATE TABLE tpcds.store_returns_t2 AS table tpcds.store_returns;

-- Delete the table.
openGauss=# DROP TABLE tpcds.store_returns_t1 ;
openGauss=# DROP TABLE tpcds.store_returns_t2 ;
openGauss=# DROP TABLE tpcds.store_returns;
```

## Helpful Links

**12.14.80 CREATE TABLE** and **12.14.159 SELECT**

# 12.14.83 CREATE TABLE PARTITION

## Function

**CREATE TABLE PARTITION** creates a partitioned table. Partitioning refers to splitting what is logically one large table into smaller physical pieces based on specific schemes. The table based on the logic is called a partitioned table, and

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each physical piece is called a partition. Data is stored on these physical partitions, instead of the logical partitioned table.

The common forms of partitioning include range partitioning, hash partitioning, list partitioning, and value partitioning. Currently, row-store and column-store tables support only range partitioning.

In range partitioning, a table is partitioned based on ranges defined by one or more columns, with no overlap between the ranges of values assigned to different partitions. Each range has a dedicated partition for data storage.

The partitioning policy for range partitioning refers to how data is inserted into partitions. Currently, range partitioning only allows the use of the range partitioning policy.

In range partitioning, a table is partitioned based on partition key values. If a record can be mapped to a partition, it is inserted into the partition; if it cannot, an error message is returned. Range partitioning is the most commonly used partitioning policy.

Partitioning can provide several benefits:

- Query performance can be improved drastically in certain situations, particularly when most of the heavily accessed rows of the table are in a single partition or a small number of partitions. Partitioning narrows the range of data search and improves data access efficiency.
- In the case of an insert or update operation on most portions of a single partition, performance can be improved by taking advantage of continuous scan of that partition instead of partitions scattered across the whole table.
- Frequent loading or deletion operations on records in a separate partition can be accomplished by reading or removing that partition. It also avoids the VACUUM overload caused by bulk DELETE operations.

## Precautions

- When specifying a partition for query, for example, **select * from tablename partition** (*partitionname*), ensure that the keyword **partition** is correct. If it is incorrect, no error is reported during the query. In this case, the query is performed based on the table alias.
- In distributed mode, you can only use SELECT to specify partitions. If other syntax is used to specify partitions, an error is reported and no alias conversion is performed.

## Syntax

```
CREATE TABLE [ IF NOT EXISTS ] partition_table_name
( [
   { column_name data_type [ COLLATE collation ] [ column_constraint [ ... ] ]
   | table_constraint
   | LIKE source_table [ like_option [...] ] }
   [, ... ]
] )
   [ WITH ( {storage_parameter = value} [, ... ] ) ]
   [ COMPRESS | NOCOMPRESS ]
   [ TABLESPACE tablespace_name ]
   [ DISTRIBUTE BY { REPLICATION | { [ HASH ] ( column_name ) } } ]
   [ TO { GROUP groupname | NODE ( nodename [, ... ] ) } ]
   PARTITION BY {
```

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```
    {RANGE (partition_key) ( partition_less_than_item [, ... ] )} |
    {RANGE (partition_key) ( partition_start_end_item [, ... ] )}
  } [ { ENABLE | DISABLE } ROW MOVEMENT ];
```

- **column_constraint** is as follows:

```
[ CONSTRAINT constraint_name ]
{ NOT NULL |
  NULL |
  CHECK ( expression ) |
  DEFAULT default_expr |
  UNIQUE [ index_parameters ] |
  PRIMARY KEY [ index_parameters |
  REFERENCES reftable [ ( refcolumn ) ] [ MATCH FULL | MATCH PARTIAL | MATCH SIMPLE ]
    [ ON DELETE action ] [ ON UPDATE action ] }
[ DEFERRABLE | NOT DEFERRABLE ][ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]
```

- **table_constraint** is as follows:

```
[ CONSTRAINT constraint_name ]
{ CHECK ( expression ) |
  UNIQUE ( column_name [, ... ] ) [ index_parameters ] |
  PRIMARY KEY ( column_name [, ... ] ) [ index_parameters |
  FOREIGN KEY ( column_name [, ... ] ) REFERENCES reftable [ ( refcolumn [, ... ] ) ]

[ DEFERRABLE | NOT DEFERRABLE ][ INITIALLY DEFERRED | INITIALLY IMMEDIATE ]
```

- **like_option** is as follows:

```
{ INCLUDING | EXCLUDING } { DEFAULTS | CONSTRAINTS | INDEXES | STORAGE | COMMENTS |
RELOPTIONS | DISTRIBUTION | ALL }
```

- **index_parameters** is as follows:

```
[ WITH ( {storage_parameter = value} [, ... ] ) ]
[ USING INDEX TABLESPACE tablespace_name ]
```

- partition_less_than_item:

```
PARTITION partition_name VALUES LESS THAN ( { partition_value | MAXVALUE } ) [TABLESPACE
tablespace_name]
```

- partition_start_end_item:

```
PARTITION partition_name {
      {START(partition_value) END (partition_value) EVERY (interval_value)} |
      {START(partition_value) END ({partition_value | MAXVALUE})} |
      {START(partition_value)} |
      {END({partition_value | MAXVALUE})}
} [TABLESPACE tablespace_name]
```

## Parameter Description

- **IF NOT EXISTS**

  Sends a notice, but does not throw an error, if a table with the same name exists.

- **partition_table_name**

  Specifies the name of a partitioned table.

  Value range: a string. It must comply with the naming convention.

- **column_name**

  Specifies the name of a column to be created in the new table.

  Value range: a string. It must comply with the naming convention.

- **data_type**

  Specifies the data type of the column.

- **COLLATE collation**

  Assigns a collation to the column (which must be of a collatable data type). If no collation is specified, the default collation is used.

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- **CONSTRAINT constraint_name**

  Specifies the name of a column or table constraint. The optional constraint clauses specify constraints that new or updated rows must satisfy for an insert or update operation to succeed. You can run the **select * from pg_collation** command to query collation rules from the **pg_collation** system catalog. The default collation rule is the row starting with **default** in the query result.

  There are two ways to define constraints:

  – A column constraint is defined as part of a column definition, and it is bound to a particular column.

  – A table constraint is not bound to a particular column but can apply to more than one column.

- **LIKE source_table [ like_option ... ]**

  Specifies a table from which the new table automatically copies all column names, their data types, and their not-null constraints.

  Unlike **INHERITS**, the new table and original table are decoupled after creation is complete. Changes to the original table will not be applied to the new table, and it is not possible to include data of the new table in scans of the original table.

  Default expressions for the copied column definitions will be copied only if **INCLUDING DEFAULTS** is specified. The default behavior is to exclude default expressions, resulting in the copied columns in the new table having default values null.

  Not-null constraints are always copied to the new table. **CHECK** constraints will only be copied if **INCLUDING CONSTRAINTS** is specified; other types of constraints will never be copied. These rules also apply to column constraints and table constraints.

  Unlike those of **INHERITS**, columns and constraints copied by **LIKE** are not merged with similarly named columns and constraints. If the same name is specified explicitly or in another **LIKE** clause, an error is reported.

  – Any indexes on the original table will not be created on the new table, unless the **INCLUDING INDEXES** clause is specified.

  – **STORAGE** settings for the copied column definitions are copied only if **INCLUDING STORAGE** is specified. The default behavior is to exclude **STORAGE** settings.

  – If **INCLUDING COMMENTS** is specified, comments for the copied columns, constraints, and indexes are copied. The default behavior is to exclude comments.

  – If **INCLUDING RELOPTIONS** is specified, the new table will copy the storage parameter (that is, **WITH** clause) of the source table. The default behavior is to exclude partition definition of the storage parameter of the source table.

  – If **INCLUDING DISTRIBUTION** is specified, the new table will copy the distribution information of the source table, including distribution type and key, and the new table cannot use **DISTRIBUTE BY** clause. The default behavior is to exclude distribution information of the original table.

  – **INCLUDING ALL** contains the meaning of **INCLUDING DEFAULTS**, **INCLUDING CONSTRAINTS**, **INCLUDING INDEXES**, **INCLUDING**

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**STORAGE**, **INCLUDING COMMENTS**, **INCLUDING RELOPTIONS**, and **INCLUDING DISTRIBUTION**.

- **WITH ( storage_parameter [= value] [, ... ] )**

  Specifies an optional storage parameter for a table or an index. Optional parameters are as follows:

  - FILLFACTOR

    The fill factor of a table is a percentage from 10 to 100. **100** (complete filling) is the default value. When a smaller fill factor is specified, **INSERT** operations pack table pages only to the indicated percentage. The remaining space on each page is reserved for updating rows on that page. This gives **UPDATE** a chance to place the updated copy of a row on the same page, which is more efficient than placing it on a different page. For a table whose entries are never updated, setting the fill factor to **100** (complete filling) is the best choice, but in heavily updated tables a smaller fill factor would be appropriate. The parameter has no meaning for column–store tables.

    Value range: 10–100

  - ORIENTATION

    Determines the storage mode of the data in the table.

    Value range:

    - **COLUMN**: The data will be stored in columns.
    - **ROW** (default value): The data will be stored in rows.

    **NOTICE**

    **orientation** cannot be modified.

  - COMPRESSION

    - Valid values for column-store tables are **LOW**, **MIDDLE**, **HIGH**, **YES**, and **NO**, and the compression level increases accordingly. The default is **LOW**.
    - Row-store tables do not support compression.

  - MAX_BATCHROW

    Specifies the maximum number of rows in a storage unit during data loading. The parameter is only valid for column-store tables.

    Value range: 10000 to 60000

  - PARTIAL_CLUSTER_ROWS

    Specifies the number of records to be partially clustered for storage during data loading. The parameter is only valid for column-store tables.

    Value range: a number greater than or equal to 100000 The value is a multiple of *MAX_BATCHROW*.

  - DELTAROW_THRESHOLD

    A reserved parameter. The parameter is only valid for column-store tables.

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Value range: 0 to 9999

- hashbucket

  Creates a hash table that uses buckets. This parameter supports only row-store tables, including row-store range tables.

  Value range: **on** and **off**

  Default value: **off**

**NOTICE**

In current version, DDL operations on hash bucket tables are affected. Therefore, you are not advised to frequently perform DDL operations on hash bucket tables.

- **COMPRESS / NOCOMPRESS**

  Specifies keyword **COMPRESS** during the creation of a table, so that the compression feature is triggered in case of bulk **INSERT** operations. If this feature is enabled, a scan is performed for all tuple data within the page to generate a dictionary and then the tuple data is compressed and stored. If **NOCOMPRESS** is specified, the table is not compressed.

  Default value: **NOCOMPRESS**, that is, tuple data is not compressed before storage. Row-store tables do not support compression.

- **TABLESPACE tablespace_name**

  Specifies that the new table will be created in the **tablespace_name** tablespace. If not specified, the default tablespace is used.

- **DISTRIBUTE BY**

  Specifies how the table is distributed or replicated between DNs.

  Value range:

  - **REPLICATION**: Each row in the table exists on all DNs, that is, each DN has complete table data.
  - **HASH (column_name)**: Each row of the table will be placed into specified DNs based on the hash value of the specified column.

**NOTICE**

- When **DISTRIBUTE BY HASH (column_name)** is specified, the primary key and its unique index must contain the **column_name** column.
- When **DISTRIBUTE BY HASH (column_name)** in a referenced table is specified, the foreign key of the reference table must contain the **column_name** column.

  Default value: **HASH(column_name)**, primary key column of **column_name** (if any) or column of the first data type that can be used as a distribution key.

  **column_name** supports the following data types:

  - INTEGER TYPES: TINYINT, SMALLINT, INT, BIGINT, NUMERIC/DECIMAL
  - CHARACTER TYPES: CHAR, BPCHAR, VARCHAR, VARCHAR2, NVARCHAR2

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  - DATA/TIME TYPES: DATE, TIME, TIMETZ, TIMESTAMP, TIMESTAMPTZ, INTERVAL, SMALLDATETIME

- **TO { GROUP groupname | NODE ( nodename [, ... ] ) }**

  **TO GROUP** specifies the node group to which the table to be created belongs. **TO NODE** is used for internal scale-out tools.

- **PARTITION BY RANGE(partition_key)**

  Creates a range partition. **partition_key** is the name of the partition key.

  (1) Assume that the **VALUES LESS THAN** syntax is used.

  **NOTICE**

  In this case, a maximum of four partition keys are supported.

  Data types supported by the partition keys are as follows: **SMALLINT**, **INTEGER**, **BIGINT**, **DECIMAL**, **NUMERIC**, **REAL**, **DOUBLE PRECISION**, **CHARACTER VARYING**(*n*), **VARCHAR**(*n*), **CHARACTER**(*n*), **CHAR**(*n*), **CHARACTER**, **CHAR**, **TEXT**, **NVARCHAR2**, **NAME**, **TIMESTAMP[(p)] [WITHOUT TIME ZONE]**, **TIMESTAMP[(p)] [WITH TIME ZONE]**, and **DATE**.

  (2) Assume that the **START END** syntax is used.

  **NOTICE**

  In this case, only one partition key is supported.

  Data types supported by the partition key are as follows: **SMALLINT**, **INTEGER**, **BIGINT**, **DECIMAL**, **NUMERIC**, **REAL**, **DOUBLE PRECISION**, **TIMESTAMP[(p)] [WITHOUT TIME ZONE]**, **TIMESTAMP[(p)] [WITH TIME ZONE]**, and **DATE**.

- **PARTITION partition_name VALUES LESS THAN ( { partition_value | MAXVALUE } )**

  Specifies information of partitions. **partition_name** is the name of a range partition. **partition_value** is the upper limit of a range partition, and the value depends on the type of **partition_key**. *MAXVALUE* usually specifies the upper limit of the last range partition.

  **NOTICE**

  - Each partition requires an upper limit.
  - The data type of the upper limit must be the same as that of the partition key.
  - In a partition list, partitions are arranged in ascending order of upper limits. A partition with a smaller upper limit value is placed before another partition with a larger one.

- **PARTITION partition_name {START (partition_value) END (partition_value) EVERY (interval_value)} | {START (partition_value) END**

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**(partition_value|MAXVALUE)} | {START(partition_value)} | {END (partition_value | MAXVALUE)**}

Specifies information of partitions.

- **partition_name**: name or name prefix of a range partition. It is the name prefix only in the following cases (assuming that **partition_name** is **p1**):
  - If **START**+**END**+**EVERY** is used, the names of partitions will be defined as **p1_1**, **p1_2**, and the like. For example, if **PARTITION p1 START(1) END(4) EVERY(1)** is defined, the generated partitions are [1, 2), [2, 3), and [3, 4), and their names are **p1_1**, **p1_2**, and **p1_3**. In this case, **p1** is a name prefix.
  - If the defined statement is in the first place and has **START** specified, the range (*MINVALUE*, **START**) will be automatically used as the first actual partition, and its name will be **p1_0**. The other partitions are then named **p1_1**, **p1_2**, and the like. For example, if **PARTITION p1 START(1), PARTITION p2 START(2)** is defined, generated partitions are (*MINVALUE*, 1), [1, 2), and [2, *MAXVALUE*), and their names will be **p1_0**, **p1_1**, and **p2**. In this case, **p1** is a name prefix and **p2** is a partition name. **MINVALUE** means the minimum value.
- **partition_value**: start value or end value of a range partition. The value depends on **partition_key** and cannot be *MAXVALUE*.
- **interval_value**: width of each partition for dividing the [**START**, **END**) range. It cannot be *MAXVALUE*. If the value of (**END** – **START**) divided by **EVERY** has a remainder, the width of only the last partition is less than the value of **EVERY**.
- *MAXVALUE* usually specifies the upper limit of the last range partition.

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**NOTICE**

1. If the defined statement is in the first place and has **START** specified, the range (*MINVALUE*, **START**) will be automatically used as the first actual partition.
2. The **START END** syntax must comply with the following rules:
   - The value of **START** (if any, same for the following situations) in each **partition_start_end_item** must be smaller than that of **END**.
   - In two adjacent **partition_start_end_item** statements, the value of the first **END** must be equal to that of the second **START**.
   - The value of **EVERY** in each **partition_start_end_item** must be a positive number (in ascending order) and must be smaller than **END** minus **START**.
   - Each partition includes the start value (unless it is *MINVALUE*) and excludes the end value. The format is as follows: [**START**, **END**).
   - Partitions created by the same **partition_start_end_item** belong to the same tablespace.
   - If **partition_name** is a name prefix of a partition, the length must not exceed 57 bytes. If there are more than 57 bytes, the prefix will be automatically truncated.
   - When creating or modifying a partitioned table, ensure that the total number of partitions in the table does not exceed the maximum value (32767).
3. In statements for creating partitioned tables, **START END** and **LESS THAN** cannot be used together.
4. The **START END** syntax in a partitioned table creation SQL statement will be replaced by the **VALUES LESS THAN** syntax when **gs_dump** is executed.

- **{ ENABLE | DISABLE } ROW MOVEMENT**

  Sets row movement.

  If the tuple value is updated on the partition key during the **UPDATE** action, the partition where the tuple is located is altered. Setting this parameter enables error messages to be reported or movement of the tuple between partitions.

  Value range:

  – **ENABLE**: Row movement is enabled.

  – **DISABLE** (default value): Row movement is disabled.

  If the row movement is enabled, an error may be reported when update and delete operations are performed concurrently. The causes are as follows:

  The old data is marked as deleted under the update and delete operations. If the row movement is enabled, the cross-partition update occurs when the partition key is updated, the kernel marks the old data in the old partition as deleted and adds a data to the new partition. As a result, the new data cannot be found by querying the old data.

  If data in the same row is concurrently operated, the cross-partition and non-cross-partition data results have different behaviors in the following three concurrency scenarios: update and update concurrency, delete and delete concurrency, update and delete concurrency.

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a. For non-cross-partition data, no error is reported for the second operation after the first operation is performed.

   If the first operation is update, the latest data can be found and operated after the second operation is performed.

   If the first operation is delete, the second operation is terminated when the current data is deleted and the latest data cannot be found.

b. For the cross-partition data result, an error is reported for the second operation after the first operation is performed.

   If the first operation is update, the second operation cannot find the latest data because the new data is in the new partition. The operation fails and an error is reported.

   If the first operation is delete, performing the second operation can find that the current data is deleted and the latest data cannot be found, but cannot determine whether the operation of deleting the old data is update or delete. If the operation is update, an error is reported. If the operation is delete, the second operation is terminated. To ensure the data correctness, an error is reported.

If the update and update concurrency, and update and delete concurrency are performed, the error can be solved only when the operations are performed serially. If the delete and delete concurrency are performed, the error can be solved by disabling the row movement.

- **NOT NULL**

  The column is not allowed to contain null values. **ENABLE** can be omitted.

- **NULL**

  Specifies that the column is allowed to contain null values. This is the default setting.

  This clause is only provided for compatibility with non-standard SQL databases. It is not recommended.

- **CHECK (condition) [ NO INHERIT ]**

  Specifies an expression producing a Boolean result where the insert or update operation of new or updated rows can succeed only when the expression result is **TRUE** or **UNKNOWN**; otherwise, an error is thrown and the database is not altered.

  A check constraint specified as a column constraint should reference only the column's values, while an expression appearing in a table constraint can reference multiple columns.

  A constraint marked with **NO INHERIT** will not propagate to child tables.

  **ENABLE** can be omitted.

- **DEFAULT default_expr**

  Assigns a default data value for a column. The value can be any variable-free expressions. (Subqueries and cross-references to other columns in the current table are not allowed.) The data type of the default expression must match the data type of the column.

  The default expression will be used in any insert operation that does not specify a value for the column. If there is no default value for a column, then the default value is null.

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- **UNIQUE index_parameters**

  **UNIQUE ( column_name [, ... ] ) index_parameters**

  Specifies that a group of one or more columns of a table can contain only unique values.

  For the purpose of a unique constraint, null is not considered equal.

  NOTE

  If **DISTRIBUTE BY REPLICATION** is not specified, the column table that contains only unique values must contain distribution keys.

- **PRIMARY KEY index_parameters**

  **PRIMARY KEY ( column_name [, ... ] ) index_parameters**

  Specifies that a column or columns of a table can contain only unique (non-duplicate) and non-null values.

  Only one primary key can be specified for a table.

  NOTE

  If **DISTRIBUTE BY REPLICATION** is not specified, the column set with a primary key constraint must contain distribution keys.

- **DEFERRABLE | NOT DEFERRABLE**

  Controls whether the constraint can be deferred. A constraint that is not deferrable will be checked immediately after every command. Checking of constraints that are deferrable can be postponed until the end of the transaction using the **SET CONSTRAINTS** command. **NOT DEFERRABLE** is the default value. Currently, only **UNIQUE** and **PRIMARY KEY** constraints accept this clause. All the other constraints are not deferrable.

- **INITIALLY IMMEDIATE | INITIALLY DEFERRED**

  If a constraint is deferrable, this clause specifies the default time to check the constraint.

  – If the constraint is **INITIALLY IMMEDIATE** (default value), it is checked after each statement.
  – If the constraint is **INITIALLY DEFERRED**, it is checked only at the end of the transaction.

  The constraint check time can be altered using the **SET CONSTRAINTS** statement.

- **USING INDEX TABLESPACE tablespace_name**

  Allows selection of the tablespace in which the index associated with a **UNIQUE** or **PRIMARY KEY** constraint will be created. If not specified, **default_tablespace** is consulted, or the default tablespace in the database if **default_tablespace** is empty.

## Examples

- Example 1: Create a range-partitioned table **tpcds.web_returns_p1**. The table has eight partitions and their partition keys are of the integer type. The ranges of the partitions are: wr_returned_date_sk < 2450815, 2450815 ≤ wr_returned_date_sk < 2451179, 2451179 ≤ wr_returned_date_sk < 2451544, 2451544 ≤ wr_returned_date_sk < 2451910, 2451910 ≤ wr_returned_date_sk < 2452275, 2452275 ≤ wr_returned_date_sk < 2452640, 2452640 ≤ wr_returned_date_sk < 2453005, and wr_returned_date_sk ≥ 2453005.

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```
-- Create the tpcds.web_returns table.
openGauss=# CREATE TABLE tpcds.web_returns
(
    W_WAREHOUSE_SK            INTEGER               NOT NULL,
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)                   ,
    W_WAREHOUSE_SQ_FT         INTEGER                       ,
    W_STREET_NUMBER           CHAR(10)                      ,
    W_STREET_NAME             VARCHAR(60)                   ,
    W_STREET_TYPE             CHAR(15)                      ,
    W_SUITE_NUMBER            CHAR(10)                      ,
    W_CITY                    VARCHAR(60)                   ,
    W_COUNTY                  VARCHAR(30)                   ,
    W_STATE                   CHAR(2)                       ,
    W_ZIP                     CHAR(10)                      ,
    W_COUNTRY                 VARCHAR(20)                   ,
    W_GMT_OFFSET              DECIMAL(5,2)
);
-- Create a range-partitioned table tpcds.web_returns_p1.
openGauss=# CREATE TABLE tpcds.web_returns_p1
(
    WR_RETURNED_DATE_SK       INTEGER                       ,
    WR_RETURNED_TIME_SK       INTEGER                       ,
    WR_ITEM_SK                INTEGER               NOT NULL,
    WR_REFUNDED_CUSTOMER_SK   INTEGER                       ,
    WR_REFUNDED_CDEMO_SK      INTEGER                       ,
    WR_REFUNDED_HDEMO_SK      INTEGER                       ,
    WR_REFUNDED_ADDR_SK       INTEGER                       ,
    WR_RETURNING_CUSTOMER_SK  INTEGER                       ,
    WR_RETURNING_CDEMO_SK     INTEGER                       ,
    WR_RETURNING_HDEMO_SK     INTEGER                       ,
    WR_RETURNING_ADDR_SK      INTEGER                       ,
    WR_WEB_PAGE_SK            INTEGER                       ,
    WR_REASON_SK              INTEGER                       ,
    WR_ORDER_NUMBER           BIGINT                NOT NULL,
    WR_RETURN_QUANTITY        INTEGER                       ,
    WR_RETURN_AMT             DECIMAL(7,2)                  ,
    WR_RETURN_TAX             DECIMAL(7,2)                  ,
    WR_RETURN_AMT_INC_TAX     DECIMAL(7,2)                  ,
    WR_FEE                    DECIMAL(7,2)                  ,
    WR_RETURN_SHIP_COST       DECIMAL(7,2)                  ,
    WR_REFUNDED_CASH          DECIMAL(7,2)                  ,
    WR_REVERSED_CHARGE        DECIMAL(7,2)                  ,
    WR_ACCOUNT_CREDIT         DECIMAL(7,2)                  ,
    WR_NET_LOSS               DECIMAL(7,2)
)
WITH (ORIENTATION = COLUMN,COMPRESSION=MIDDLE)
DISTRIBUTE BY HASH (WR_ITEM_SK)
PARTITION BY RANGE(WR_RETURNED_DATE_SK)
(
        PARTITION P1 VALUES LESS THAN(2450815),
        PARTITION P2 VALUES LESS THAN(2451179),
        PARTITION P3 VALUES LESS THAN(2451544),
        PARTITION P4 VALUES LESS THAN(2451910),
        PARTITION P5 VALUES LESS THAN(2452275),
        PARTITION P6 VALUES LESS THAN(2452640),
        PARTITION P7 VALUES LESS THAN(2453005),
        PARTITION P8 VALUES LESS THAN(MAXVALUE)
);

-- Import data from the example data table.
openGauss=# INSERT INTO tpcds.web_returns_p1 SELECT * FROM tpcds.web_returns;

-- Delete the P8 partition.
openGauss=# ALTER TABLE tpcds.web_returns_p1 DROP PARTITION P8;

-- Add a partition WR_RETURNED_DATE_SK with values ranging from 2453005 to 2453105.
openGauss=# ALTER TABLE tpcds.web_returns_p1 ADD PARTITION P8 VALUES LESS THAN (2453105);
```

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```
-- Add a partition WR_RETURNED_DATE_SK with values ranging from 2453105 to MAXVALUE.
openGauss=# ALTER TABLE tpcds.web_returns_p1 ADD PARTITION P9 VALUES LESS THAN
(MAXVALUE);

-- Delete the P8 partition.
openGauss=# ALTER TABLE tpcds.web_returns_p1 DROP PARTITION FOR (2453005);

-- Rename the P7 partition to P10.
openGauss=# ALTER TABLE tpcds.web_returns_p1 RENAME PARTITION P7 TO P10;

-- Rename the P6 partition to P11.
openGauss=# ALTER TABLE tpcds.web_returns_p1 RENAME PARTITION FOR (2452639) TO P11;

-- Query the number of rows in the P10 partition.
openGauss=# SELECT count(*) FROM tpcds.web_returns_p1 PARTITION (P10);
 count
--------
 0
(1 row)

-- Query the number of rows in the P1 partition.
openGauss=# SELECT COUNT(*) FROM tpcds.web_returns_p1 PARTITION FOR (2450815);
 count
--------
 0
(1 row)
```

- Example 2: Create a range-partitioned table **tpcds.web_returns_p2**. The table has eight partitions and their partition keys are of the integer type. The upper limit of the eighth partition is *MAXVALUE*.

  The ranges of the partitions are: wr_returned_date_sk < 2450815, 2450815 ≤ wr_returned_date_sk < 2451179, 2451179 ≤ wr_returned_date_sk < 2451544, 2451544 ≤ wr_returned_date_sk < 2451910, 2451910 ≤ wr_returned_date_sk < 2452275, 2452275 ≤ wr_returned_date_sk < 2452640, 2452640 ≤ wr_returned_date_sk < 2453005, and wr_returned_date_sk ≥ 2453005.

  The tablespace of the **tpcds.web_returns_p2** partitioned table is **example1**. Partitions **P1** to **P7** have no specified tablespaces, and use the **example1** tablespace of the **tpcds.web_returns_p2** partitioned table. The tablespace of the **P8** partitioned table is **example2**.

  Assume that *CN and DN data directory*/**pg_location/mount1/path1**, *CN and DN data directory*/**pg_location/mount2/path2**, *CN and DN data directory*/**pg_location/mount3/path3**, and *CN and DN data directory*/**pg_location/mount4/path4** are empty directories for which user **dwsadmin** has read and write permissions.

```
openGauss=# CREATE TABLESPACE example1 RELATIVE LOCATION 'tablespace1/tablespace_1';
openGauss=# CREATE TABLESPACE example2 RELATIVE LOCATION 'tablespace2/tablespace_2';
openGauss=# CREATE TABLESPACE example3 RELATIVE LOCATION 'tablespace3/tablespace_3';
openGauss=# CREATE TABLESPACE example4 RELATIVE LOCATION 'tablespace4/tablespace_4';

openGauss=# CREATE TABLE tpcds.web_returns_p2
(
    WR_RETURNED_DATE_SK       INTEGER                   ,
    WR_RETURNED_TIME_SK       INTEGER                   ,
    WR_ITEM_SK                INTEGER             NOT NULL,
    WR_REFUNDED_CUSTOMER_SK   INTEGER                   ,
    WR_REFUNDED_CDEMO_SK      INTEGER                   ,
    WR_REFUNDED_HDEMO_SK      INTEGER                   ,
    WR_REFUNDED_ADDR_SK       INTEGER                   ,
    WR_RETURNING_CUSTOMER_SK  INTEGER                   ,
    WR_RETURNING_CDEMO_SK     INTEGER                   ,
    WR_RETURNING_HDEMO_SK     INTEGER                   ,
    WR_RETURNING_ADDR_SK      INTEGER                   ,
    WR_WEB_PAGE_SK            INTEGER                   ,
    WR_REASON_SK              INTEGER                   ,
```

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```
    WR_ORDER_NUMBER           BIGINT                NOT NULL,
    WR_RETURN_QUANTITY        INTEGER                       ,
    WR_RETURN_AMT             DECIMAL(7,2)                  ,
    WR_RETURN_TAX             DECIMAL(7,2)                  ,
    WR_RETURN_AMT_INC_TAX     DECIMAL(7,2)                  ,
    WR_FEE                    DECIMAL(7,2)                  ,
    WR_RETURN_SHIP_COST       DECIMAL(7,2)                  ,
    WR_REFUNDED_CASH          DECIMAL(7,2)                  ,
    WR_REVERSED_CHARGE        DECIMAL(7,2)                  ,
    WR_ACCOUNT_CREDIT         DECIMAL(7,2)                  ,
    WR_NET_LOSS               DECIMAL(7,2)
)
TABLESPACE example1
DISTRIBUTE BY HASH (WR_ITEM_SK)
PARTITION BY RANGE(WR_RETURNED_DATE_SK)
(
        PARTITION P1 VALUES LESS THAN(2450815),
        PARTITION P2 VALUES LESS THAN(2451179),
        PARTITION P3 VALUES LESS THAN(2451544),
        PARTITION P4 VALUES LESS THAN(2451910),
        PARTITION P5 VALUES LESS THAN(2452275),
        PARTITION P6 VALUES LESS THAN(2452640),
        PARTITION P7 VALUES LESS THAN(2453005),
        PARTITION P8 VALUES LESS THAN(MAXVALUE) TABLESPACE example2
)
ENABLE ROW MOVEMENT;

-- Create a partitioned table using LIKE.
openGauss=# CREATE TABLE tpcds.web_returns_p3 (LIKE tpcds.web_returns_p2 INCLUDING
PARTITION);

-- Change the tablespace of the P1 partition to example2.
openGauss=# ALTER TABLE tpcds.web_returns_p2 MOVE PARTITION P1 TABLESPACE example2;

-- Change the tablespace of the P2 partition to example3.
openGauss=# ALTER TABLE tpcds.web_returns_p2 MOVE PARTITION P2 TABLESPACE example3;

-- Split the P8 partition at 2453010.
openGauss=# ALTER TABLE tpcds.web_returns_p2 SPLIT PARTITION P8 AT (2453010) INTO
(
        PARTITION P9,
        PARTITION P10
);

-- Merge the P6 and P7 partitions into one.
openGauss=# ALTER TABLE tpcds.web_returns_p2 MERGE PARTITIONS P6, P7 INTO PARTITION P8;

-- Modify the migration attribute of the partitioned table.
openGauss=# ALTER TABLE tpcds.web_returns_p2 DISABLE ROW MOVEMENT;
-- Delete tables and tablespaces.
openGauss=# DROP TABLE tpcds.web_returns_p1;
openGauss=# DROP TABLE tpcds.web_returns_p2;
openGauss=# DROP TABLE tpcds.web_returns_p3;
openGauss=# DROP TABLESPACE example1;
openGauss=# DROP TABLESPACE example2;
openGauss=# DROP TABLESPACE example3;
openGauss=# DROP TABLESPACE example4;
```

- Example 3: Use **START END** to create and modify a range-partitioned table.

  Assume that **/home/omm/startend_tbs1**, **/home/omm/startend_tbs2**, **/home/omm/startend_tbs3**, and **/home/omm/startend_tbs4** are empty directories for which user **omm** has the read and write permissions.

```
-- Create tablespaces.
openGauss=# CREATE TABLESPACE startend_tbs1 LOCATION '/home/omm/startend_tbs1';
openGauss=# CREATE TABLESPACE startend_tbs2 LOCATION '/home/omm/startend_tbs2';
openGauss=# CREATE TABLESPACE startend_tbs3 LOCATION '/home/omm/startend_tbs3';
openGauss=# CREATE TABLESPACE startend_tbs4 LOCATION '/home/omm/startend_tbs4';
```

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```
-- Create a temporary schema.
openGauss=# CREATE SCHEMA tpcds;
openGauss=# SET CURRENT_SCHEMA TO tpcds;

-- Create a partitioned table with the partition key of the integer type.
openGauss=# CREATE TABLE tpcds.startend_pt (c1 INT, c2 INT)
TABLESPACE startend_tbs1
DISTRIBUTE BY HASH (c1)
PARTITION BY RANGE (c2) (
    PARTITION p1 START(1) END(1000) EVERY(200) TABLESPACE startend_tbs2,
    PARTITION p2 END(2000),
    PARTITION p3 START(2000) END(2500) TABLESPACE startend_tbs3,
    PARTITION p4 START(2500),
    PARTITION p5 START(3000) END(5000) EVERY(1000) TABLESPACE startend_tbs4
)
ENABLE ROW MOVEMENT;

-- View the information of the partitioned table.
openGauss=# SELECT relname, boundaries, spcname FROM pg_partition p JOIN pg_tablespace t ON
p.reltablespace=t.oid and p.parentid='tpcds.startend_pt'::regclass ORDER BY 1;
   relname   | boundaries |    spcname
-------------+------------+---------------
 p1_0        | {1}        | startend_tbs2
 p1_1        | {201}      | startend_tbs2
 p1_2        | {401}      | startend_tbs2
 p1_3        | {601}      | startend_tbs2
 p1_4        | {801}      | startend_tbs2
 p1_5        | {1000}     | startend_tbs2
 p2          | {2000}     | startend_tbs1
 p3          | {2500}     | startend_tbs3
 p4          | {3000}     | startend_tbs1
 p5_1        | {4000}     | startend_tbs4
 p5_2        | {5000}     | startend_tbs4
 startend_pt |            | startend_tbs1
(12 rows)

-- Import data and check the data volume in a partition.
openGauss=# INSERT INTO tpcds.startend_pt VALUES (GENERATE_SERIES(0, 4999),
GENERATE_SERIES(0, 4999));
openGauss=# SELECT COUNT(*) FROM tpcds.startend_pt PARTITION FOR (0);
 count
-------
     1
(1 row)

openGauss=# SELECT COUNT(*) FROM tpcds.startend_pt PARTITION (p3);
 count
-------
   500
(1 row)

-- Add partitions [5000, 5300), [5300, 5600), [5600, 5900), and [5900, 6000).
openGauss=# ALTER TABLE tpcds.startend_pt ADD PARTITION p6 START(5000) END(6000)
EVERY(300) TABLESPACE startend_tbs4;

-- Add the partition p7, specified by MAXVALUE.
openGauss=# ALTER TABLE tpcds.startend_pt ADD PARTITION p7 END(MAXVALUE);

-- Rename the partition p7 to p8.
openGauss=# ALTER TABLE tpcds.startend_pt RENAME PARTITION p7 TO p8;

-- Delete the partition p8.
openGauss=# ALTER TABLE tpcds.startend_pt DROP PARTITION p8;

-- Rename the partition where 5950 is located to p71.
openGauss=# ALTER TABLE tpcds.startend_pt RENAME PARTITION FOR(5950) TO p71;

-- Split the partition [4000, 5000) where 4500 is located.
openGauss=# ALTER TABLE tpcds.startend_pt SPLIT PARTITION FOR(4500) INTO(PARTITION q1
```

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```
START(4000) END(5000) EVERY(250) TABLESPACE startend_tbs3);

-- Change the tablespace of the partition p2 to startend_tbs4.
openGauss=# ALTER TABLE tpcds.startend_pt MOVE PARTITION p2 TABLESPACE startend_tbs4;

-- View the partition status.
openGauss=# SELECT relname, boundaries, spcname FROM pg_partition p JOIN pg_tablespace t ON
p.reltablespace=t.oid and p.parentid='tpcds.startend_pt'::regclass ORDER BY 1;
   relname   | boundaries |    spcname
-------------+------------+---------------
 p1_0        | {1}        | startend_tbs2
 p1_1        | {201}      | startend_tbs2
 p1_2        | {401}      | startend_tbs2
 p1_3        | {601}      | startend_tbs2
 p1_4        | {801}      | startend_tbs2
 p1_5        | {1000}     | startend_tbs2
 p2          | {2000}     | startend_tbs4
 p3          | {2500}     | startend_tbs3
 p4          | {3000}     | startend_tbs1
 p5_1        | {4000}     | startend_tbs4
 p6_1        | {5300}     | startend_tbs4
 p6_2        | {5600}     | startend_tbs4
 p6_3        | {5900}     | startend_tbs4
 p71         | {6000}     | startend_tbs4
 q1_1        | {4250}     | startend_tbs3
 q1_2        | {4500}     | startend_tbs3
 q1_3        | {4750}     | startend_tbs3
 q1_4        | {5000}     | startend_tbs3
 startend_pt |            | startend_tbs1
(19 rows)

-- Delete tables and tablespaces.
openGauss=# DROP SCHEMA tpcds CASCADE;
openGauss=# DROP TABLESPACE startend_tbs1;
openGauss=# DROP TABLESPACE startend_tbs2;
openGauss=# DROP TABLESPACE startend_tbs3;
openGauss=# DROP TABLESPACE startend_tbs4;
```

## Helpful Links

**12.14.31 ALTER TABLE PARTITION** and **12.14.125 DROP TABLE**

# 12.14.84 CREATE TEXT SEARCH CONFIGURATION

## Function

**CREATE TEXT SEARCH CONFIGURATION** creates a text search configuration. A text search configuration specifies a text search parser that can divide a string into tokens, plus dictionaries that can be used to determine which tokens are of interest for searching.

## Precautions

- If only the parser is specified, the new text search configuration initially has no mapping from token types to dictionaries, and therefore will ignore all words. Subsequently, **ALTER TEXT SEARCH CONFIGURATION** must be used to create mapping to make the configuration useful. If **COPY** is specified, the parser, mapping and parameters of the text search configuration is copied automatically.
- If the schema name is given, the text search configuration will be created in the specified schema. Otherwise, the configuration will be created in the current schema.

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- The user who defines a text search configuration becomes its owner.
- **PARSER** and **COPY** options are mutually exclusive, because when an existing configuration is copied, its parser selection is copied too.
- If only the parser is specified, the new text search configuration initially has no mapping from token types to dictionaries, and therefore will ignore all words.

## Syntax

```
CREATE TEXT SEARCH CONFIGURATION name
    ( PARSER = parser_name | COPY = source_config )
    [ WITH ( {configuration_option = value} [, ...] )];
```

## Parameter Description

- **name**

  Specifies the name of the text search configuration to be created. The name can be schema-qualified.

- **parser_name**

  Specifies the name of the text search parser to use for this configuration.

- **source_config**

  Specifies the name of an existing text search configuration to copy.

- **configuration_option**

  Specifies parameters for the text search configuration, particularly for the parser executed by **parser_name** or contained by **source_config**.

  Value range: The default and **ngram** parsers are supported. The parser of default type has no corresponding **configuration_option**. Table 12-121 lists **configuration_option** for **ngram** parsers.

  **Table 12-121** Configuration parameters for **ngram** parsers

| Parser | Parameter | Description | Value Range |
| --- | --- | --- | --- |
| ngram | gram_size | Length of word segmentation | Integer, 1 to 4<br>Default value: **2** |
| | punctuation_ignore | Whether to ignore punctuations | • **true** (default value): Ignore punctuations.<br>• **false**: Do not ignore punctuations. |
| | grapsymbol_ignore | Whether to ignore graphical characters | • **true**: Ignore graphical characters.<br>• **false** (default value): Do not ignore graphical characters. |

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## Examples

```
-- Create a text search configuration.
openGauss=# CREATE TEXT SEARCH CONFIGURATION ngram2 (parser=ngram) WITH (gram_size = 2,
grapsymbol_ignore = false);

-- Create a text search configuration.
openGauss=# CREATE TEXT SEARCH CONFIGURATION ngram3 (copy=ngram2) WITH (gram_size = 2,
grapsymbol_ignore = false);

-- Add type mapping.
openGauss=# ALTER TEXT SEARCH CONFIGURATION ngram2 ADD MAPPING FOR multisymbol WITH
simple;

-- Create user joe.
openGauss=# CREATE USER joe IDENTIFIED BY 'xxxxxxxxxx';

-- Change the owner of the text search configuration.
openGauss=# ALTER TEXT SEARCH CONFIGURATION ngram2 OWNER TO joe;

-- Change the schema of the text search configuration.
openGauss=# ALTER TEXT SEARCH CONFIGURATION ngram2 SET SCHEMA joe;

-- Rename the text search configuration.
openGauss=# ALTER TEXT SEARCH CONFIGURATION joe.ngram2 RENAME TO ngram_2;

-- Delete the type mapping.
openGauss=# ALTER TEXT SEARCH CONFIGURATION joe.ngram_2 DROP MAPPING IF EXISTS FOR
multisymbol;

-- Delete the text search configuration.
openGauss=# DROP TEXT SEARCH CONFIGURATION joe.ngram_2;
openGauss=# DROP TEXT SEARCH CONFIGURATION ngram3;

-- Delete the schema and user joe.
openGauss=# DROP SCHEMA IF EXISTS joe CASCADE;
openGauss=# DROP ROLE IF EXISTS joe;
```

## Helpful Links

**12.14.33 ALTER TEXT SEARCH CONFIGURATION** and **12.14.127 DROP TEXT SEARCH CONFIGURATION**

# 12.14.85 CREATE TEXT SEARCH DICTIONARY

## Function

**CREATE TEXT SEARCH DICTIONARY** creates a full-text retrieval dictionary. A dictionary is used to identify and process particular words during full-text retrieval.

Dictionaries are created by using predefined templates (defined in the **15.2.100 PG_TS_TEMPLATE** system catalog). Five types of dictionaries can be created, **Simple**, **Ispell**, **Synonym**, **Thesaurus**, and **Snowball**. These dictionaries are used to handle different types of tasks.

## Precautions

- A user with the **SYSADMIN** permission can create a dictionary. Then, the user automatically becomes the owner of the dictionary.
- A dictionary cannot be created in **pg_temp** mode.
- After a dictionary is created or modified, any modification to the customized dictionary definition file will not affect the dictionary in the database. To

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make such modifications take effect in the dictionary in the database, run the **ALTER** statement to update the definition file of the dictionary.

## Syntax

```
CREATE TEXT SEARCH DICTIONARY name (
    TEMPLATE = template
    [, option = value [, ... ]]
);
```

## Parameter Description

- **name**

  Specifies the name of a dictionary to be created. (If you do not specify a schema name, the dictionary will be created in the current schema.)

  Value range: a string, which complies with the identifier naming convention. A value can contain a maximum of 63 characters.

- **template**

  Specifies a template name.

  Value range: templates (**Simple**, **Synonym**, **Thesaurus**, **Ispell**, and **Snowball**) defined in the **15.2.100 PG_TS_TEMPLATE** system catalog

- **option**

  Specifies a parameter name. Each type of dictionaries has a template containing their custom parameters. Parameters function in a way irrelevant to their setting sequence.

  – Parameters for a **Simple** dictionary

    ▪ **STOPWORDS**

      Specifies the name of a file listing stop words. The default file name extension is .stop. In the file, each line defines a stop word. Dictionaries will ignore blank lines and spaces in the file and convert stop-word phrases into lowercase.

    ▪ **ACCEPT**

      Specifies whether to accept a non-stop word as recognized. Default value: **true**

      If **ACCEPT=true** is set for a **Simple** dictionary, no token will be passed to subsequent dictionaries. In this case, you are advised to place the **Simple** dictionary at the end of the dictionary list. If **ACCEPT=false** is set, you are advised to place the **Simple** dictionary before at least one dictionary in the list.

    ▪ **FILEPATH**

      Specifies the directory for storing dictionary files. The directory can be a local directory or an OBS directory. (The OBS directory can be specified only in security mode. You can add the securitymode option during startup to enter the security mode.) The local directory format is **file://***absolute_path*. The OBS directory format is **obs://***bucket_name***/path accesskey=ak secretkey=sk region=rg**. The default value is the directory where predefined dictionary files are located. If any of the **FILEPATH** and **STOPWORDS** parameters is specified, the other one must also be specified.

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- Parameters for a **Synonym** dictionary
  - **SYNONYM**

    Specifies the name of the definition file for a **Synonym** dictionary. The default file name extension is .syn.

    The file is a list of synonyms. Each line is in the format of *token synonym*, that is, token and its synonym separated by a space.

  - **CASESENSITIVE**

    Specifies whether tokens and their synonyms are case sensitive. The default value is **false**, indicating that tokens and synonyms in dictionary files will be converted into lowercase. If this parameter is set to **true**, they will not be converted into lowercase.

  - **FILEPATH**

    Specifies the directory for storing **Synonym** dictionary files. The directory can be a local directory or an OBS directory. (The OBS directory can be specified only in security mode. You can add the **securitymode** option during startup to enter the security mode.) The local directory format is **file://***absolute_path*. The OBS directory format is **obs://***bucket_name***/path accesskey=ak secretkey=sk region=rg**. The default value is the directory where predefined dictionary files are located.
- Parameters for a **Thesaurus** dictionary
  - **DICTFILE**

    Specifies the name of a dictionary definition file. The default file name extension is .ths.

    The file is a list of synonyms. Each line is in the format of *sample words* **:** *indexed words*. The colon (:) is used as a separator between a phrase and its substitute word. If multiple sample words are matched, the TZ selects the longest one.

  - **DICTIONARY**

    Specifies the name of a subdictionary used for word normalization. This parameter is mandatory and only one subdictionary name can be specified. The specified subdictionary must exist. It is used to identify and normalize input text before phrase matching.

    If an input word cannot be recognized by the subdictionary, an error will be reported. In this case, remove the word or update the subdictionary to make the word recognizable. In addition, an asterisk (*) can be placed at the beginning of an indexed word to skip the application of a subdictionary on it, but all sample words must be recognizable by the subdictionary.

    If the sample words defined in the dictionary file contain stop words defined in the subdictionary, use question marks (?) to replace them. Assume that **a** and **the** are stop words defined in the subdictionary.

    ```
    ? one ? two : swsw
    ```

    **a one the two** and **the one a two** will be matched and output as **swsw**.

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- **FILEPATH**

  Specifies the directory for storing dictionary definition files. The directory can be a local directory or an OBS directory. (The OBS directory can be specified only in security mode. You can add the securitymode option during startup to enter the security mode.) The local directory format is **file://***absolute_path*. The OBS directory format is **obs://***bucket_name***/path accesskey=ak secretkey=sk region=rg**. The default value is the directory where predefined dictionary files are located.

– Parameters for an **Ispell** dictionary

  - **DICTFILE**

    Specifies the name of a dictionary definition file. The default file name extension is .dict.

  - **AFFFILE**

    Specifies the name of an affix file. The default file name extension is .affix.

  - **STOPWORDS**

    Specifies the name of a file listing stop words. The default file name extension is .stop. The file content format is the same as that of the file for a **Simple** dictionary.

  - **FILEPATH**

    Specifies the directory for storing dictionary files. The directory can be a local directory or an OBS directory. (The OBS directory can be specified only in security mode. You can add the **securitymode** option during startup to enter the security mode.) The local directory format is **file://***absolute_path*. The OBS directory format is **obs://***bucket_name***/path accesskey=ak secretkey=sk region=rg**. The default value is the directory where predefined dictionary files are located.

– Parameters for a **Snowball** dictionary

  - **LANGUAGE**

    Specifies the name of a language whose stemming algorithm will be used. According to spelling rules in the language, the algorithm normalizes the variants of an input word into a basic word or a stem.

  - **STOPWORDS**

    Specifies the name of a file listing stop words. The default file name extension is .stop. The file content format is the same as that of the file for a **Simple** dictionary.

  - **FILEPATH**

    Specifies the directory for storing dictionary definition files. You can specify a local directory or an OBS directory. (The OBS directory can be specified only in security mode. You can enter the security mode by adding the **securitymode** option during startup.) The local directory format is **file://***absolute_path*. The OBS directory format is **obs://***bucket_name***/path accesskey=ak secretkey=sk region=rg**. The

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default value is the directory where predefined dictionary files are located. If any of the **FILEPATH** and **STOPWORDS** parameters is specified, the other one must also be specified.

NOTE

The name of a dictionary definition file can contain only lowercase letters, digits, and underscores (_).

- **value**

  Specifies a parameter value. If the value is not an identifier or a number, enclose it with single quotation marks (''). You can also enclose identifiers and numbers.

## Examples

See examples in **12.8.7 Configuration Examples**.

## Helpful Links

**12.14.34 ALTER TEXT SEARCH DICTIONARY** and **12.14.85 CREATE TEXT SEARCH DICTIONARY**

# 12.14.86 CREATE TRIGGER

## Function

**CREATE TRIGGER** creates a trigger. The trigger will be associated with the specified table or view, and will execute the specified function operations are performed.

## Precautions

- Currently, triggers can be created only on ordinary row-store tables, instead of on column-store tables, temporary tables, or unlogged tables.
- If multiple triggers of the same kind are defined for the same event, they will be fired in alphabetical order by name.
- Triggers are usually used for data association and synchronization between multiple tables. SQL execution performance is greatly affected. Therefore, you are advised not to use this statement when a large amount of data needs to be synchronized and performance requirements are high.
- When a trigger meets the following conditions, the trigger statement and trigger itself can be pushed together down to a DN for execution, improving the trigger execution performance:
  - Switch **enable_trigger_shipping** and **enable_fast_query_shipping** on.
  - The trigger function used by the source table is a PL/pgSQL function (recommended).
  - The source and target tables have the same type and number of distribution keys, are both row-store tables, and belong to the same node group.
  - The **INSERT**, **UPDATE**, or **DELETE** statement on the source table contains an expression about equality comparison between all the distribution keys and the *NEW* or *OLD* variable.

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  - The **INSERT**, **UPDATE**, or **DELETE** statement on the source table can be pushed down without a trigger.
  - There are only six types of triggers (**INSERT BEFORE FOR EACH ROW**, **INSERT AFTER FOR EACH ROW**, **UPDATE BEFORE FOR EACH ROW**, **UPDATE AFTER FOR EACH ROW**, **DELETE BEFORE FOR EACH ROW**, and **DELETE AFTER FOR EACH ROW**) on the source table, and all the triggers can be pushed down.
- The **INSERT ON DUPLICATE KEY UPDATE** statement cannot fire a trigger.
- When a trigger statement is executed, the permission is determined by the trigger creator.
- To create a trigger, you must have the TRIGGER permission on the specified table.

## Syntax

```
CREATE [ CONSTRAINT ] TRIGGER trigger_name { BEFORE | AFTER | INSTEAD OF } { event [ OR ... ] }
   ON table_name
   [ FROM referenced_table_name ]
   { NOT DEFERRABLE | [ DEFERRABLE ] { INITIALLY IMMEDIATE | INITIALLY DEFERRED } }
   [ FOR [ EACH ] { ROW | STATEMENT } ]
   [ WHEN ( condition ) ]
   EXECUTE PROCEDURE function_name ( arguments );
```

Events include:

```
   INSERT
   UPDATE [ OF column_name [, ... ] ]
   DELETE
   TRUNCATE
```

## Parameter Description

- **CONSTRAINT**

  (Optional) Creates a constraint trigger. That is, the trigger is used as a constraint. This is the same as a regular trigger except that the timing of the trigger firing can be adjusted using **SET CONSTRAINTS**. Constraint triggers must be **AFTER ROW** triggers.

- **trigger_name**

  Specifies the name of the trigger to be created. This must be distinct from the name of any other trigger for the same table. The name cannot be schema-qualified — the trigger inherits the schema of its table. For a constraint trigger, this is also the name to use when modifying the trigger's behavior using **12.14.162 SET CONSTRAINTS**.

  Value range: a string, which complies with the identifier naming convention and contains a maximum of 63 characters.

- **BEFORE**

  Specifies that the function is called before the event.

- **AFTER**

  Specifies that the function is called after the event. A constraint trigger can only be specified as **AFTER**.

- **INSTEAD OF**

  Specifies that the function is called instead of the event.

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- **event**

  Specifies the event that will fire the trigger. Values are **INSERT**, **UPDATE**, **DELETE**, and **TRUNCATE**. Multiple events can be specified using **OR**.

  For **UPDATE** events, it is possible to specify a list of columns using this syntax:

  ```
  UPDATE OF column_name1 [, column_name2 ... ]
  ```

  The trigger will only fire if at least one of the listed columns is mentioned as a target of the **UPDATE** statement. **INSTEAD OF UPDATE** events do not allow a list of columns.

- **table_name**

  Specifies the name of the table for which the trigger is created.

  Value range: name of an existing table in the database

- **referenced_table_name**

  Specifies the name of another table referenced by the constraint. This option is used for foreign-key constraints. It can only be specified for constraint triggers. Because foreign keys are not supported currently, this option is not recommended for general use.

  Value range: name of an existing table in the database

- **DEFERRABLE | NOT DEFERRABLE**

  Specifies the start time of the trigger. It can only be specified for constraint triggers. They determine whether the constraint is deferrable.

  For details, see **12.14.80 CREATE TABLE**.

- **INITIALLY IMMEDIATE | INITIALLY DEFERRED**

  If the constraint is deferrable, the two clauses specify the default time to check the constraint. It can only be specified for constraint triggers.

  For details, see **12.14.80 CREATE TABLE**.

- **FOR EACH ROW | FOR EACH STATEMENT**

  Specifies the frequency of firing the trigger.

  - **FOR EACH ROW** indicates that the trigger should be fired once for every row affected by the trigger event.
  - **FOR EACH STATEMENT** indicates that the trigger should be fired just once per SQL statement.

  If neither is specified, the default is **FOR EACH STATEMENT**. Constraint triggers can only be marked as **FOR EACH ROW**.

- **condition**

  Specifies whether the trigger function will actually be executed. If **WHEN** is specified, the function will be called only when **condition** returns **true**.

  In **FOR EACH ROW** triggers, the **WHEN** condition can refer to columns of the old and/or new row values by writing **OLD.***column name* or **NEW.***column name* respectively. In addition, **INSERT** triggers cannot refer to **OLD**, and **DELETE** triggers cannot refer to **NEW**.

  **INSTEAD OF** triggers do not support **WHEN** conditions.

  Currently, **WHEN** expressions cannot contain subqueries.

  Note that for constraint triggers, evaluation of the **WHEN** condition is not deferred, but occurs immediately after the row update operation is performed.

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If the condition does not evaluate to **true**, then the trigger is not queued for deferred execution.

- **function_name**

  Specifies a user-defined function, which must be declared as taking no parameters and returning type trigger. This is executed when a trigger fires.

- **arguments**

  Specifies an optional comma-separated list of parameters to be provided to the function when the trigger is executed. The parameters are literal string constants. Simple names and numeric constants can also be written here, but they will all be converted to strings. Check the description of the implementation language of the trigger function to find out how these parameters can be accessed within the function.

  NOTE

  The following details trigger types:

  - **INSTEAD OF** triggers must be marked as **FOR EACH ROW** and can be defined only on views.
  - **BEFORE** and **AFTER** triggers on a view must be marked as **FOR EACH STATEMENT**.
  - **TRUNCATE** triggers must be marked as **FOR EACH STATEMENT**.

**Table 12-122** Types of triggers supported on tables and views

| When | Event | Row-Level | Statement-Level |
| --- | --- | --- | --- |
| BEFORE | INSERT/UPDATE/DELETE | Tables | Tables and views |
| | TRUNCATE | Not supported. | Tables |
| AFTER | INSERT/UPDATE/DELETE | Tables | Tables and views |
| | TRUNCATE | Not supported. | Tables |
| INSTEAD OF | INSERT/UPDATE/DELETE | Views | Not supported. |
| | TRUNCATE | Not supported. | Not supported. |

**Table 12-123** Special variables in PL/pgSQL functions

| Variable | Description |
| --- | --- |
| NEW | New tuple for **INSERT** and **UPDATE** operations. This variable is **NULL** for **DELETE** operations. |

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| Variable | Description |
| --- | --- |
| OLD | Old tuple for **UPDATE** and **DELETE** operations. This variable is **NULL** for **INSERT** operations. |
| TG_NAME | Trigger name. |
| TG_WHEN | Trigger timing (**BEFORE**, **AFTER**, or **INSTEAD OF**). |
| TG_LEVEL | Trigger frequency (**ROW** or **STATEMENT**). |
| TG_OP | Trigger event (**INSERT**, **UPDATE**, **DELETE**, or **TRUNCATE**). |
| TG_RELID | OID of the table where the trigger resides. |
| TG_RELNAME | Name of the table where the trigger resides. (This variable has been replaced by **TG_TABLE_NAME**.) |
| TG_TABLE_NAME | Name of the table where the trigger resides. |
| TG_TABLE_SCHEMA | Schema of the table where the trigger resides. |
| TG_NARGS | Number of parameters for the trigger function. |
| TG_ARGV[] | List of parameters for the trigger function. |

## Examples

```
-- Create a source table and a destination table.
openGauss=# CREATE TABLE test_trigger_src_tbl(id1 INT, id2 INT, id3 INT);
openGauss=# CREATE TABLE test_trigger_des_tbl(id1 INT, id2 INT, id3 INT);

-- Create a trigger function.
openGauss=# CREATE OR REPLACE FUNCTION tri_insert_func() RETURNS TRIGGER AS
        $$
        DECLARE
        BEGIN
                INSERT INTO test_trigger_des_tbl VALUES(NEW.id1, NEW.id2, NEW.id3);
                RETURN NEW;
        END
        $$ LANGUAGE PLPGSQL;

openGauss=# CREATE OR REPLACE FUNCTION tri_update_func() RETURNS TRIGGER AS
        $$
        DECLARE
        BEGIN
                UPDATE test_trigger_des_tbl SET id3 = NEW.id3 WHERE id1=OLD.id1;
                RETURN OLD;
        END
        $$ LANGUAGE PLPGSQL;
```

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```
openGauss=# CREATE OR REPLACE FUNCTION TRI_DELETE_FUNC() RETURNS TRIGGER AS
        $$
        DECLARE
        BEGIN
                DELETE FROM test_trigger_des_tbl WHERE id1=OLD.id1;
                RETURN OLD;
        END
        $$ LANGUAGE PLPGSQL;

-- Create an INSERT trigger.
openGauss=# CREATE TRIGGER insert_trigger
        BEFORE INSERT ON test_trigger_src_tbl
        FOR EACH ROW
        EXECUTE PROCEDURE tri_insert_func();

-- Create an UPDATE trigger.
openGauss=# CREATE TRIGGER update_trigger
        AFTER UPDATE ON test_trigger_src_tbl
        FOR EACH ROW
        EXECUTE PROCEDURE tri_update_func();

-- Create a DELETE trigger.
openGauss=# CREATE TRIGGER delete_trigger
        BEFORE DELETE ON test_trigger_src_tbl
        FOR EACH ROW
        EXECUTE PROCEDURE tri_delete_func();

-- Execute the INSERT event and check the trigger results.
openGauss=# INSERT INTO test_trigger_src_tbl VALUES(100,200,300);
openGauss=# SELECT * FROM test_trigger_src_tbl;
openGauss=# SELECT * FROM test_trigger_des_tbl;  // Check whether the trigger operation takes effect.

-- Execute the UPDATE event and check the trigger results.
openGauss=# UPDATE test_trigger_src_tbl SET id3=400 WHERE id1=100;
openGauss=# SELECT * FROM test_trigger_src_tbl;
openGauss=# SELECT * FROM test_trigger_des_tbl;  // Check whether the trigger operation takes effect.

-- Execute the DELETE event and check the trigger results.
openGauss=# DELETE FROM test_trigger_src_tbl WHERE id1=100;
openGauss=# SELECT * FROM test_trigger_src_tbl;
openGauss=# SELECT * FROM test_trigger_des_tbl;  // Check whether the trigger operation takes effect.

-- Modify a trigger.
openGauss=# ALTER TRIGGER delete_trigger ON test_trigger_src_tbl RENAME TO delete_trigger_renamed;

-- Disable insert_trigger.
openGauss=# ALTER TABLE test_trigger_src_tbl DISABLE TRIGGER insert_trigger;

-- Disable all triggers on the current table.
openGauss=# ALTER TABLE test_trigger_src_tbl DISABLE TRIGGER ALL;

-- Delete triggers.
openGauss=# DROP TRIGGER insert_trigger ON test_trigger_src_tbl;
openGauss=# DROP TRIGGER update_trigger ON test_trigger_src_tbl;
openGauss=# DROP TRIGGER delete_trigger_renamed ON test_trigger_src_tbl;
```

## Helpful Links

12.14.35 ALTER TRIGGER, 12.14.129 DROP TRIGGER, and 12.14.30 ALTER TABLE

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# 12.14.87 CREATE TYPE

## Function

**CREATE TYPE** registers a new data type for use in the current database. The user who defines a type becomes its owner. Types are designed only for row-store tables.

The following data types can be created: composite type, base type, shell type, enumerated type, and set type.

- Composite type

  A composite type is specified by a list of attribute names and data types. If the data type of an attribute is collatable, the attribute's collation rule can also be specified. This is essentially the same as the row type of a table, but using **CREATE TYPE** avoids the need to create an actual table when all that is wanted is to define a type. A stand-alone composite type is useful as the parameter or return type of a function.

  To create a composite type, you must have the **USAGE** permission on all of its attribute types.

- Base type

  You can create a base type (scalar type). Generally, the functions required by a base type have to be coded in C or another low-level language.

- Shell type

  A shell type is simply a placeholder for a type to be defined later; it is created by issuing **CREATE TYPE** with no parameters except for the type name. Shell types are needed as forward references when base types are created.

- Enumerated type

  An enumerated type is a list of one or more quoted labels, each of which must be 1 to 64 bytes long.

- Set type

  It is similar to an array but has no length limit. It is mainly used in stored procedures.

- A user granted with the CREATE ANY TYPE permission can create types in the public and user schemas.

## Precautions

If a schema name is given then the type is created in the specified schema. Otherwise, it is created in the current schema. The type name must be distinct from the name of any existing type or domain in the same schema. (Because tables have associated data types, the type name must also be distinct from the name of any existing table in the same schema.)

## Syntax

```
CREATE TYPE name AS
    ( [ attribute_name data_type [ COLLATE collation ] [, ... ] ] )

CREATE TYPE name (
    INPUT = input_function,
```

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```
    OUTPUT = output_function
    [ , RECEIVE = receive_function ]
    [ , SEND = send_function ]
    [ , TYPMOD_IN = type_modifier_input_function ]
    [ , TYPMOD_OUT = type_modifier_output_function ]
    [ , ANALYZE = analyze_function ]
    [ , INTERNALLENGTH = { internallength | VARIABLE } ]
    [ , PASSEDBYVALUE ]
    [ , ALIGNMENT = alignment ]
    [ , STORAGE = storage ]
    [ , LIKE = like_type ]
    [ , CATEGORY = category ]
    [ , PREFERRED = preferred ]
    [ , DEFAULT = default ]
    [ , ELEMENT = element ]
    [ , DELIMITER = delimiter ]
    [ , COLLATABLE = collatable ]
)

CREATE TYPE name

CREATE TYPE name AS ENUM
    ( [ 'label' [, ... ] ] )

CREATE TYPE name AS TABLE OF data_type
```

## Parameter Description

Composite type

- **name**

  Specifies the name (optionally schema-qualified) of the type to be created.

- **attribute_name**

  Specifies the name of an attribute (column) for the composite type.

- **data_type**

  Specifies the name of an existing data type to become a column of the composite type. You can use **%ROWTYPE** to indirectly reference the type of a table, or **%TYPE** to indirectly reference the type of a column in a table or composite type.

- **collation**

  Specifies the name of an existing collation rule to be associated with a column of the composite type. You can run the **select * from pg_collation** command to query collation rules from the **pg_collation** system catalog. The default collation rule is the row starting with **default** in the query result.

Base type

When creating a base type, you can place parameters in any order. The **input_function** and **output_function** parameters are mandatory, and other parameters are optional.

- **input_function**

  Specifies the name of a function that converts data from the type's external textual form to its internal form.

  The input function may be declared as taking one parameter of type cstring or taking three parameters of types cstring, oid, and integer.

  – The first parameter is the input text as a C string,

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  - the second parameter is the type's own OID (except for array types, which instead receive their element type's OID),
  - and the third is the typmod of the destination column, if known (**-1** will be passed if not).

  The input function must return a value of the data type itself. Usually, an input function should be declared **STRICT**; if it is not, it will be called with a **NULL** first parameter when reading a **NULL** input value. The function must still return **NULL** in this case, unless it raises an error. (This case is mainly meant to support domain input functions, which might need to reject **NULL** inputs.)

  NOTE

  The input and output functions can be declared to have results or parameters of the new type, when they have to be created before the new type can be created. The type should first be defined as a shell type, which is a placeholder type that has no attributes except a name and an owner. This is done by issuing the **CREATE TYPE** *name* statement, with no additional parameters. Then the I/O functions can be defined referencing the shell type. Finally, **CREATE TYPE** with a full definition replaces the shell entry with a complete, valid type definition, after which the new type can be used normally.

- **output_function**

  Specifies the name of a function that converts data from the type's internal form to its external textual form.

  The output function must be declared as taking one parameter of the new data type. The output function must return type cstring. Output functions are not invoked for **NULL** values.

- **receive_function**

  (Optional) Specifies the name of a function that converts data from the type's external binary form to its internal form.

  If this function is not supplied, the type cannot participate in binary input. The binary representation should be chosen to be cheap to convert to internal form, while being reasonably portable. (For example, the standard integer data types use network byte order as the external binary representation, while the internal representation is in the machine's native byte order.) The receive function should perform adequate checking to ensure that the value is valid.

  The receive function may be declared as taking one parameter of type internal or taking three parameters of types internal, oid, integer.

  - The first parameter is a pointer to a StringInfo buffer holding the received byte string;
  - the latter two are the same as for the text input function.

  The receive function must return a value of the data type itself. Usually, a receive function should be declared **STRICT**; if it is not, it will be called with a **NULL** first parameter when reading a **NULL** input value. The function must still return **NULL** in this case, unless it raises an error. (This case is mainly meant to support domain receive functions, which might need to reject **NULL** inputs.)

- **send_function**

  (Optional) Specifies the name of a function that converts data from the type's internal form to its external binary form.

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If this function is not supplied, the type cannot participate in binary output. The send function must be declared as taking one parameter of the new data type. The send function must return type bytea. Send functions are not invoked for **NULL** values.

- **type_modifier_input_function**

  (Optional) Specifies the name of a function that converts an array of modifiers for a type to its internal format.

- **type_modifier_output_function**

  (Optional) Specifies the name of a function that converts the internal format of modifiers for a type to its external text format.

  NOTE

  **type_modifier_input_function** and **type_modifier_output_function** are needed if the type supports modifiers, that is optional constraints attached to a type declaration, such as char(5) or numeric(30,2). GaussDB allows user-defined types to take one or more simple constants or identifiers as modifiers. However, this information must be capable of being packed into a single non-negative integer value for storage in the system catalogs. Declared modifiers are passed to **type_modifier_input_function** in the cstring array format. It must check the values for validity (throwing an error if they are wrong), and if they are correct, return a single non-negative integer value that will be stored as the column "typmod". Type modifiers will be rejected if the type does not have a **type_modifier_input_function**. The **type_modifier_output_function** converts the internal integer typmod value back to the correct form for user display. It must return a cstring value that is the exact string to append to the type name; for example numeric's function might return (30,2). It is allowed to omit the **type_modifier_output_function**, in which case the default display format is just the stored typmod integer value enclosed in parentheses.

- **analyze_function**

  (Optional) Specifies the name of a function that performs statistical analysis for the data type.

  By default, **ANALYZE** will attempt to gather statistics using the type's "equals" and "less-than" operators, if there is a default b-tree operator class for the type. For non-scalar types, this behavior is likely to be unsuitable, so it can be overridden by specifying a custom analysis function. The analysis function must be declared to take one parameter of type internal and return a Boolean result.

- **internallength**

  (Optional) Specifies the length in bytes of the new type's internal representation. The default assumption is that it is variable-length.

  While the details of the new type's internal representation are only known to the I/O functions and other functions you create to work with the type, there are several attributes of the internal representation that must be declared to GaussDB. Foremost of these is **internallength**. Base data types can be fixed-length, in which case **internallength** is a positive integer, or variable length, indicated by setting **internallength** to **VARIABLE**. (Internally, this is represented by setting **typlen** to **-1**.) The internal representation of all variable-length types must start with a 4-byte integer giving the total length of this value of the type.

- **PASSEDBYVALUE**

  (Optional) Indicates that values of this data type are passed by value, rather than by reference. You cannot pass by value types whose internal

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representation is larger than the size of the Datum type (4 bytes on most machines, 8 bytes on a few).

- **alignment**

  (Optional) Specifies the storage alignment requirement of the data type. If specified, it must be **char**, **int2**, **int4**, or **double**; the default is **int4**.

  The allowed values equate to alignment on 1, 2, 4, or 8 byte boundaries. Note that variable-length types must have an alignment of at least 4, since they necessarily contain an int4 as their first component.

- **storage**

  (Optional) Specifies the storage strategy for the data type.

  If specified, it must be **plain**, **external**, **extended**, or **main**; the default is **plain**.

  - **plain** specifies that data of the type will always be stored in-line and not compressed. (Only **plain** is allowed for fixed-length types.)
  - **extended** specifies that the system will first try to compress a long data value, and will move the value out of the main table row if it is still too long.
  - **external** allows the value to be moved out of the main table, but the system will not try to compress it.
  - **main** allows compression, but discourages moving the value out of the main table. (Data items with this storage strategy might still be moved out of the main table if there is no other way to make a row fit, but they will be kept in the main table preferentially over **extended** and **external** items.)

    All **storage** values other than **plain** imply that the functions of the data type can handle values that have been toasted. The specific other value given merely determines the default **TOAST** storage strategy for columns of a toastable data type; users can pick other strategies for individual columns using **ALTER TABLE SET STORAGE**.

- **like_type**

  (Optional) Specifies the name of an existing data type that the new type will have the same representation as. The values of **internallength**, **passedbyvalue**, **alignment**, and **storage** are copied from that type, unless overridden by explicit specification elsewhere in this **CREATE TYPE** statement.

  Specifying representation in this way is especially useful when the low-level implementation of a new type references an existing type.

- **category**

  (Optional) Specifies the category code (a single ASCII character) for this type. The default is **U** for a user-defined type. You may also choose other ASCII characters to create custom categories.

- **preferred**

  (Optional) Specifies whether a type is preferred within its type category. If it is, the value will be **TRUE**, else **FALSE**. The default is **FALSE**. Be very careful about creating a preferred type within an existing type category, as this could cause surprising changes in behavior.

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> NOTE
>
> The **category** and **preferred** parameters can be used to help control which implicit cast will be applied in ambiguous situations. Each data type belongs to a category named by a single ASCII character, and each type is either preferred or not within its category. The parser will prefer casting to preferred types (but only from other types within the same category) when this rule is helpful in resolving overloaded functions or operators. For types that have no implicit casts to or from any other types, it is sufficient to leave these settings at the defaults. However, for a group of related types that have implicit casts, it is often helpful to mark them all as belonging to a category and select one or two of the most general types as being preferred within the category. The **category** parameter is especially useful when adding a user-defined type to an existing built-in category, such as the numeric or string types. However, it is also possible to create entirely-user-defined type categories. Select any ASCII character other than an uppercase letter to name such a category.

- **default**

  (Optional) Specifies the default value for the data type. If this is omitted, the default is null.

  A default value can be specified, in case a user wants columns of the data type to default to something other than the null value. Specify the default with the **DEFAULT** keyword. (Such a default can be overridden by an explicit **DEFAULT** clause attached to a particular column.)

- **element**

  (Optional) Specifies the type of array elements when an array type is created. For example, to define an array of 4-byte integers (int4), specify **ELEMENT = int4**.

- **delimiter**

  (Optional) Specifies the delimiter character to be used between values in arrays made of this type.

  **delimiter** can be set to a specific character. The default delimiter is the comma (,). Note that the delimiter is associated with the array element type, not the array type itself.

- **collatable**

  (Optional) Specifies whether this type's operations can use collation information. If they can, the value will be **TRUE**, else **FALSE** (default).

  If **collatable** is **TRUE**, column definitions and expressions of the type may carry collation information through use of the **COLLATE** clause. It is up to the implementations of the functions operating on the type to actually make use of the collation information; this does not happen automatically merely by marking the type collatable.

- **label**

  (Optional) Represents the textual label associated with one value of an enumerated type. It is a string of 1 to 63 characters.

> NOTE
>
> Whenever a user-defined type is created, GaussDB automatically creates an associated array type whose name consists of the element type's name prepended with an underscore (_).

## Examples

```
-- Create a composite type, create a table, insert data, and make a query.
openGauss=# CREATE TYPE compfoo AS (f1 int, f2 text);
```

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```
openGauss=# CREATE TABLE t1_compfoo(a int, b compfoo);
openGauss=# CREATE TABLE t2_compfoo(a int, b compfoo);
openGauss=# INSERT INTO t1_compfoo values(1,(1,'demo'));
openGauss=# INSERT INTO t2_compfoo select * from t1_typ5;
openGauss=# SELECT (b).f1 FROM t1_compfoo;
openGauss=# SELECT * FROM t1_compfoo t1 join t2_compfoo t2 on (t1.b).f1=(t1.b).f1;

-- Rename the data type.
openGauss=# ALTER TYPE compfoo RENAME TO compfoo1;

-- Change the owner of the user-defined type compfoo1 to usr1.
CREATE USER usr1 PASSWORD 'xxxxxxxxxx';
openGauss=# ALTER TYPE compfoo1 OWNER TO usr1;

-- Change the schema of the user-defined type compfoo1 to usr1.
openGauss=# ALTER TYPE compfoo1 SET SCHEMA usr1;

Add a new attribute to the data type.
openGauss=# ALTER TYPE usr1.compfoo1 ADD ATTRIBUTE f3 int;

Delete the compfoo1 type.
openGauss=# DROP TYPE usr1.compfoo1 cascade;

Delete related tables and users.
openGauss=# DROP TABLE t1_compfoo;
openGauss=# DROP TABLE t2_compfoo;
openGauss=# DROP SCHEMA usr1;
openGauss=# DROP USER usr1;

-- Create an enumerated type.
openGauss=# CREATE TYPE bugstatus AS ENUM ('create', 'modify', 'closed');

-- Add a label.
openGauss=# ALTER TYPE bugstatus ADD VALUE IF NOT EXISTS 'regress' BEFORE 'closed';

-- Rename the label.
openGauss=# ALTER TYPE bugstatus RENAME VALUE 'create' TO 'new';

-- Create a set type.
openGauss=# CREATE TYPE compfoo_table AS TABLE OF compfoo;

-- Compile the .so file and create a shell type.
openGauss=# CREATE TYPE complex;
-- This statement creates a placeholder for the type to be defined so that the type can be referenced when its I/O functions are defined. Then, you can define I/O functions. Note that the functions must be declared to take the NOT FENCED mode during creation.
openGauss=# CREATE FUNCTION
complex_in(cstring)
    RETURNS complex
    AS 'filename'
    LANGUAGE C IMMUTABLE STRICT not fenced;

openGauss=# CREATE FUNCTION
complex_out(complex)
    RETURNS cstring
    AS 'filename'
    LANGUAGE C IMMUTABLE STRICT not fenced;

openGauss=# CREATE FUNCTION
complex_recv(internal)

RETURNS complex

AS 'filename'

LANGUAGE C IMMUTABLE STRICT not fenced;

openGauss=# CREATE FUNCTION
complex_send(complex)
```

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```
RETURNS bytea

AS 'filename'

LANGUAGE C IMMUTABLE STRICT not fenced;
-- Finally, provide a complete definition of the data type.
openGauss=# CREATE TYPE complex (

internallength = 16,

input = complex_in,

output = complex_out,

receive = complex_recv,

send = complex_send,

alignment = double
);
```

The C functions corresponding to the input, output, receive, and send functions are defined as follows:

```
-- Define a structure body Complex.
typedef struct Complex {
    double      x;
    double      y;
} Complex;

-- Define an input function.
PG_FUNCTION_INFO_V1(complex_in);

Datum
complex_in(PG_FUNCTION_ARGS)
{
    char       *str = PG_GETARG_CSTRING(0);
    double      x,
                y;
    Complex    *result;

    if (sscanf(str, " ( %lf , %lf )", &x, &y) != 2)
        ereport(ERROR,
                (errcode(ERRCODE_INVALID_TEXT_REPRESENTATION),
                 errmsg("invalid input syntax for complex: \"%s\"",
                        str)));

    result = (Complex *) palloc(sizeof(Complex));
    result->x = x;
    result->y = y;
    PG_RETURN_POINTER(result);
}

-- Define an output function.
PG_FUNCTION_INFO_V1(complex_out);

Datum
complex_out(PG_FUNCTION_ARGS)
{
        Complex    *complex = (Complex *) PG_GETARG_POINTER(0);
        char       *result;

        result = (char *) palloc(100);
        snprintf(result, 100, "(%g,%g)", complex->x, complex->y);
        PG_RETURN_CSTRING(result);
}

-- Define a receive function.
PG_FUNCTION_INFO_V1(complex_recv);
```

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```
Datum
complex_recv(PG_FUNCTION_ARGS)
{
    StringInfo  buf = (StringInfo) PG_GETARG_POINTER(0);
    Complex    *result;

    result = (Complex *) palloc(sizeof(Complex));
    result->x = pq_getmsgfloat8(buf);
    result->y = pq_getmsgfloat8(buf);
    PG_RETURN_POINTER(result);
}

-- Define a send function.
PG_FUNCTION_INFO_V1(complex_send);

Datum
complex_send(PG_FUNCTION_ARGS)
{
    Complex    *complex = (Complex *) PG_GETARG_POINTER(0);
    StringInfoData buf;

    pq_begintypsend(&buf);
    pq_sendfloat8(&buf, complex->x);
    pq_sendfloat8(&buf, complex->y);
    PG_RETURN_BYTEA_P(pq_endtypsend(&buf));
}
```

## Helpful Links

**12.14.36 ALTER TYPE** and **12.14.130 DROP TYPE**

# 12.14.88 CREATE USER

## Function

**CREATE USER** creates a user.

## Precautions

- A user created using the **CREATE USER** statement has the **LOGIN** permission by default.
- When you run the **CREATE USER** command to create a user, the system creates a schema with the same name as the user in the database where the command is executed.
- The owner of an object created by a system administrator in a schema with the same name as a common user is the common user, not the system administrator.

## Syntax

```
CREATE USER user_name [ [ WITH ] option [ ... ] ] [ ENCRYPTED | UNENCRYPTED ] { PASSWORD |
IDENTIFIED BY } { 'password' [EXPIRED] | DISABLE };
```

The **option** clause is used to configure information, including permissions and properties.

```
{SYSADMIN | NOSYSADMIN}
    | {MONADMIN | NOMONADMIN}
    | {OPRADMIN | NOOPRADMIN}
    | {POLADMIN | NOPOLADMIN}
```

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```
| {AUDITADMIN | NOAUDITADMIN}
| {CREATEDB | NOCREATEDB}
| {USEFT | NOUSEFT}
| {CREATEROLE | NOCREATEROLE}
| {INHERIT | NOINHERIT}
| {LOGIN | NOLOGIN}
| {REPLICATION | NOREPLICATION}
| {INDEPENDENT | NOINDEPENDENT}
| {VCADMIN | NOVCADMIN}
| {PERSISTENCE | NOPERSISTENCE}
| CONNECTION LIMIT connlimit
| VALID BEGIN 'timestamp'
| VALID UNTIL 'timestamp'
| RESOURCE POOL 'respool'
| USER GROUP 'groupuser'
| PERM SPACE 'spacelimit'
| TEMP SPACE 'tmpspacelimit'
| SPILL SPACE 'spillspacelimit'
| NODE GROUP logic_cluster_name
| IN ROLE role_name [, ...]
| IN GROUP role_name [, ...]
| ROLE role_name [, ...]
| ADMIN role_name [, ...]
| USER role_name [, ...]
| SYSID uid
| DEFAULT TABLESPACE tablespace_name
| PROFILE DEFAULT
| PROFILE profile_name
| PGUSER
```

## Parameter Description

- **user_name**

  Specifies the name of the user to be created.

  Value range: a string. It must comply with the naming convention. A value can contain a maximum of 63 characters. If a username contains uppercase letters, the database automatically converts the uppercase letters into lowercase letters. To create a username that contains uppercase letters, enclose the username with double quotation marks ("").

- **password**

  Specifies the login password.

  The new password must:

  – Contain at least eight characters. This is the default length.

  – Differ from the username or the username spelled backward.

  – Contain at least three of the following character types: uppercase characters, lowercase characters, digits, and special characters (limited to ~!@#$ %^&*()-_=+\|[{}];:,<.>/?). If the password contains characters other than the preceding characters, an error will be reported during statement execution.

  – The password can also be a ciphertext character string that meets the format requirements. This mode is mainly used to import user data. You are not advised to use it directly. If a ciphertext password is used, the user must know the plaintext corresponding to the ciphertext password and ensure that the plaintext password meets the complexity requirements. The database does not verify the complexity of the ciphertext password. Instead, the security of the ciphertext password is ensured by the user.

  – Be enclosed by single quotation marks when a user is created.

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Value range: a string

For details about other parameters, see **Parameter Description** in "CREATE ROLE".

## Examples

```
-- Create the jim user and set its login password to xxxxxxxxxx.
openGauss=# CREATE USER jim PASSWORD 'xxxxxxxxxx';

-- Alternatively, you can run the following statement:
openGauss=# CREATE USER kim IDENTIFIED BY 'xxxxxxxxxx';

-- To create a user with the CREATEDB permission, add the CREATEDB keyword.
openGauss=# CREATE USER dim CREATEDB PASSWORD 'xxxxxxxxxx';

-- Change the login password of jim from xxxxxxxxxx to Abcd@123.
openGauss=# ALTER USER jim IDENTIFIED BY 'Abcd@123' REPLACE 'xxxxxxxxxx';

-- Add the CREATEROLE permission to jim.
openGauss=# ALTER USER jim CREATEROLE;

-- Lock jim.
openGauss=# ALTER USER jim ACCOUNT LOCK;

-- Delete users.
openGauss=# DROP USER kim CASCADE;
openGauss=# DROP USER jim CASCADE;
openGauss=# DROP USER dim CASCADE;
```

## Helpful Links

**12.14.37 ALTER USER**, **12.14.74 CREATE ROLE**, and **12.14.131 DROP USER**

# 12.14.89 CREATE VIEW

## Function

**CREATE VIEW** creates a view. A view is a virtual table, not a base table. Only view definition is stored in the database and view data is not. The data is stored in a base table. If data in the base table changes, the data in the view changes accordingly. In this sense, a view is like a window through which users can know their interested data and data changes in the database.

## Precautions

A user granted with the **CREATE ANY TABLE** permission can create views in the public and user schemas.

## Syntax

```
CREATE [ OR REPLACE ] [ TEMP | TEMPORARY ] VIEW view_name [ ( column_name [, ...] ) ]
    [ WITH ( {view_option_name [= view_option_value]} [, ... ] ) ]
    AS query;
```

NOTE

You can use **WITH(security_barrier)** to create a relatively secure view. This prevents attackers from printing base table data by using the **RAISE** statement of low-cost functions.

After a view is created, you are not allowed to use REPLACE to modify column names in the view or delete the columns.

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## Parameter Description

- **OR REPLACE**

  Redefines the view if it already exists.

- **TEMP | TEMPORARY**

  Creates a temporary view.

- **view_name**

  Specifies the name (optionally schema-qualified) of the view to be created.

  Value range: a string. It must comply with the identifier naming convention.

- **column_name**

  Specifies an optional list of names to be used for columns of the view. If not given, the column names are deduced from the query.

  Value range: a string. It must comply with the identifier naming convention.

- **view_option_name [= view_option_value]**

  Specifies an optional parameter for a view.

  Currently, **view_option_name** supports only the **security_barrier** parameter. This parameter is used when the view attempts to provide row-level security.

  Value range: **TRUE** or **FALSE**

- **query**

  Specifies a **SELECT** or **VALUES** statement that will provide the columns and rows of the view.

**NOTICE**

If **query** contains a clause specifying the partition of a partitioned table, the OID of the specified partition is hardcoded to the system catalog when the view is created. If the partition DDL syntax that causes the change in the OID of the specified partition is used, for example, DROP, SPLIT, or MERGE, the view is unavailable. In this case, you need to create a view.

## Examples

```
-- Create a view consisting of columns whose spcname is pg_default.
openGauss=# CREATE VIEW myView AS
    SELECT * FROM pg_tablespace WHERE spcname = 'pg_default';

-- Query the view.
openGauss=# SELECT * FROM myView ;

-- Delete the view.
openGauss=# DROP VIEW myView;
```

## Helpful Links

12.14.38 ALTER VIEW and 12.14.132 DROP VIEW

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# 12.14.90 CREATE WORKLOAD GROUP

## Function

**CREATE WORKLOAD GROUP** creates a workload group, associates it with a resource pool, and specifies the number of concurrent SQL statements in the resource pool.

## Precautions

Only a user with the **CREATE** permission on the current database can perform this operation.

## Syntax

```
CREATE WORKLOAD GROUP wg_name
    [ USING RESOURCE POOL pool_name [ WITH ( ACT_STATEMENTS = counts) ] ];
```

## Parameter Description

- **wg_name**

  Specifies the workload group name.

  NOTE

  The workload group must be unique in a database.

  Value range: a string. It must comply with the naming convention.

- **pool_name**

  Specifies the name of a resource pool.

  Value range: a string. It must comply with the naming convention.

- **counts**

  Specifies the number of concurrent SQL statements in the resource pool that the workload group belongs to.

  Value range: an integer ranging from –1 to 2147483647

## Examples

```
-- Create a default workload group in the default resource pool.
openGauss=# CREATE WORKLOAD GROUP wg_name1;

-- Create the resource pool pool1.
openGauss=# CREATE RESOURCE POOL pool1;

-- Create a workload group and associate it with pool1.
openGauss=# CREATE WORKLOAD GROUP wg_name2 USING RESOURCE POOL pool1;

-- Create a workload group, associate it with pool1, and set the number of concurrent SQL statements to 10.
openGauss=# CREATE WORKLOAD GROUP wg_name3 USING RESOURCE POOL pool1 WITH (ACT_STATEMENTS=10);

-- Delete the created workload groups and resource pool.
openGauss=# DROP WORKLOAD GROUP wg_name1;
openGauss=# DROP WORKLOAD GROUP wg_name2;
openGauss=# DROP WORKLOAD GROUP wg_name3;
openGauss=# DROP RESOURCE POOL pool1;
```

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## Helpful Links

12.14.39 ALTER WORKLOAD GROUP and 12.14.133 DROP WORKLOAD GROUP

# 12.14.91 CREATE WEAK PASSWORD DICTIONARY

## Function

**CREATE WEAK PASSWORD DICTIONARY** inserts one or more weak passwords into the **gs_global_config** table.

## Precautions

- Only the initial user, system administrator, and security administrator have the permission to execute this syntax.
- Passwords in the weak password dictionary are stored in the **gs_global_config** system catalog.
- The weak password dictionary is empty by default. You can use this syntax to add one or more weak passwords.
- When a user attempts to execute this syntax to insert a weak password that already exists in the **gs_global_config** table, only one weak password is retained in the table.

## Syntax

```
CREATE WEAK PASSWORD DICTIONARY
    [WITH VALUES] ( {'weak_password'} [, ...] );
```

## Parameter Description

weak_password

Weak password

Value range: a character string.

## Example

```
-- Insert a single weak password into the gs_global_config system catalog.
openGauss=# CREATE WEAK PASSWORD DICTIONARY WITH VALUES ('password1');

-- Insert multiple weak passwords into the gs_global_config system catalog.
openGauss=# CREATE WEAK PASSWORD DICTIONARY WITH VALUES ('password2'),('password3');

-- Clear all weak passwords in the gs_global_config system catalog.
openGauss=# DROP WEAK PASSWORD DICTIONARY;

-- View existing weak passwords.
openGauss=# SELECT * FROM gs_global_config WHERE NAME LIKE 'weak_password';
```

## Helpful Links

13.14.119-DROP WEAK PASSWORD DICTIONARY

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# 12.14.92 CURSOR

## Function

**CURSOR** defines a cursor to retrieve a small number of rows at a time out of a larger query.

To process SQL statements, the stored procedure process assigns a memory segment to store context association. Cursors are handles or pointers pointing to context regions. With cursors, stored procedures can control alterations in context regions.

## Precautions

- **CURSOR** is used only in transaction blocks.
- Generally, **CURSOR** and **SELECT** both have text returns. Since data is stored in binary format in the system, the system needs to convert the data from the binary format to the text format. If data is returned in text format, client applications need to convert the data back to the binary format for processing. **FETCH** implements conversion between binary data and text data.
- Binary cursors should be used carefully. Text usually occupies larger space than binary data. A binary cursor returns internal binary data, which is easier to operate. A text cursor returns text, which is easier to retrieve and therefore reduces workload on the client. As an example, if a query returns a value of one from an integer column, you would get a string of 1 with a default cursor, whereas with a binary cursor you would get a 4-byte field containing the internal representation of the value (in big-endian byte order).

## Syntax

```
CURSOR cursor_name
    [ BINARY ]  [ NO SCROLL ]  [ { WITH | WITHOUT } HOLD ]
    FOR query ;
```

## Parameter Description

- **cursor_name**

  Specifies the name of the cursor to be created.

  Value range: a string. It must comply with the naming convention.

- **BINARY**

  Causes the cursor to return data in binary rather than in text format.

- **NO SCROLL**

  Specifies how the cursor retrieves rows.

  - **NO SCROLL**: specifies that the cursor cannot be used to retrieve rows in a nonsequential fashion.
  - Unspecified: Based on the query's execution plan, the system automatically determines whether the cursor can be used to retrieve rows in a nonsequential fashion.

- **WITH HOLD | WITHOUT HOLD**

  Specifies whether the cursor can continue to be used after the transaction that created it successfully commits.

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  - **WITH HOLD**: The cursor can continue to be used after the transaction that created it successfully commits.
  - **WITHOUT HOLD**: The cursor cannot be used outside of the transaction that created it.
  - If neither **WITH HOLD** nor **WITHOUT HOLD** is specified, the default is **WITHOUT HOLD**.
  - Cross-node transactions (for example, DDL-contained transactions created in a coordinator cluster) do not support **WITH HOLD**.

- **query**

  Uses a **SELECT** or **VALUES** clause to specify the rows to be returned by the cursor.

  Value range: **SELECT** or **VALUES** clause

## Examples

See **Examples** in **FETCH**.

## Helpful Links

**12.14.139 FETCH**

# 12.14.93 DEALLOCATE

## Function

**DEALLOCATE** deallocates a previously prepared statement. If you do not explicitly deallocate a prepared statement, it is deallocated when the session ends.

The **PREPARE** keyword is always ignored.

## Precautions

None

## Syntax

```
DEALLOCATE [ PREPARE ] { name | ALL };
```

## Parameter Description

- **name**

  Specifies the name of the prepared statement to be deallocated.

- **ALL**

  Deallocates all prepared statements.

## Examples

None

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# 12.14.94 DECLARE

## Function

**DECLARE** defines a cursor to retrieve a small number of rows at a time out of a larger query and can be the start of an anonymous block.

This section describes usage of cursors. The usage of anonymous blocks is available in **12.14.41 BEGIN**.

To process SQL statements, the stored procedure process assigns a memory segment to store context association. Cursors are handles or pointers pointing to context regions. With cursors, stored procedures can control alterations in context regions.

Generally, **CURSOR** and **SELECT** both have text returns. Since data is stored in binary format in the system, the system needs to convert the data from the binary format to the text format. If data is returned in text format, client applications need to convert the data back to the binary format for processing. **FETCH** implements conversion between binary data and text data.

## Precautions

- **CURSOR** is used only in transaction blocks.
- Binary cursors should be used carefully. Text usually occupies larger space than binary data. A binary cursor returns internal binary data, which is easier to operate. A text cursor returns text, which is easier to retrieve and therefore reduces workload on the client. As an example, if a query returns a value of one from an integer column, you would get a string of 1 with a default cursor, whereas with a binary cursor you would get a 4-byte field containing the internal representation of the value (in big-endian byte order).

## Syntax

- Define a cursor.

```
DECLARE cursor_name [ BINARY ] [ NO SCROLL ]
    CURSOR [ { WITH | WITHOUT } HOLD ] FOR query ;
```

- Enable an anonymous block.

```
[DECLARE [declare_statements]]
BEGIN
execution_statements
END;
/
```

## Parameter Description

- **cursor_name**

  Specifies the name of the cursor to be created.

  Value range: a string. It must comply with the naming convention.

- **BINARY**

  Causes the cursor to return data in binary rather than in text format.

- **NO SCROLL**

  Specifies how the cursor retrieves rows.

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  - **NO SCROLL**: specifies that the cursor cannot be used to retrieve rows in a nonsequential fashion.
  - Unspecified: Based on the query's execution plan, the system automatically determines whether the cursor can be used to retrieve rows in a nonsequential fashion.

- **WITH HOLD**

  **WITHOUT HOLD**

  Specifies whether the cursor can continue to be used after the transaction that created it successfully commits.
  - **WITH HOLD**: The cursor can continue to be used after the transaction that created it successfully commits.
  - **WITHOUT HOLD**: The cursor cannot be used outside of the transaction that created it.
  - If neither **WITH HOLD** nor **WITHOUT HOLD** is specified, the default is **WITHOUT HOLD**.

- **query**

  Uses a **SELECT** or **VALUES** clause to specify the rows to be returned by the cursor.

  Value range: **SELECT** or **VALUES** clause

- **declare_statements**

  Declares a variable, including its name and type, for example, **sales_cnt int**.

- **execution_statements**

  Specifies the statement to be executed in an anonymous block.

  Value range: an existing function name

## Examples

For details about how to start a transaction, see **Examples** in **BEGIN**.

For details about how to define a cursor, see **Examples** in **FETCH**.

## Helpful Links

**12.14.41 BEGIN** and **12.14.139 FETCH**

# 12.14.95 DELETE

## Function

**DELETE** deletes rows that satisfy the **WHERE** clause from the specified table. If the **WHERE** clause is absent, the effect is to delete all rows in the table. The result is a valid, but an empty table.

## Precautions

- The owner of a table, users granted with the **DELETE** permission on the table, or users granted with the **DELETE ANY TABLE** permission can delete data from the table. The system administrator has the permission to delete data

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from the table by default, as well as the **SELECT** permission on any table in the **USING** clause or whose values are read in **condition**.

- For row-store tables, **DELETE** can be used if the tables have primary key constraints or the execution plan can be pushed down.
- For column-store tables, **DELETE** can be used only when the execution plan can be pushed down.
- For column-store tables, the **RETURNING** clause is currently not supported.
- For a time series table, only deletion by time is supported. The **RETURNING** clause is not supported.

## Syntax

```
[ WITH [ RECURSIVE ] with_query [, ...] ]
DELETE [/*+ plan_hint */] [FROM] [ ONLY ] table_name [ * ] [ [ AS ] alias ]
    [ USING using_list ]
    [ WHERE condition | WHERE CURRENT OF cursor_name ]
    [ RETURNING { * | { output_expr [ [ AS ] output_name ] } [, ...] } ];
```

## Parameter Description

- **WITH [ RECURSIVE ] with_query [, ...]**

  Specifies one or more subqueries that can be referenced by name in the main query, which is equivalent to a temporary table.

  If **RECURSIVE** is specified, it allows a **SELECT** subquery to reference itself by name.

  Format of **with_query**:

  ```
  with_query_name [ ( column_name [, ...] ) ] AS [ [ NOT ] MATERIALIZED ]
  ( {select | values | insert | update | delete} )
  ```

  – **with_query_name** specifies the name of the result set generated by a subquery. Such names can be used to access the result sets of subqueries in a query.

  – **column_name** specifies the column name displayed in the subquery result set.

  – Each subquery can be a **SELECT**, **VALUES**, **INSERT**, **UPDATE** or **DELETE** statement.

  – You can use **MATERIALIZED** or **NOT MATERIALIZED** to modify the CTE.

  - If **MATERIALIZED** is specified, the WITH query will be materialized, and a copy of the subquery result set is generated. The copy is directly queried at the reference point. Therefore, the WITH subquery cannot be jointly optimized with the **SELECT** statement trunk (for example, predicate pushdown and equivalence class transfer). In this scenario, you can use **NOT MATERIALIZED** for modification. If the WITH query can be executed as a subquery inline, the preceding optimization can be performed.
  - If the user does not explicitly declare the materialized attribute, comply with the following rules: If the CTE is referenced only once in the trunk statement to which it belongs and semantically supports inline execution, it will be rewritten as subquery inline execution. Otherwise, the materialized execution will be performed in CTE Scan mode.

- **plan_hint** clause

  Follows the **DELETE** keyword in the **/*+ */** format. It is used to optimize the plan of a **DELETE** statement block. For details, see **10.3.9 Hint-based Tuning**.

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In each statement, only the first **/*+** *plan_hint* ***/** comment block takes effect as a hint. Multiple hints can be written.

- **ONLY**

  If **ONLY** is specified before the table name, matching rows are deleted from the named table only. If **ONLY** is not specified, matching rows are also deleted from any tables inheriting from the named table.

- **table_name**

  Specifies the name (optionally schema-qualified) of the table to delete rows from.

  Value range: an existing table name

- **alias**

  Specifies a substitute name for the target table.

  Value range: a string. It must comply with the identifier naming convention.

- **using_list**

  Specifies the **USING** clause.

- **condition**

  Specifies an expression that returns a value of type Boolean. Only rows for which this expression returns **true** will be deleted. You are not advised to use numeric types such as int for **condition**, because such types can be implicitly converted to bool values (non-zero values are implicitly converted to **true** and **0** is implicitly converted to **false**), which may cause unexpected results.

- **WHERE CURRENT OF cursor_name**

  This parameter is reserved.

- **output_expr**

  Specifies an expression to be computed and returned by the **DELETE** statement after each row is deleted. The expression can use any column names of the table. Write ***** to return all columns.

- **output_name**

  Specifies a name to use for a returned column.

  Value range: a string. It must comply with the identifier naming convention.

## Examples

```
-- Create the tpcds.customer_address_bak table.
openGauss=# CREATE TABLE tpcds.customer_address_bak AS TABLE tpcds.customer_address;

-- Delete employees whose ca_address_sk is smaller than 14888 from the tpcds.customer_address_bak table.
openGauss=# DELETE FROM tpcds.customer_address_bak WHERE ca_address_sk < 14888;

-- Delete all data from the tpcds.customer_address_bak table.
openGauss=# DELETE FROM tpcds.customer_address_bak;

Delete the tpcds.customer_address_bak table.
openGauss=# DROP TABLE tpcds.customer_address_bak;
```

## Suggestions

- delete

  To delete all records in a table, use the **truncate** syntax.

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# 12.14.96 DO

## Function

**DO** executes an anonymous code block.

The code block is treated as though it were the body of a function with no parameters, returning **void**. It is parsed and executed a single time.

## Precautions

- The procedural language to be used must already have been installed into the current database by means of **CREATE LANGUAGE**. **plpgsql** is installed by default, but other languages are not.
- The user must have the **USAGE** permission on the procedural language, or must be a system administrator if the language is untrusted.

## Syntax

```
DO [ LANGUAGE lang_name ] code;
```

## Parameter Description

- **lang_name**

  Specifies the name of the procedural language the code is written in. If omitted, the default is **plpgsql**.

- **code**

  Specifies the procedural language code to be executed. This must be specified as a string literal.

## Examples

```
-- Create the webuser user.
openGauss=# CREATE USER webuser PASSWORD 'xxxxxxxxxx';

-- Grant all permissions on all views in the tpcds schema to the webuser user.
openGauss=# DO $$DECLARE r record;
BEGIN
   FOR r IN SELECT c.relname,n.nspname FROM pg_class c,pg_namespace n
         WHERE c.relnamespace = n.oid AND n.nspname = 'tpcds' AND relkind IN ('r','v')
   LOOP
      EXECUTE 'GRANT ALL ON ' || quote_ident(r.table_schema) || '.' || quote_ident(r.table_name) || ' TO
webuser';
   END LOOP;
END$$;


-- Delete the webuser user.
openGauss=# DROP USER webuser CASCADE;
```

# 12.14.97 DROP APP WORKLOAD GROUP MAPPING

## Function

**DROP APP WORKLOAD GROUP MAPPING** deletes an app workload group mapping.

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## Precautions

Only a user with the **DROP** permission on the current database can perform this operation.

## Syntax

```
DROP APP WORKLOAD GROUP MAPPING [ IF EXISTS ] app_name;
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified app workload group mapping does not exist.

- **app_name**

  Specifies the name of the app workload group mapping to be deleted. The name was specified during **CREATE APP WORKLOAD GROUP MAPPING**.

  Value range: a string. It must comply with the naming convention.

## Examples

See **Examples** in **CREATE APP WORKLOAD GROUP MAPPING**.

## Helpful Links

**12.14.2 ALTER APP WORKLOAD GROUP MAPPING** and **12.14.51 CREATE APP WORKLOAD GROUP MAPPING**

# 12.14.98 DROP AUDIT POLICY

## Function

**DROP AUDIT POLICY** deletes an audit policy.

## Precautions

Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.

## Syntax

```
DROP AUDIT POLICY [IF EXISTS] policy_name;
```

## Parameter Description

**policy_name**

Specifies the audit policy name, which must be unique.

Value range: a string. It must comply with the naming convention.

## Examples

See **Examples** in **CREATE AUDIT POLICY**.

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### Helpful Links

12.14.52 CREATE AUDIT POLICY and 12.14.3 ALTER AUDIT POLICY

## 12.14.99 DROP CLIENT MASTER KEY

### Function

**DROP CLIENT MASTER KEY** deletes a CMK.

### Precautions

- Only the CMK owner or a user who has been granted the DROP permission can run this command. By default, the system administrator has this permission.
- This command can only be used to delete the metadata information recorded in the system catalog of the database, but cannot be used to delete the CMK file. You need to use KeyTool to delete the CMK file.

### Syntax

```
DROP CLIENT MASTER KEY [ IF EXISTS ] client_master_key_name [CASCADE];
```

### Parameter Description

- **IF EXISTS**

  If a specified CMK does not exist, a notice rather than an error is issued.
- **client_master_key_name**

  Name of a CMK to be deleted.

  Value range: a string. It is the name of an existing CMK.
- **CASCADE**

  Indicates automatically deleting objects that depend on the CMK.

### Examples

```
-- Delete a CMK object.
openGauss=> DROP CLIENT MASTER KEY ImgCMK CASCADE;
NOTICE:  drop cascades to column setting: imgcek
DROP GLOBAL SETTING
```

## 12.14.100 DROP COLUMN ENCRYPTION KEY

### Function

**CREATE COLUMN ENCRYPTION KEY** deletes a column encryption key (CEK).

### Precautions

Only the CEK owner or a user who has been granted the DROP permission can run this command. By default, the system administrator has this permission.

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## Syntax

```
DROP COLUMN ENCRYPTION KEY [ IF EXISTS ] column_encryption_key_name [CASCADE];
```

## Parameter Description

- **IF EXISTS**

  If a specified CEK does not exist, a notice rather than an error is issued.

- **column_encryption_key_name**

  Name of a CEK to be deleted.

  Value range: a string. It is the name of an existing CEK.

## Examples

```
-- Delete a CEK object.
openGauss=# DROP COLUMN ENCRYPTION KEY ImgCEK CASCADE;
ERROR:  cannot drop column setting: imgcek cascadely because encrypted column depend on it.
HINT:  we have to drop encrypted column: name, ... before drop column setting: imgcek cascadely.
```

# 12.14.101 DROP DATABASE

## Function

**DROP DATABASE** deletes a database.

## Precautions

- Only the database owner or a user granted with the DROP permission can run the **DROP DATABASE** command. The system administrator has this permission by default.
- The preinstalled POSTGRES, TEMPLATE0, and TEMPLATE1 databases are protected and therefore cannot be deleted. To check databases in the current service, run the gsql statement **\l**.
- If any users are connected to the database, the database cannot be deleted. To check the current database connections, open the **dv_sessions** view.
- **DROP DATABASE** cannot be executed within a transaction block.
- Before deleting a database, run the **CLEAN CONNECTION TO ALL FORCE FOR DATABASE** *XXXX* command to forcibly stop the existing user connections and backend threads, preventing database deletion failures caused by running backend threads. Forcibly stopping backend threads may cause data inconsistency in the current database. Therefore, execute this command only when you are sure to delete the database.
- If **DROP DATABASE** fails and is rolled back, run **DROP DATABASE IF EXISTS** again.

**NOTICE**

**DROP DATABASE** cannot be undone.

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## Syntax

```
DROP DATABASE [ IF EXISTS ] database_name ;
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified database does not exist.
- **database_name**

  Specifies the name of the database to be deleted.

  Value range: an existing database name

## Examples

See **Examples** in **CREATE DATABASE**.

## Helpful Links

**12.14.57 CREATE DATABASE**

## Suggestions

- drop database

  Do not delete databases during transactions.

# 12.14.102 DROP DATA SOURCE

## Function

**DROP DATA SOURCE** deletes a data source.

## Precautions

Only an owner, system administrator, or initial user can delete a data source.

## Syntax

```
DROP DATA SOURCE [IF EXISTS] src_name [CASCADE | RESTRICT];
```

## Parameter Description

- **src_name**

  Specifies the name of the data source to be deleted.

  Value range: a string. It must comply with the naming convention.
- **IF EXISTS**

  Reports a notice instead of an error if the specified data source does not exist.
- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects that depend on the data source.
  - **RESTRICT**: refuses to delete the data source if any objects depend on it. This is the default action.

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Currently, no objects depend on data sources. Therefore, **CASCADE** is equivalent to **RESTRICT**, and they are reserved to ensure backward compatibility.

## Examples

```
-- Create a data source.
openGauss=# CREATE DATA SOURCE ds_tst1;

-- Delete the data source.
openGauss=# DROP DATA SOURCE ds_tst1 CASCADE;
openGauss=# DROP DATA SOURCE IF EXISTS ds_tst1 RESTRICT;
```

## Helpful Links

**12.14.58 CREATE DATA SOURCE** and **12.14.6 ALTER DATA SOURCE**

# 12.14.103 DROP DIRECTORY

## Function

**DROP DIRECTORY** deletes a directory.

## Precautions

When **enable_access_server_directory** is set to **off**, only the initial user is allowed to delete directory objects. When **enable_access_server_directory** is set to **on**, a user with the SYSADMIN permission, the owner of the directory object, a user who is granted with the DROP permission of the directory, or a user who inherits the **gs_role_directory_drop** permission of the built-in role can delete directory objects.

## Syntax

```
DROP DIRECTORY [ IF EXISTS ] directory_name;
```

## Parameter Description

- **directory_name**

  Specifies the name of the directory to be deleted.

  Value range: an existing directory name

## Examples

```
-- Create a directory.
openGauss=# CREATE OR REPLACE DIRECTORY  dir  as '/tmp/';

-- Delete a foreign table.
openGauss=# DROP DIRECTORY dir;
```

## Helpful Links

**12.14.59 CREATE DIRECTORY** and **12.14.8 ALTER DIRECTORY**

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# 12.14.104 DROP FOREIGN TABLE

## Function

**DROP FOREIGN TABLE** deletes a foreign table.

## Precautions

**DROP FOREIGN TABLE** forcibly deletes the specified table and the indexes depending on the table. After the table is deleted, the functions and stored procedures that need to use this table cannot be executed.

## Syntax

```
DROP FOREIGN TABLE [ IF EXISTS ]
    table_name [, ...] [ CASCADE | RESTRICT ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified table does not exist.

- **table_name**

  Specifies the name of the table to be deleted.

  Value range: an existing table name

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects (such as views) that depend on the table.
  - **RESTRICT**: refuses to delete the table if any objects depend on it. This is the default action.

## Examples

See **Examples** in **CREATE FOREIGN TABLE**.

## Helpful Links

**12.14.9 ALTER FOREIGN TABLE (for Import and Export)** and **12.14.60 CREATE FOREIGN TABLE (for Import and Export)**

# 12.14.105 DROP FUNCTION

## Function

**DROP FUNCTION** deletes a function.

## Precautions

If a function involves operations on temporary tables, **DROP FUNCTION** cannot be used.

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Only the function owner or a user granted with the DROP permission can run the **DROP FUNCTION** command. The system administrator has this permission by default.

## Syntax

```
DROP FUNCTION [ IF EXISTS ] function_name
[ ( [ { [ argname ] [ argmode ] argtype} [, ...] ] ) [ CASCADE | RESTRICT ] ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified function does not exist.

- **function_name**

  Specifies the name of the function to be deleted.

  Value range: an existing function name

- **argmode**

  Specifies the parameter mode of the function.

- **argname**

  Specifies the parameter name of the function.

- **argtype**

  Specifies the parameter type of the function.

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects (such as operators) that depend on the function.
  - **RESTRICT**: refuses to delete the function if any objects depend on it. This is the default action.

## Examples

See **Examples** in **CREATE FUNCTION**.

## Helpful Links

**12.14.10 ALTER FUNCTION** and **12.14.61 CREATE FUNCTION**

# 12.14.106 DROP GLOBAL CONFIGURATION

## Function

**DROP GLOBAL CONFIGURATION** deletes parameter values from the **gs_global_config** system catalog.

## Precautions

Only the initial database user can run this command.

The **weak_password** keyword cannot be deleted.

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### Syntax

```
DROP GLOBAL CONFIGURATION Parameter name, Parameter name...;
```

### Parameter Description

The parameter is a parameter that already exists in the **gs_global_config** system catalog. If you delete a parameter that does not exist, an error will be reported.

## 12.14.107 DROP GROUP

### Function

**DROP GROUP** deletes a user group. **DROP GROUP** is an alias for **DROP ROLE**.

### Precautions

**DROP GROUP** is available only to users with the **CREATE ROLE** permission granted by the administrator.

### Syntax

```
DROP GROUP [ IF EXISTS ] group_name [, ...];
```

### Parameter Description

See **Parameter Description** in **DROP ROLE**.

### Helpful Links

- **12.14.62 CREATE GROUP**
- **12.14.12 ALTER GROUP**
- **12.14.119 DROP ROLE**

## 12.14.108 DROP INDEX

### Function

**DROP INDEX** deletes an index.

### Precautions

Only the index owner, a user of a schema where the index resides, or a user who has the INDEX permission on the table where the index resides can run the **DROP INDEX** command. The system administrator has this permission by default.

### Syntax

```
DROP INDEX [ IF EXISTS ]
    index_name [, ...] [ CASCADE | RESTRICT ];
```

### Parameter Description

- **IF EXISTS**

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Reports a notice instead of an error if the specified index does not exist.

- **index_name**

  Specifies the name of the index to be deleted.

  Value range: an existing index

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects that depend on the index.
  - **RESTRICT**: refuses to delete the index if any objects depend on it. This is the default action.

### Examples

See **Examples** in **CREATE INDEX**.

### Helpful Links

**12.14.13 ALTER INDEX** and **12.14.64 CREATE INDEX**

## 12.14.109 DROP LANGUAGE

This version does not support this syntax.

## 12.14.110 DROP MASKING POLICY

### Function

**DROP MASKING POLICY** deletes an anonymization policy.

### Precautions

Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.

### Syntax

```
DROP MASKING POLICY [ IF EXISTS ] policy_name;
```

### Parameter Description

**policy_name**

Specifies the audit policy name, which must be unique.

Value range: a string. It must comply with the naming convention.

### Examples

```
-- Delete an anonymization policy.
openGauss=# DROP MASKING POLICY IF EXISTS maskpol1;

-- Delete a group of anonymization policies.
openGauss=# DROP MASKING POLICY IF EXISTS maskpol1, maskpol2, maskpol3;
```

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### Helpful Links

5.1.13.14.14-ALTER MASKING POLICY and 5.13.14.59-CREATE MASKING POLICY

## 12.14.111 DROP MATERIALIZED VIEW

### Function

**DROP MATERIALIZED VIEW** deletes an existing materialized view from the database.

### Precautions

The owner of a materialized view, owner of the schema of the materialized view, users granted with the DROP permission on the materialized view, or users granted with the DROP ANY TABLE permission can run the **DROP MATERIALIZED VIEW** command. By default, the system administrator has the permission to run the command.

### Syntax

```
DROP MATERIALIZED VIEW [ IF EXISTS ] mv_name [, ...] [ CASCADE | RESTRICT ];
```

### Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified materialized view does not exist.

- **mv_name**

  Name of the materialized view to be deleted.

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects that depend on a materialized view.
  - **RESTRICT**: refuses to delete a materialized view if any objects depend on it. This is the default value.

### Examples

```
-- Delete the materialized view named my_mv.
openGauss=# DROP MATERIALIZED VIEW my_mv;
```

### Helpful Links

12.14.17 ALTER MATERIALIZED VIEW, 12.14.63 CREATE INCREMENTAL MATERIALIZED VIEW, 12.14.67 CREATE MATERIALIZED VIEW, 12.14.80 CREATE TABLE, 12.14.150 REFRESH INCREMENTAL MATERIALIZED VIEW, and 12.14.151 REFRESH MATERIALIZED VIEW

## 12.14.112 DROP MODEL

This syntax is not supported in distributed scenarios.

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# 12.14.113 DROP NODE

## Function

**DROP NODE** deletes a node.

## Precautions

**CREATE NODE GROUP** is an interface of the cluster management tool. You are not advised to use this interface, because doing so affects the cluster. Only the administrator has the permission to use this interface.

## Syntax

```
DROP NODE [ IF EXISTS ] nodename [WITH ( cnnodename [, ... ] )];
```

## Parameter Description

**IF EXISTS**

Reports a notice instead of an error if the specified node does not exist.

**nodename**

Specifies the name of the node to be deleted.

Value range: an existing node name

**cnnodename**

Specifies the CN name. If it is specified, **DROP NODE** will be executed on both the connected CN and the specified CN. If it is not specified, DN deletion must be performed on all CNs, and CN deletion must be performed on all CNs except the CN to be deleted.

Value range: an existing CN name

## Helpful Links

- **12.14.69 CREATE NODE**
- **12.14.18 ALTER NODE**

# 12.14.114 DROP NODE GROUP

## Function

**DROP NODE GROUP** deletes a node group.

## Precautions

- **DROP NODE GROUP** is an interface of the cluster management tool.
- Only the system administrator or a user who has the **DROP** permission can perform this operation.

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## Syntax

```
DROP NODE GROUP groupname [DISTRIBUTE FROM src_group_name];
```

## Parameter Description

**groupname**

Specifies the name of the node group to be deleted.

Value range: an existing node group name

**DISTRIBUTE FROM src_group_name**

If the node group to be deleted originates from the logical cluster node group specified by **src_group_name**, set **src_group_name** to specify the logical cluster node group to which node information will be synchronized after redistribution. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) This statement is used only for redistribution during scale-out. You are not advised to use it, because it may lead to data distribution errors and logical cluster unavailability.

## Helpful Links

**12.14.70 CREATE NODE GROUP**

# 12.14.115 DROP OWNED

## Function

**DROP OWNED** deletes the database objects owned by a database role.

## Precautions

- This interface will revoke the role's permissions on all objects in the current database and shared objects (databases and tablespaces).
- **DROP OWNED** is often used to prepare for removing one or more roles. Because **DROP OWNED** affects only the objects in the current database, you need to run this statement in each database that contains the objects owned by the role to be removed.
- Using the **CASCADE** option may cause this statement to recursively remove objects owned by other users.
- The databases and tablespaces owned by the role will not be removed.

## Syntax

```
DROP OWNED BY name [, ...] [ CASCADE | RESTRICT ];
```

## Parameter Description

- **name**

  Specifies the role name.

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects that depend on the objects to be deleted.

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  - **RESTRICT**: refuses to delete the objects if other objects depend on them. This is the default action.

### Helpful Links

**12.14.148 REASSIGN OWNED** and **12.14.119 DROP ROLE**

## 12.14.116 DROP PROCEDURE

### Function

**DROP PROCEDURE** deletes a stored procedure.

### Precautions

None

### Syntax

```
DROP PROCEDURE [ IF EXISTS  ] procedure_name ;
```

### Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified stored procedure does not exist.

- **procedure_name**

  Specifies the name of the stored procedure to be deleted.

  Value range: an existing stored procedure name

### Examples

See **Examples** in **CREATE PROCEDURE**.

### Helpful Links

**12.14.71 CREATE PROCEDURE**

## 12.14.117 DROP RESOURCE LABEL

### Function

**DROP RESOURCE LABEL** deletes a resource label.

### Precautions

Only user **poladmin**, user **sysadmin**, or the initial user can perform this operation.

### Syntax

```
DROP RESOURCE LABEL [IF EXISTS] policy_name[, ...]*;
```

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## Parameter Description

**label_name**

Specifies the resource label name.

Value range: a string. It must comply with the naming convention.

## Examples

```
-- Delete a resource label.
openGauss=# DROP RESOURCE LABEL IF EXISTS res_label1;

-- Delete a group of resource labels.
openGauss=# DROP RESOURCE LABEL IF EXISTS res_label1, res_label2, res_label3;
```

## Helpful Links

**5.1.13.14.17-ALTER RESOURCE LABEL** and **5.1.13.14.64-CREATE RESOURCE LABEL**

# 12.14.118 DROP RESOURCE POOL

The current feature is a lab feature. Contact Huawei technical support before using it.

## Function

**DROP RESOURCE POOL** deletes a resource pool.

NOTE

The resource pool cannot be deleted if it is associated with a role.

## Precautions

Only a user with the **DROP** permission on the current database can perform this operation.

## Syntax

```
DROP RESOURCE POOL [ IF EXISTS ] pool_name;
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified resource pool does not exist.

- **pool_name**

  Specifies the name of the resource pool to be deleted.

  Value range: a string. It must comply with the naming convention.

NOTE

In a multi-tenant scenario, deleting a group resource pool also deletes the related service resource pools. A resource pool can be deleted only when it is not associated with any users.

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### Examples

See **Examples** in **CREATE RESOURCE POOL**.

### Helpful Links

**12.14.21 ALTER RESOURCE POOL** and **12.14.73 CREATE RESOURCE POOL**

## 12.14.119 DROP ROLE

### Function

**DROP ROLE** deletes a role.

### Precautions

None

### Syntax

```
DROP ROLE [ IF EXISTS ] role_name [, ...];
```

### Parameter Description

- **IF EXISTS**
  Reports a notice instead of an error if the specified role does not exist.
- **role_name**
  Specifies the name of the role to be deleted.
  Value range: an existing role name

### Examples

See **Examples** in **CREATE ROLE**.

### Helpful Links

**12.14.74 CREATE ROLE**, **12.14.22 ALTER ROLE**, and **12.14.163 SET ROLE**

## 12.14.120 DROP ROW LEVEL SECURITY POLICY

### Function

**DROP ROW LEVEL SECURITY POLICY** deletes a row-level access control policy from a table.

### Precautions

Only the owner of a table or a system administrator has the **DROP ROW LEVEL SECURITY POLICY** permission.

### Syntax

```
DROP [ ROW LEVEL SECURITY ] POLICY [ IF EXISTS ] policy_name ON table_name [ CASCADE | RESTRICT ]
```

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## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified row-level access control policy does not exist.

- **policy_name**

  Specifies the name of a row-level access control policy to be deleted.

  – table_name

    Specifies the name of the table containing the row-level access control policy.

  – CASCADE/RESTRICT

    Currently, no objects depend on row-level access control policies. Therefore, **CASCADE** is equivalent to **RESTRICT**, and they are reserved to ensure backward compatibility.

## Examples

```
-- Create the data table all_data.
openGauss=# CREATE TABLE all_data(id int, role varchar(100), data varchar(100));

-- Create a row-level access control policy.
openGauss=# CREATE ROW LEVEL SECURITY POLICY all_data_rls ON all_data USING(role =
CURRENT_USER);

-- Delete a row-level access control policy.
openGauss=# DROP ROW LEVEL SECURITY POLICY all_data_rls ON all_data;
```

## Helpful Links

**12.14.23 ALTER ROW LEVEL SECURITY POLICY** and **12.14.75 CREATE ROW LEVEL SECURITY POLICY**

# 12.14.121 DROP SCHEMA

## Function

**DROP SCHEMA** deletes a schema from the current database.

## Precautions

Only the schema owner or a user granted with the DROP permission can run the **DROP SCHEMA** command. The system administrator has this permission by default.

## Syntax

```
DROP SCHEMA [ IF EXISTS ] schema_name [, ...] [ CASCADE | RESTRICT ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified schema does not exist.

- **schema_name**

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Specifies the name of the schema to be deleted.

Value range: an existing schema name

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes all the objects contained in the schema.
  - **RESTRICT**: refuses to delete the schema if the schema contains objects. This is the default action.

**NOTICE**

Schemas beginning with **pg_temp** or **pg_toast_temp** are for internal use. Do not delete them. Otherwise, unexpected consequences may be incurred.

**NOTE**

The schema currently being used cannot be deleted. To delete it, switch to another schema first.

## Examples

See **Examples** in **CREATE SCHEMA**.

## Helpful Links

**12.14.24 ALTER SCHEMA** and **12.14.76 CREATE SCHEMA**

# 12.14.122 DROP SEQUENCE

## Function

**DROP SEQUENCE** deletes a sequence from the current database.

## Precautions

Only the owner of a sequence, the owner of the schema of the sequence, or users granted with the DROP permission on the sequence can delete the sequence. By default, the system administrator has the permission to delete the sequence.

## Syntax

```
DROP SEQUENCE [ IF EXISTS ] { [schema.] sequence_name } [ , ... ] [ CASCADE | RESTRICT ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified sequence does not exist.
- **name**

  Specifies the name of the sequence to be deleted.
- **CASCADE**

  Automatically deletes the objects that depend on the sequence.

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- **RESTRICT**

  Refuses to delete the sequence if any objects depend on it. This is the default action.

## Examples

```
-- Create an ascending sequence named serial, starting from 101.
openGauss=# CREATE SEQUENCE serial START 101;

-- Delete a sequence.
openGauss=# DROP SEQUENCE serial;
```

## Helpful Links

**12.14.25 ALTER SEQUENCE** and **12.14.122 DROP SEQUENCE**

# 12.14.123 DROP SERVER

## Function

**DROP SERVER** deletes a data server.

## Precautions

Only the server owner or a user granted with the DROP permission can run the **DROP SERVER** command. The system administrator has this permission by default.

## Syntax

```
DROP SERVER [ IF EXISTS ] server_name [ {CASCADE | RESTRICT} ] ;
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified data server does not exist.

- **server_name**

  Specifies the name of the data server to be deleted.

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects that depend on the data server.
  - **RESTRICT**: refuses to delete the server if any objects depend on it. This is the default action.

## Examples

See **Examples** in **CREATE SERVER**.

## Helpful Links

**12.14.26 ALTER SERVER** and **12.14.78 CREATE SERVER**

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# 12.14.124 DROP SYNONYM

## Function

**DROP SYNONYM** deletes a synonym.

## Precautions

Only the owner of a synonym or a system administrator has the **DROP SYNONYM** permission.

## Syntax

```
DROP SYNONYM [ IF EXISTS ] synonym_name [ CASCADE | RESTRICT ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified synonym does not exist.

- **synonym_name**

  Specifies the name (optionally schema-qualified) of the synonym to be deleted.

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects (such as views) that depend on the synonym.
  - **RESTRICT**: refuses to delete the synonym if any objects depend on it. This is the default action.

## Examples

See **Examples** in **CREATE SYNONYM**.

## Helpful Links

**12.14.28 ALTER SYNONYM** and **12.14.79 CREATE SYNONYM**

# 12.14.125 DROP TABLE

## Function

**DROP TABLE** deletes a table.

## Precautions

**DROP TABLE** forcibly deletes the specified table and the indexes depending on the table. After the table is deleted, the functions and stored procedures that need to use this table cannot be executed. Deleting a partitioned table also deletes all partitions in the table.

The owner of a table, the owner of the schema of the table, users granted with the DROP permission on the table, or users granted with the DROP ANY TABLE

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permission can delete the specified table. The system administrator has the permission to delete the specified table by default.

## Syntax

```
DROP TABLE [ IF EXISTS ]
   { [schema.]table_name } [, ...] [ CASCADE | RESTRICT ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified table does not exist.

- **schema**

  Specifies the schema name.

- **table_name**

  Specifies the table name.

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects (such as views) that depend on the table.
  - **RESTRICT**: refuses to delete the table if any objects depend on it. This is the default action.

## Examples

See **Examples** in **CREATE TABLE**.

## Helpful Links

**12.14.30 ALTER TABLE** and **12.14.80 CREATE TABLE**

# 12.14.126 DROP TABLESPACE

## Function

**DROP TABLESPACE** deletes a tablespace.

## Precautions

- Only the tablespace owner or a user granted with the DROP permission can run the **DROP TABLESPACE** command. The system administrator has this permission by default.
- The tablespace to be deleted should not contain any database objects. Otherwise, an error will be reported.
- **DROP TABLESPACE** cannot be rolled back and therefore cannot be run in transaction blocks.
- During execution of **DROP TABLESPACE**, database queries by other sessions using **\db** may fail and need to be reattempted.
- If **DROP TABLESPACE** fails to be executed, run **DROP TABLESPACE IF EXISTS**.

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## Syntax

```
DROP TABLESPACE [ IF EXISTS ] tablespace_name;
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified tablespace does not exist.

- **tablespace_name**

  Specifies the name of the tablespace to be deleted.

  Value range: an existing tablespace name

## Examples

See **Examples** in **CREATE TABLESPACE**.

## Helpful Links

**12.14.32 ALTER TABLESPACE** and **12.14.81 CREATE TABLESPACE**

## Suggestions

- drop tablespace

  Do not delete tablespaces during transactions.

# 12.14.127 DROP TEXT SEARCH CONFIGURATION

## Function

**DROP TEXT SEARCH CONFIGURATION** deletes a text search configuration.

## Precautions

Only the owner of a text search configuration has the **DROP TEXT SEARCH CONFIGURATION** permission.

## Syntax

```
DROP TEXT SEARCH CONFIGURATION [ IF EXISTS ] name [ CASCADE | RESTRICT ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified text search configuration does not exist.

- **name**

  Specifies the name (optionally schema-qualified) of the text search configuration to be deleted.

- **CASCADE**

  Automatically deletes the objects that depend on the text search configuration.

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- **RESTRICT**

  Refuses to delete the text search configuration if any objects depend on it. This is the default action.

## Examples

See **Examples** in **CREATE TEXT SEARCH CONFIGURATION**.

## Helpful Links

**12.14.33 ALTER TEXT SEARCH CONFIGURATION** and **12.14.84 CREATE TEXT SEARCH CONFIGURATION**

# 12.14.128 DROP TEXT SEARCH DICTIONARY

## Function

**DROP TEXT SEARCH DICTIONARY** deletes a full-text retrieval dictionary.

## Precautions

- Predefined dictionaries do not support the **DROP** operation.
- Only the owner of a dictionary or a system administrator has the **DROP TEXT SEARCH DICTIONARY** permission.
- Execute **DROP...CASCADE** only when necessary because this operation will delete the text search configurations that use this dictionary.

## Syntax

```
DROP TEXT SEARCH DICTIONARY [ IF EXISTS ] name [ CASCADE | RESTRICT ]
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified full-text retrieval dictionary does not exist.

- **name**

  Specifies the name (optionally schema-qualified) of the full-text retrieval dictionary to be deleted. (If you do not specify a schema name, the dictionary will be deleted in the current schema by default.)

  Value range: an existing dictionary name

- **CASCADE**

  Automatically deletes the objects that depend on the full-text retrieval dictionary and other objects that depend on these objects.

  If any text search configuration uses the dictionary, the **DROP** statement will fail. You can add **CASCADE** to delete all text search configurations and dictionaries that use this dictionary.

- **RESTRICT**

  Refuses to delete the full-text retrieval dictionary if any object depends on it. This is the default action.

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## Examples

```
-- Delete the english dictionary.
DROP TEXT SEARCH DICTIONARY english;
```

## Helpful Links

12.14.34 ALTER TEXT SEARCH DICTIONARY and 12.14.85 CREATE TEXT SEARCH DICTIONARY

# 12.14.129 DROP TRIGGER

## Function

**DROP TRIGGER** deletes a trigger.

## Precautions

Only the owner of a trigger or a system administrator has the **DROP TRIGGER** permission.

## Syntax

```
DROP TRIGGER [ IF EXISTS ] trigger_name ON table_name [ CASCADE | RESTRICT ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified trigger does not exist.
- **trigger_name**

  Specifies the name of the trigger to be deleted.

  Value range: an existing trigger name
- **table_name**

  Specifies the name of the table containing the trigger.

  Value range: name of the table containing the trigger
- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects that depend on the trigger.
  - **RESTRICT**: refuses to delete the trigger if any objects depend on it. This is the default action.

## Examples

For details, see **Examples** in 12.14.86 CREATE TRIGGER.

## Helpful Links

12.14.86 CREATE TRIGGER, 12.14.35 ALTER TRIGGER, and 12.14.30 ALTER TABLE

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# 12.14.130 DROP TYPE

## Function

**DROP TYPE** deletes a user-defined data type.

## Precautions

Only the type owner or a user granted with the DROP permission can run the **DROP TYPE** command. The system administrator has this permission by default.

## Syntax

```
DROP TYPE [ IF EXISTS ] name [, ...] [ CASCADE | RESTRICT ]
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified type does not exist.

- **name**

  Specifies the name (optionally schema-qualified) of the type to be deleted.

- **CASCADE**

  Automatically deletes the objects (such as fields, functions, and operators) that depend on the type.

  **RESTRICT**

  Refuses to delete the type if any objects depend on it. This is the default action.

## Examples

See **Examples** in **CREATE TYPE**.

## Helpful Links

**12.14.87 CREATE TYPE** and **12.14.36 ALTER TYPE**

# 12.14.131 DROP USER

## Function

**DROP USER** deletes a user and the schema with the same name as the user.

## Precautions

- **CASCADE** is used to delete the objects (excluding databases) that depend on the user. **CASCADE** cannot delete locked objects unless the objects are unlocked or the processes locking the objects are killed.
- In GaussDB, the **postgresql.conf** file contains the **enable_kill_query** parameter. This parameter affects **CASCADE**.

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  - If **enable_kill_query** is **on** and **CASCADE** is used, the statement automatically kills the processes locking dependent objects and then deletes the specified user.
  - If **enable_kill_query** is **off** and **CASCADE** is used, the statement waits until the processes locking dependent objects stop and then deletes the specified user.
- If the dependent objects are other databases or reside in other databases, manually delete them before deleting the user from the current database. **DROP USER** cannot delete objects across databases.
- Before deleting a user, you need to delete all the objects owned by the user and revoke the user's permissions on other objects. Alternatively, you can specify CASCADE to delete the objects owned by the user and the granted permissions.
- In a multi-tenant scenario, the service user will also be deleted when you delete a user group. If you want to use **CASCADE**, set **CASCADE** for the service user as well. If any error is reported for one user, other users cannot be deleted either.
- If the user has an error table specified when the GDS foreign table is created, the user cannot be deleted by specifying the **CASCADE** keyword in the **DROP USER** statement.
- If a data source depends on the user, the user cannot be deleted directly. You need to manually delete the data source first.

## Syntax

```
DROP USER [ IF EXISTS ] user_name [, ...] [ CASCADE | RESTRICT ];
```

## Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified user does not exist.

- **user_name**

  Specifies the name of the user to be deleted.

  Value range: an existing username

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes objects that depend on the user and revokes the permissions granted to the user.
  - **RESTRICT**: refuses to delete a user if the user has any dependent objects or has been granted permissions on other objects. This is the default value.

    NOTE

    In GaussDB, the **postgresql.conf** file contains the **enable_kill_query** parameter. This parameter affects **CASCADE**.

    - If **enable_kill_query** is **on** and **CASCADE** is used, the statement automatically kills the processes locking dependent objects and then deletes the specified user.
    - If **enable_kill_query** is **off** and **CASCADE** is used, the statement waits until the processes locking dependent objects stop and then deletes the specified user.

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### Examples

See **Examples** in **CREATE USER**.

### Helpful Links

**12.14.37 ALTER USER** and **12.14.88 CREATE USER**

## 12.14.132 DROP VIEW

### Function

**DROP VIEW** forcibly deletes a view from the database.

### Precautions

The owner of a view, owner of the schema of the view, users granted with the DROP permission on the view, or users granted with the DROP ANY TABLE permission can run the **DROP VIEW** command. By default, the system administrator has the permission to run the command.

### Syntax

```
DROP VIEW [ IF EXISTS ] view_name [, ...] [ CASCADE | RESTRICT ];
```

### Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified view does not exist.
- **view_name**

  Specifies the name of the view to be deleted.

  Value range: an existing view name
- **CASCADE | RESTRICT**
  - **CASCADE**: automatically deletes the objects (such as other views) that depend on the view.
  - **RESTRICT**: refuses to delete the view if any objects depend on it. This is the default action.

### Examples

See **Examples** in **CREATE VIEW**.

### Helpful Links

**12.14.38 ALTER VIEW** and **12.14.89 CREATE VIEW**

## 12.14.133 DROP WORKLOAD GROUP

### Function

**DROP WORKLOAD GROUP** deletes a workload group.

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### Precautions

Only a user with the **DROP** permission on the current database can perform this operation.

### Syntax

```
DROP WORKLOAD GROUP [ IF EXISTS ] wg_name;
```

### Parameter Description

- **IF EXISTS**

  Reports a notice instead of an error if the specified workload group does not exist.

- **wg_name**

  Specifies the name of the workload group to be deleted. The workload group must be unique in a database.

  Value range: an existing workload group name

### Examples

See **Examples** in **CREATE WORKLOAD GROUP**.

### Helpful Links

**12.14.39 ALTER WORKLOAD GROUP** and **12.14.90 CREATE WORKLOAD GROUP**

## 12.14.134 DROP WEAK PASSWORD DICTIONARY

### Function

**DROP WEAK PASSWORD DICTIONARY** clears all weak passwords in **gs_global_config**.

### Precautions

Only the initial user, system administrator, and security administrator have the permission to execute this syntax.

### Syntax

```
DROP WEAK PASSWORD DICTIONARY;
```

### Description

None.

### Example

See **12.14.91 CREATE WEAK PASSWORD DICTIONARY**.

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## Helpful Links

13.14.82-CREATE WEAK PASSWORD DICTIONARY

# 12.14.135 EXECUTE

## Function

**EXECUTE** executes a prepared statement. Because a prepared statement exists only in the lifetime of the session, the prepared statement must be created earlier in the current session by using the **PREPARE** statement.

## Precautions

If the **PREPARE** statement creating the prepared statement declares some parameters, the parameter set passed to the **EXECUTE** statement must be compatible. Otherwise, an error will occur.

## Syntax

```
EXECUTE name [ ( parameter [, ...] ) ];
```

## Parameter Description

- **name**

  Specifies the name of the prepared statement to be executed.

- **parameter**

  Specifies a parameter of the prepared statement. It must be an expression that generates a value compatible with the data type of the parameter specified when the prepared statement was created.

## Examples

```
-- Create the reason table.
openGauss=# CREATE TABLE tpcds.reason (
    CD_DEMO_SK          INTEGER          NOT NULL,
    CD_GENDER           character(16)            ,
    CD_MARITAL_STATUS   character(100)
)
;

-- Insert data.
openGauss=# INSERT INTO tpcds.reason VALUES(51, 'AAAAAAAADDAAAAAA', 'reason 51');

-- Create the reason_t1 table.
openGauss=# CREATE TABLE tpcds.reason_t1 AS TABLE tpcds.reason;

-- Create a prepared statement for an INSERT statement and execute the prepared statement.
openGauss=# PREPARE insert_reason(integer,character(16),character(100)) AS INSERT INTO
tpcds.reason_t1 VALUES($1,$2,$3);

openGauss=# EXECUTE insert_reason(52, 'AAAAAAAADDAAAAAA', 'reason 52');

-- Delete the reason and reason_t1 tables.
openGauss=# DROP TABLE tpcds.reason;
openGauss=# DROP TABLE tpcds.reason_t1;
```

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# 12.14.136 EXECUTE DIRECT

## Function

**EXECUTE DIRECT** executes an SQL statement on a specified node. Generally, the execution of SQL statements is automatically allocated to proper nodes by the cluster load. **EXECUTE DIRECT** is mainly used for database maintenance and testing.

## Precautions

- When **enable_nonsysadmin_execute_direct** is **off**, only a system administrator has the **EXECUTE DIRECT** permission.
- To ensure data consistency across nodes, **EXECUTE DIRECT** can execute only **SELECT**; it cannot execute DDL, DML, or transaction statements.
- When the stddev aggregation calculation is performed on the specified DN using such statements, the result set is returned in triplet. For example, {3, 8, 30} indicates that the count result is 3, the sum result is 8, and the sum of squares is 30. When the AVG aggregation calculation is performed on the specified DN using such statements, the result set is returned in a binary tuple, for example, {4,2}. The result of count is 4, and that of sum is 2. Note: When data is stored in columns, the result of calling the AVG function is not defined. Use the **stddev_samp** function.
- When multiple nodes are specified, aggregate functions are not supported. If the query contains an aggregate function, the message "EXECUTE DIRECT on multinode not support agg functions." is returned.
- CN nodes do not store user table data. Therefore, do not execute **SELECT** for querying user tables on a CN node.
- If the SQL statement to be executed is also **EXECUTE DIRECT**, do not nest it into **EXECUTE DIRECT**; instead, directly execute the inner **EXECUTE DIRECT**.
- The query result of the **agg** function is inconsistent with that on the CN. Multiple pieces of information are returned. The **array_avg** function is not supported.

## Syntax

```
EXECUTE DIRECT ON ( nodename [, ... ] ) query ;
EXECUTE DIRECT ON { COORDINATORS | DATANODES | ALL } query;
```

## Parameter Description

- **nodename**

  Specifies the node name.

  Value range: an existing node name
- **query**

  Specifies the SQL statement to be executed.
- COORDINATORS

  Run the query statement on all CNs.
- DATANODES

  Run the query statement on all DNs.

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- ALL
  Run the query statement on all CNs and DNs.

## Examples

```
-- Query the node distribution status of the current cluster.
openGauss=# SELECT * FROM pgxc_node;
 node_name   | node_type | node_port |   node_host    | node_port1 |   node_host1   | hostis_primary |
nodeis_primary | nodeis_preferred |   node_id   | sctp_port | control_port | sctp_port1 | control_port1
-------------+-----------+-----------+---------------+------------+---------------+----------------+----------------
+------------------+-------------+-----------+--------------+------------+---------------
 cn_5001      | C         |      8050 | 10.180.155.74  |       8050 | 10.180.155.74  | t              | f              |
f                |  1120683504 |         0 |            0 |          0 |             0
 cn_5003      | C         |      8050 | 10.180.157.130 |       8050 | 10.180.157.130 | t              | f              |
f                |  -125853378 |         0 |            0 |          0 |             0
 dn_6001_6002 | D         |     40050 | 10.180.155.74  |      45050 | 10.146.187.231 | t              | f              |
f                |  1644780306 |     40052 |        40052 |      45052 |         45052
 dn_6003_6004 | D         |     40050 | 10.146.187.231 |      45050 | 10.180.157.130 | t              | f              |
f                |  -966646068 |     40052 |        40052 |      45052 |         45052
 dn_6005_6006 | D         |     40050 | 10.180.157.130 |      45050 | 10.180.155.74  | t              | f              |
f                |   868850011 |     40052 |        40052 |      45052 |         45052
 cn_5002      | C         |      8050 | localhost      |       8050 | localhost      | t              | f              | f              |
-1736975100 |         0 |            0 |          0 |             0
(6 rows)

-- Query records in the tpcds.customer_address table on dn_6001_6002.
openGauss=# EXECUTE DIRECT ON(dn_6001_6002) 'select count(*) from tpcds.customer_address';
 count
-------
 16922
(1 row)

-- Query records in the tpcds.customer_address table.
openGauss=# SELECT count(*) FROM tpcds.customer_address;
 count
-------
 50000
(1 row)
```

# 12.14.137 EXPLAIN

## Function

**EXPLAIN** shows the execution plan of an SQL statement.

The execution plan shows how the tables referenced by the statement will be scanned - by plain sequential scan, index scan, etc. - and if multiple tables are referenced, what join algorithms will be used to bring together the required rows from each input table.

The most critical part of the display is the estimated statement execution cost, which is the planner's guess at how long it will take to run the statement.

The **ANALYZE** option causes the statement to be actually executed, not only planned. The total elapsed time expended within each plan node (in milliseconds) and total number of rows it actually returned are added to the display. This is useful for seeing whether the planner's estimates are close to reality.

## Precautions

The statement is actually executed when the **ANALYZE** option is used. If you wish to use **EXPLAIN ANALYZE** on an **INSERT**, **UPDATE**, **DELETE**, **CREATE TABLE AS**, or

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**EXECUTE** statement without letting the statement affect your data, use this approach:

```
START TRANSACTION;
EXPLAIN ANALYZE ...;
ROLLBACK;
```

## Syntax

- Display the execution plan of an SQL statement, which supports multiple options and has no requirements for the order of options.

  ```
  EXPLAIN [ (  option  [, ...] )  ] statement;
  ```

  The syntax of the **option** clause is as follows:

  ```
  ANALYZE [ boolean ] |
     ANALYSE [ boolean ] |
     VERBOSE [ boolean ] |
     COSTS [ boolean ] |
     CPU [ boolean ] |
     DETAIL [ boolean ] |
     NODES [ boolean ] |
     NUM_NODES [ boolean ] |
     BUFFERS [ boolean ] |
     TIMING [ boolean ] |
     PLAN [ boolean ] |
     FORMAT { TEXT | XML | JSON | YAML }
  ```

- Display the execution plan of an SQL statement, where options are in order.

  ```
  EXPLAIN  { [  { ANALYZE  | ANALYSE  }  ] [ VERBOSE  ]  | PERFORMANCE  } statement;
  ```

## Parameter Description

- **statement**

  Specifies the SQL statement to explain.

- **ANALYZE boolean | ANALYSE boolean**

  Specifies whether to display actual run times and other statistics.

  Value range:

  - **TRUE** (default): displays them.
  - **FALSE**: does not display them.

- **VERBOSE boolean**

  Specifies whether to display additional information regarding the plan.

  Value range:

  - **TRUE** (default): displays it.
  - **FALSE**: does not display it.

- **COSTS boolean**

  Specifies whether to display the estimated total cost of each plan node, estimated number of rows, estimated width of each row.

  Value range:

  - **TRUE** (default): displays them.
  - **FALSE**: does not display them.

- **CPU boolean**

  Specifies whether to display CPU usage.

  Value range:

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  - **TRUE** (default): displays it.
  - **FALSE**: does not display it.
- **DETAIL boolean**

  Specifies whether to display DN information.

  Value range:
  - **TRUE** (default): displays it.
  - **FALSE**: does not display it.
- **NODES boolean**

  Specifies whether to display information about the nodes executed by query.

  Value range:
  - **TRUE** (default): displays it.
  - **FALSE**: does not display it.
- **NUM_NODES boolean**

  Specifies whether to display the number of executing nodes.

  Value range:
  - **TRUE** (default): displays it.
  - **FALSE**: does not display it.
- **BUFFERS boolean**

  Specifies whether to display buffer usage.

  Value range:
  - **TRUE** (default): displays it.
  - **FALSE**: does not display it.
- **TIMING boolean**

  Specifies whether to display the actual startup time and time spent on the output node.

  Value range:
  - **TRUE** (default): displays them.
  - **FALSE**: does not display them.
- **PLAN** boolean

  Specifies whether to store the execution plan in **PLAN_TABLE**. If this parameter is set to **on**, the execution plan is stored in **PLAN_TABLE** and not displayed on the screen. Therefore, this parameter cannot be used together with other parameters when it is set to **on**.

  Value range:
  - **TRUE** (default): The execution plan is stored in **PLAN_TABLE** and not displayed on the screen. If the plan is stored successfully, "EXPLAIN SUCCESS" is returned.
  - **FALSE**: The execution plan is not stored in **PLAN_TABLE** but is displayed on the screen.
- **FORMAT**

  Specifies the output format.

  Value range: **TEXT**, **XML**, **JSON**, and **YAML**

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Default value: **TEXT**

- **PERFORMANCE**

  Prints all relevant information in execution.

## Examples

```
-- Create the tpcds.customer_address_p1 table.
openGauss=# CREATE TABLE tpcds.customer_address_p1 AS TABLE tpcds.customer_address;

-- Change the value of explain_perf_mode to normal.
openGauss=# SET explain_perf_mode=normal;

-- Display an execution plan for simple queries in the table.
openGauss=# EXPLAIN SELECT * FROM tpcds.customer_address_p1;
QUERY PLAN
--------------------------------------------------
Data Node Scan  (cost=0.00..0.00 rows=0 width=0)
Node/s: All DNs
(2 rows)

-- Generate an execution plan in JSON format (with explain_perf_mode being normal).
openGauss=# EXPLAIN(FORMAT JSON) SELECT * FROM tpcds.customer_address_p1;
             QUERY PLAN
-------------------------------------
 [                             +
   {                           +
     "Plan": {                   +
       "Node Type": "Data Node Scan",+
       "Startup Cost": 0.00,       +
       "Total Cost": 0.00,         +
       "Plan Rows": 0,             +
       "Plan Width": 0,            +
       "Node/s": "All DNs"     +
     }                           +
   }                           +
 ]
(1 row)

-- If there is an index and we use a query with an indexable WHERE condition, EXPLAIN might show a
different plan.
openGauss=# EXPLAIN SELECT * FROM tpcds.customer_address_p1 WHERE ca_address_sk=10000;
QUERY PLAN
--------------------------------------------------
Data Node Scan  (cost=0.00..0.00 rows=0 width=0)
Node/s: dn_6005_6006
(2 rows)

-- Generate an execution plan in YAML format (with explain_perf_mode being normal).
openGauss=# EXPLAIN(FORMAT YAML) SELECT * FROM tpcds.customer_address_p1 WHERE
ca_address_sk=10000;
           QUERY PLAN
---------------------------------
 - Plan:                     +
     Node Type: "Data Node Scan"+
     Startup Cost: 0.00        +
     Total Cost: 0.00          +
     Plan Rows: 0              +
     Plan Width: 0             +
     Node/s: "dn_6005_6006"
(1 row)

-- Here is an example of a query plan with cost estimates suppressed:
openGauss=# EXPLAIN(COSTS FALSE)SELECT * FROM tpcds.customer_address_p1 WHERE
ca_address_sk=10000;
      QUERY PLAN
------------------------
 Data Node Scan
   Node/s: dn_6005_6006
```

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```
(2 rows)

-- Here is an example of a query plan for a query using an aggregate function:
openGauss=# EXPLAIN SELECT SUM(ca_address_sk) FROM tpcds.customer_address_p1 WHERE
ca_address_sk<10000;
                                QUERY PLAN
-----------------------------------------------------------------------------------
 Aggregate  (cost=18.19..14.32 rows=1 width=4)
   ->  Streaming (type: GATHER)  (cost=18.19..14.32 rows=3 width=4)
         Node/s: All DNs
         ->  Aggregate  (cost=14.19..14.20 rows=3 width=4)
               ->  Seq Scan on customer_address_p1  (cost=0.00..14.18 rows=10 width=4)
                     Filter: (ca_address_sk < 10000)
(6 rows)

-- Delete the tpcds.customer_address_p1 table.
openGauss=# DROP TABLE tpcds.customer_address_p1;
```

## Helpful Links

12.14.40 ANALYZE | ANALYSE

# 12.14.138 EXPLAIN PLAN

## Function

**EXPLAIN PLAN** saves information about an execution plan into the **PLAN_TABLE** table. Different from the **EXPLAIN** statement, **EXPLAIN PLAN** only saves plan information; it does not print information on the screen.

## Syntax

```
EXPLAIN PLAN
[ SET STATEMENT_ID = string ]
FOR statement ;
```

## Parameter Description

- **PLAN**: saves plan information into **PLAN_TABLE**. If information is stored successfully, "EXPLAIN SUCCESS" is returned.
- **STATEMENT_ID**: tags each query. The tag information will be stored in **PLAN_TABLE**.

  NOTE

  If **SET STATEMENT_ID** is not specified when the **EXPLAIN PLAN** statement is executed, **STATEMENT_ID** is left empty by default. In addition, the value of **STATEMENT_ID** cannot exceed 30 bytes. Otherwise, an error will be reported.

## Precautions

- **EXPLAIN PLAN** cannot be executed on DNs.
- Plan information cannot be collected for SQL statements that failed to be executed.
- Data in **PLAN_TABLE** is in a session-level lifecycle. Sessions are isolated from users, and therefore users can only view the data of the current session and current user.
- **PLAN_TABLE** cannot be joined with GDS foreign tables.

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- For a query that cannot be pushed down, object information cannot be collected and only such information as **REMOTE_QUERY** and **CTE** can be collected. For details, see **Example 2**.

## Example 1

You can perform the following steps to collect execution plans of SQL statements by running **EXPLAIN PLAN**:

**Step 1** Run the **EXPLAIN PLAN** statement.

NOTE

After the **EXPLAIN PLAN** statement is executed, plan information is automatically stored in **PLAN_TABLE**. **INSERT**, **UPDATE**, and **ANALYZE** cannot be performed on **PLAN_TABLE**.

For details about **PLAN_TABLE**, see **15.3.214 PLAN_TABLE**.

```
explain plan set statement_id='TPCH-Q4' for
select
o_orderpriority,
count(*) as order_count
from
orders
where
o_orderdate >= '1993-07-01'::date
and o_orderdate < '1993-07-01'::date + interval '3 month'
and exists (
select
*
from
lineitem
where
l_orderkey = o_orderkey
and l_commitdate < l_receiptdate
)
group by
o_orderpriority
order by
o_orderpriority;
```

**Step 2** Query **PLAN_TABLE.**

```
SELECT * FROM PLAN_TABLE;
```

```
 statement_id | plan_id  | id |      operation      |   options   | object_name | object_type | object_owner |                projection
--------------+----------+----+---------------------+-------------+-------------+-------------+--------------+-------------------------------------------
 TPCH-Q4      | 16781167 |  1 | ROW ADAPTER         |             |             |             |              | ORDERS.O_ORDERPRIORITY, (PG_CATALOG.COUNT(*))
 TPCH-Q4      | 16781167 |  2 | VECTOR SORT         |             |             |             |              | ORDERS.O_ORDERPRIORITY, (PG_CATALOG.COUNT(*))
 TPCH-Q4      | 16781167 |  3 | VECTOR AGGREGATE    | HASHED      |             |             |              | ORDERS.O_ORDERPRIORITY, PG_CATALOG.COUNT(*)
 TPCH-Q4      | 16781167 |  4 | VECTOR STREAMING    | GATHER      |             |             |              | ORDERS.O_ORDERPRIORITY, (COUNT(*))
 TPCH-Q4      | 16781167 |  5 | VECTOR AGGREGATE    | HASHED      |             |             |              | ORDERS.O_ORDERPRIORITY, COUNT(*)
 TPCH-Q4      | 16781167 |  6 | VECTOR NESTED LOOPS | SEMI        |             |             |              | ORDERS.O_ORDERPRIORITY
 TPCH-Q4      | 16781167 |  7 | TABLE ACCESS        | CSTORE SCAN | ORDERS      | TABLE       | TPCH         | ORDERS.O_ORDERPRIORITY, ORDERS.O_ORDERKEY
 TPCH-Q4      | 16781167 |  8 | VECTOR MATERIALIZE  |             |             |             |              | LINEITEM.L_ORDERKEY
 TPCH-Q4      | 16781167 |  9 | TABLE ACCESS        | CSTORE SCAN | LINEITEM    | TABLE       | TPCH         | LINEITEM.L_ORDERKEY
```

**Step 3** Delete data from **PLAN_TABLE**.

```
DELETE FROM PLAN_TABLE WHERE xxx;
```

**----End**

## Example 2

For a query that cannot be pushed down, only such information as **REMOTE_QUERY** and **CTE** can be collected from **PLAN_TABLE** after **EXPLAIN PLAN** is executed.

Scenario 1: The optimizer generates a plan for pushing down statements. In this case, only **REMOTE_QUERY** can be collected.

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```
explain plan set statement_id = 'test remote query' for
select
current_user
from
customer;
```

Query **PLAN_TABLE.**

```
SELECT * FROM PLAN_TABLE;
```

```
   statement_id    | plan_id  | id |   operation    |  options  |   object_name    | object_type  | object_owner |  projection
-------------------+----------+----+----------------+-----------+------------------+--------------+--------------+--------------
 test remote query | 29360133 |  1 | NESTED LOOPS   | CARTESIAN |                  |              |              | 'apple'::name
 test remote query | 29360133 |  2 | DATA NODE SCAN |           | customer         | REMOTE_QUERY |              |
 test remote query | 29360133 |  3 | DATA NODE SCAN |           | customer_address | REMOTE_QUERY |              |
(3 rows)
```

Scenario 2: For a query with **WITH RECURSIVE** that cannot be pushed down, only **CTE** can be collected.

Disable **enable_stream_recursive** so that the query cannot be pushed down.

```
set enable_stream_recursive = off;
```

Run the **EXPLAIN PLAN** statement.

```
explain plan set statement_id = 'cte can not be push down'
for
with recursive rq as
(
  select id, name from  chinamap where id = 11
  union all
  select origin.id, rq.name || ' > ' || origin.name
  from rq join chinamap origin on origin.pid = rq.id
)
select id, name from rq order by 1;
```

Query **PLAN_TABLE**.

```
SELECT * FROM PLAN_TABLE;
```

```
       statement_id       | plan_id  | id | operation | options | object_name | object_type | object_owner |   projection
--------------------------+----------+----+-----------+---------+-------------+-------------+--------------+----------------
 cte can not be push down | 25166071 |  1 | SORT      |         |             |             |              | rq.id, rq.name
 cte can not be push down | 25166071 |  2 | CTE SCAN  |         | rq          | CTE         |              | rq.id, rq.name
(2 rows)
```

# 12.14.139 FETCH

## Function

**FETCH** retrieves rows using a previously created cursor.

A cursor has an associated position, which is used by **FETCH**. The cursor position can be before the first row of the query result, on any particular row of the result, or after the last row of the result.

- When created, a cursor is positioned before the first row.
- After fetching some rows, the cursor is positioned on the row most recently retrieved.
- If **FETCH** runs off the end of the available rows then the cursor is left positioned after the last row, or before the first row if fetching backward.
- **FETCH ALL** or **FETCH BACKWARD ALL** will always leave the cursor positioned after the last row or before the first row.

## Precautions

- If the cursor is declared with **NO SCROLL**, backward fetches like **FETCH BACKWARD** are not allowed.

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- The forms **NEXT**, **PRIOR**, **FIRST**, **LAST**, **ABSOLUTE**, and **RELATIVE** fetch a single row after moving the cursor appropriately. If there is no such row, an empty result is returned, and the cursor is left positioned before the first row (backward fetch) or after the last row (forward fetch) as appropriate.
- The forms using **FORWARD** and **BACKWARD** retrieve the indicated number of rows moving in the forward or backward direction, leaving the cursor positioned on the last-returned row or after (backward fetch)/before (forward fetch) all rows if the **count** exceeds the number of rows available.
- **RELATIVE 0**, **FORWARD 0**, and **BACKWARD 0** all request fetching the current row without moving the cursor, that is, re-fetching the most recently fetched row. This will succeed unless the cursor is positioned before the first row or after the last row; in which case, no row is returned.
- If the cursor of **FETCH** involves a column-store table, backward fetches like **BACKWARD**, **PRIOR**, and **FIRST** are not allowed.

## Syntax

```
FETCH [ direction { FROM | IN } ] cursor_name;
```

The **direction** clause specifies optional parameters.

```
NEXT
  | PRIOR
  | FIRST
  | LAST
  | ABSOLUTE count
  | RELATIVE count
  | count
  | ALL
  | FORWARD
  | FORWARD count
  | FORWARD ALL
  | BACKWARD
  | BACKWARD count
  | BACKWARD ALL
```

## Parameter Description

- **direction_clause**

  Defines the fetch direction.

  Value range:

  - **NEXT** (default value)

    Fetches the next row.
  - PRIOR

    Fetches the prior row.
  - FIRST

    Fetches the first row of the query (same as **ABSOLUTE 1**).
  - LAST

    Fetches the last row of the query (same as **ABSOLUTE -1**).
  - ABSOLUTE count

    Fetches the *count*'th row of the query.

    **ABSOLUTE** fetches are not any faster than navigating to the desired row with a relative move: the underlying implementation must traverse all the intermediate rows anyway.

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Value range: a possibly-signed integer

- If *count* is positive, the *count*'th row of the query will be fetched. If *count* is less than the current cursor position, rewind is required, which is currently not supported.
- If *count* is negative or 0, backward scanning is required, which is currently not supported.

– RELATIVE count

Fetches the *count*'th succeeding row or the *count*'th prior row if count is negative.

Value range: a possibly-signed integer

- If *count* is positive, the *count*'th succeeding row will be fetched.
- If *count* is negative or 0, backward scanning is required, which is currently not supported.
- If the current row contains no data, **RELATIVE 0** returns null.

– count

Fetches the next *count* rows (same as **FORWARD** *count*).

– ALL

Fetches all remaining rows (same as **FORWARD ALL**).

– FORWARD

Fetches the next row (same as **NEXT**).

– FORWARD count

Fetches the next or prior *count* rows (same as **RELATIVE** *count*).

– FORWARD ALL

Fetches all remaining rows.

– BACKWARD

Fetches the prior row (same as **PRIOR**).

– BACKWARD count

Fetches the prior *count* rows (scanning backwards).

Value range: a possibly-signed integer

- If *count* is positive, *count* prior rows will be fetched.
- If *count* is a negative, *count* succeeding rows will be fetched.
- **BACKWARD 0** re-fetches the current row, if any.

– BACKWARD ALL

Fetches all prior rows (scanning backwards).

- **{ FROM | IN } cursor_name**

Specifies the cursor name using the keyword **FROM** or **IN**.

Value range: an existing cursor name

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## Examples

```
-- (For the SELECT statement, traverse a table using a cursor.) Start a transaction.
openGauss=# START TRANSACTION;

-- Set up cursor1.
openGauss=# CURSOR cursor1 FOR SELECT * FROM tpcds.customer_address ORDER BY 1;

-- Fetch the first three rows in cursor1.
openGauss=# FETCH FORWARD 3 FROM cursor1;
 ca_address_sk |  ca_address_id   | ca_street_number |    ca_street_name    | ca_street_type  | ca_suite_number
|     ca_city     |    ca_county    | ca_state |   ca_zip   |  ca_country   | ca_gmt_offset |   ca_location_type
---------------+------------------+------------------+----------------------+-----------------+-----------------
+-----------------+-----------------+----------+------------+---------------+---------------+----------------------
           1 | AAAAAAAABAAAAAAA | 18               | Jackson              | Parkway         | Suite 280       |
Fairfield       | Maricopa County | AZ       | 86192      | United States |         -7.00 | condo
           2 | AAAAAAAACAAAAAAA | 362              | Washington 6th       | RD              | Suite 80        |
Fairview        | Taos County     | NM       | 85709      | United States |         -7.00 | condo
           3 | AAAAAAAADAAAAAAA | 585              | Dogwood Washington | Circle          | Suite Q         |
Pleasant Valley | York County     | PA       | 12477      | United States |         -5.00 | single family
(3 rows)

-- Close the cursor and commit the transaction.
openGauss=# CLOSE cursor1;

-- End the transaction.
openGauss=# END;

-- (For the VALUES clause, traverse the clause using a cursor.) Start a transaction.
openGauss=# START TRANSACTION;

-- Set up cursor2.
openGauss=# CURSOR cursor2 FOR VALUES(1,2),(0,3) ORDER BY 1;

-- Fetch the first two rows in cursor2.
openGauss=# FETCH FORWARD 2 FROM cursor2;
column1 | column2
---------+---------
0 |       3
1 |       2
(2 rows)

-- Close the cursor and commit the transaction.
openGauss=# CLOSE cursor2;

-- End the transaction.
openGauss=# END;

-- (WITH HOLD cursor) Start a transaction.
openGauss=# START TRANSACTION;

-- Set up a WITH HOLD cursor.
openGauss=# DECLARE cursor1 CURSOR WITH HOLD FOR SELECT * FROM tpcds.customer_address ORDER
BY 1;

-- Fetch the first two rows in cursor1.
openGauss=# FETCH FORWARD 2 FROM cursor1;
 ca_address_sk |  ca_address_id   | ca_street_number |    ca_street_name    | ca_street_type  | ca_suite_number
|     ca_city     |    ca_county    | ca_state |   ca_zip   |  ca_country   | ca_gmt_offset |   ca_location_type
---------------+------------------+------------------+----------------------+-----------------+-----------------
+-----------------+-----------------+----------+------------+---------------+---------------+----------------------
           1 | AAAAAAAABAAAAAAA | 18               | Jackson              | Parkway         | Suite 280       |
Fairfield       | Maricopa County | AZ       | 86192      | United States |         -7.00 | condo
           2 | AAAAAAAACAAAAAAA | 362              | Washington 6th       | RD              | Suite 80        |
Fairview        | Taos County     | NM       | 85709      | United States |         -7.00 | condo
(2 rows)

-- End the transaction.
openGauss=# END;
```

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```
-- Fetch the next row in cursor1.
openGauss=# FETCH FORWARD 1 FROM cursor1;
 ca_address_sk |  ca_address_id   | ca_street_number |   ca_street_name   | ca_street_type  | ca_suite_number
|     ca_city     |    ca_county    | ca_state |   ca_zip   |  ca_country   | ca_gmt_offset |   ca_location_type
---------------+-----------------+------------------+--------------------+-----------------+-----------------
+-----------------+-----------------+----------+------------+---------------+---------------+----------------------
           3 | AAAAAAAADAAAAAAA | 585              | Dogwood Washington | Circle          | Suite Q         |
Pleasant Valley | York County     | PA       | 12477      | United States |         -5.00 | single family
(1 row)

-- Close the cursor.
openGauss=# CLOSE cursor1;
```

## Helpful Links

**12.14.45 CLOSE** and **12.14.143 MOVE**

# 12.14.140 GRANT

## Function

**GRANT** grants permissions to roles and users.

**GRANT** is used in the following scenarios:

- **Granting system permissions to roles or users**

  System permissions are also called user attributes, including **SYSADMIN**, **CREATEDB**, **CREATEROLE**, **AUDITADMIN**, **MONADMIN**, **OPRADMIN**, **POLADMIN**, **INHERIT**, **REPLICATION**, **VCADMIN**, and **LOGIN**.

  They can be specified only by the **CREATE ROLE** or **ALTER ROLE** statement. The **SYSADMIN** permissions can be granted and revoked using **GRANT ALL PRIVILEGE** and **REVOKE ALL PRIVILEGE**, respectively. System permissions cannot be inherited by a user from a role, and cannot be granted using **PUBLIC**.

- **Granting database object permissions to roles or users**

  Grant permissions on a database object (table, view, column, database, function, schema, or tablespace) to a role or user.

  **GRANT** gives specific permissions on a database object to one or more roles. These permissions are added to those already granted, if any.

  The keyword **PUBLIC** indicates that the permissions are to be granted to all roles, including those that might be created later. **PUBLIC** can be thought of as an implicitly defined group that always includes all roles. Any particular role will have the sum of permissions granted directly to it, permissions granted to any role it is presently a member of, and permissions granted to **PUBLIC**.

  If **WITH GRANT OPTION** is specified, the recipient of the permission can in turn grant it to others. Without a grant option, the recipient cannot do that. This option cannot be granted to **PUBLIC**, which is a unique GaussDB attribute.

  GaussDB grants the permissions on certain types of objects to **PUBLIC**. By default, permissions on tables, columns, sequences, foreign data sources, foreign servers, schemas, and tablespaces are not granted to **PUBLIC**, but the following permissions are granted to **PUBLIC**: **CONNECT** and **CREATE TEMP TABLE** permissions on databases, **EXECUTE** permission on functions, and

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**USAGE** permission on languages and data types (including domains). An object owner can revoke the default permissions granted to **PUBLIC** and grant permissions to other users as needed. For security purposes, you are advised to create an object and set its permissions in the same transaction so that other users do not have time windows to use the object. In addition, you can restrict the permissions of the **PUBLIC** user group by referring to t"Permission Management" in *Security Hardening Guide*. These default permissions can be modified using the **ALTER DEFAULT PRIVILEGES** command.

By default, an object owner has all permissions on the object. For security purposes, the owner can discard some permissions. However, the **ALTER**, **DROP**, **COMMENT**, **INDEX**, **VACUUM**, and re-grantable permissions of the object are inherent permissions implicitly owned by the owner.

- **Granting the permissions of one role or user to others**

  Grant the permissions of one role or user to others. In this case, every role or user can be regarded as a set of one or more database permissions.

  If **WITH ADMIN OPTION** is specified, the recipients can in turn grant the permissions to other roles or users or revoke the permissions they have granted to other roles or users. If recipients' permissions are changed or revoked later, the grantees' permissions will also change.

  Database administrators can grant or revoke permissions for any roles or users. Roles with the **CREATEROLE** permission can grant or revoke permissions for non-admin roles.

- **Granting ANY permissions to roles or users**

  Grant ANY permissions to a specified role or user. For details about the value range of the ANY permissions, see the syntax. If **WITH ADMIN OPTION** is specified, the grantee can grant the ANY permissions to or revoke them from other roles or users. The ANY permissions can be inherited by a role but cannot be granted to **PUBLIC**. An initial user and the system administrator when separation of duties is disabled can grant the ANY permissions to or revoke them from any role or user.

  Currently, the following ANY permissions are supported: **CREATE ANY TABLE**, **ALTER ANY TABLE**, **DROP ANY TABLE**, **SELECT ANY TABLE**, **INSERT ANY TABLE**, **UPDATE ANY TABLE**, **DELETE ANY TABLE**, **CREATE ANY SEQUENCE**, **CREATE ANY INDEX**, **CREATE ANY FUNCTION**, **EXECUTE ANY FUNCTION**, **CREATE ANY PACKAGE**, **EXECUTE ANY PACKAGE**, and **CREATE ANY TYPE**. For details about the ANY permission scope, see **Table 12-124**.

## Precautions

- It is not allowed to grant the ANY permissions to **PUBLIC** or revoke the ANY permissions from **PUBLIC**.
- The ANY permissions are database permissions and are valid only for database objects that are granted with the permissions. For example, **SELECT ANY TABLE** only allows a user to view all user table data in the current database, but the user does not have the permission to view user tables in other databases.
- Even if a user is granted with the ANY permissions, the user cannot perform INSERT, DELETE, UPDATE, or SELECT operations on the objects of private users.
- The ANY permissions and the original permissions do not affect each other.

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- If a user is granted with the **CREATE ANY TABLE** permission, the owner of a table created in a schema with the same name as the user is the creator of the schema. When the user performs other operations on the table, the user needs to be granted with the corresponding operation permission.
- Exercise caution when granting the CREATE ANY FUNMCTION permission to users to prevent other users from using SECURITY DEFINER functions for privilege escalation.

## Syntax

- Grant the table or view access permission to a user or role.

```
GRANT { { SELECT | INSERT | UPDATE | DELETE | TRUNCATE | REFERENCES | TRIGGER | ALTER | DROP
| COMMENT | INDEX | VACUUM } [, ...]
    | ALL [ PRIVILEGES ] }
  ON { [ TABLE ] table_name [, ...]
    | ALL TABLES IN SCHEMA schema_name [, ...] }
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the column access permission to a user or role.

```
GRANT { {{ SELECT | INSERT | UPDATE | REFERENCES | COMMENT } ( column_name [, ...] )} [, ...]
    | ALL [ PRIVILEGES ] ( column_name [, ...] ) }
  ON [ TABLE ] table_name [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the sequence access permission to a specified user or role.

```
GRANT { { SELECT | UPDATE | USAGE | ALTER | DROP | COMMENT } [, ...]
    | ALL [ PRIVILEGES ] }
  ON { [ SEQUENCE ] sequence_name [, ...]
    | ALL SEQUENCES IN SCHEMA schema_name [, ...] }
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the database access permission to a user or role.

```
GRANT { { CREATE | CONNECT | TEMPORARY | TEMP | ALTER | DROP | COMMENT } [, ...]
    | ALL [ PRIVILEGES ] }
  ON DATABASE database_name [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the domain access permission to a user or role.

```
GRANT { USAGE | ALL [ PRIVILEGES ] }
  ON DOMAIN domain_name [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

  **NOTE**

  In the current version, the domain access permission cannot be granted.

- Grant the CMK access permission to a specified user or role.

```
GRANT { { USAGE | DROP } [, ...] | ALL [ PRIVILEGES ] }
  ON { CLIENT_MASTER_KEY client_master_key
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the column encryption key (CEK) access permission to a specified user or role.

```
GRANT { { USAGE | DROP } [, ...]| ALL [ PRIVILEGES ] }
  ON { COLUMN_ENCRYPTION_KEY column_encryption_key
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the foreign data source access permission to a user or role.

```
GRANT { USAGE | ALL [ PRIVILEGES ] }
  ON FOREIGN DATA WRAPPER fdw_name [, ...]
```

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```
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the foreign server access permission to a user or role.

```
GRANT { { USAGE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON FOREIGN SERVER server_name [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the function access permission to a user or role.

```
GRANT { { EXECUTE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON { FUNCTION {function_name ( [ {[ argmode ] [ arg_name ] arg_type} [, ...] ] )} [, ...]
    | ALL FUNCTIONS IN SCHEMA schema_name [, ...] }
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the procedural procedure access permission to a user or role.

```
GRANT { { EXECUTE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON { PROCEDURE {proc_name ( [ {[ argmode ] [ arg_name ] arg_type} [, ...] ] )} [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

- Grant the procedural language access permission to a user or role.

```
GRANT { USAGE | ALL [ PRIVILEGES ] }
  ON LANGUAGE lang_name [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

**NOTE**

In the current version, all users can create C functions, whereas only users with the **sysadmin** permission can create Java and internal functions.

- When a user with the **sysadmin** permission grants the permission for creating C functions to others, the user must specify a recipient and cannot use **GRANT USAGE ON LANGUAGE C TO PUBLIC**.
- When a user with the **sysadmin** permission grants the permission for creating C functions to others, the user cannot specify **WITH GRANT OPTION**.

- Grant the sub-cluster access permission to a user or role.

```
GRANT { { CREATE | USAGE | COMPUTE | ALTER | DROP } [, ...] | ALL [ PRIVILEGES ] }
  ON NODE GROUP group_name [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

**NOTE**

When the **create** permission of a sub-cluster is granted to a specified user or role, the **usage** and **compute** permissions are granted to the specified user or role by default.

- Grant the schema access permission to a user or role.

```
GRANT { { CREATE | USAGE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON SCHEMA schema_name [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

**NOTE**

When you grant table or view permissions to other users, you also need to grant the **USAGE** permission on the schema that the tables and views belong to. Without the **USAGE** permission, the users with table or view permissions can only see the object names, but cannot access them.

- Grant the large object access permission to a specified user or role.

```
GRANT { { SELECT | UPDATE } [, ...] | ALL [ PRIVILEGES ] }
  ON LARGE OBJECT loid [, ...]
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

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> **NOTE**
>
> In the current version, the large object access permission cannot be granted.

- Grant the tablespace access permission to a user or role.

```
GRANT { { CREATE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
    ON TABLESPACE tablespace_name [, ...]
    TO { [ GROUP ] role_name | PUBLIC } [, ...]
    [ WITH GRANT OPTION ];
```

- Grant the type access permission to a user or role.

```
GRANT { { USAGE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
    ON TYPE type_name [, ...]
    TO { [ GROUP ] role_name | PUBLIC } [, ...]
    [ WITH GRANT OPTION ];
```

> **NOTE**
>
> In the current version, the type access permission cannot be granted.

- Grant the data source permission to a role.

```
GRANT { USAGE | ALL [PRIVILEGES]}
  ON DATA SOURCE src_name [, ...]
  TO { [GROUP] role_name | PUBLIC } [, ...]
  [WITH GRANT OPTION];
```

- Grant the directory permission to a role.

```
GRANT { { READ | WRITE | ALTER | DROP } [, ...] | ALL [PRIVILEGES] }
  ON DIRECTORY directory_name [, ...]
  TO { [GROUP] role_name | PUBLIC } [, ...]
  [WITH GRANT OPTION];
```

- Grant the package permission to a role.

```
GRANT { { EXECUTE | ALTER | DROP | COMMENT } [, ...] | ALL [PRIVILEGES] }
  ON PACKAGE package_name [, ...]
  TO { [GROUP] role_name | PUBLIC } [, ...]
  [WITH GRANT OPTION];
```

> **NOTE**
>
> In the current version, the package access permission cannot be granted.

- Grant a role's permissions to another user or role.

```
GRANT role_name [, ...]
  TO role_name [, ...]
  [ WITH ADMIN OPTION ];
```

- Grant the **sysadmin** permission to a role.

```
GRANT ALL { PRIVILEGES | PRIVILEGE }
  TO role_name;
```

- Grant the ANY permissions to another user or role.

```
GRANT { CREATE ANY TABLE | ALTER ANY TABLE | DROP ANY TABLE | SELECT ANY TABLE | INSERT
ANY TABLE | UPDATE ANY TABLE |
  DELETE ANY TABLE | CREATE ANY SEQUENCE | CREATE ANY INDEX | CREATE ANY FUNCTION |
EXECUTE ANY FUNCTION |
  CREATE ANY PACKAGE | EXECUTE ANY PACKAGE | CREATE ANY TYPE } [, ...]
  TO [ GROUP ] role_name [, ...]
  [ WITH ADMIN OPTION ];
```

> **NOTE**
>
> In the current version, the package access permission cannot be granted.

## Parameter Description

The possible permissions are:

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- **SELECT**

  Allows **SELECT** from any table, view, or sequence.

- **INSERT**

  Allows **INSERT** of a new row into a table.

- **UPDATE**

  Allows **UPDATE** of any column of a table. **SELECT ... FOR UPDATE** and **SELECT ... FOR SHARE** also require this permission on at least one column, in addition to the **SELECT** permission.

- **DELETE**

  Allows **DELETE** of a row from a table.

- **TRUNCATE**

  Allows **TRUNCATE** on a table.

- **REFERENCES**

  Allows creation of a foreign key constraint referencing a table. This permission is required on both referencing and referenced tables.

- **TRIGGER**

  Allows the creation of a trigger on the specified table.

- **CREATE**
  - For databases, allows new schemas to be created within the database.
  - For schemas, allows new objects to be created within the schema. To rename an existing object, you must own the object and have the **CREATE** permission on the schema of the object.
  - For tablespaces, allows tables to be created within the tablespace, and allows databases and schemas to be created that have the tablespace as their default tablespace.
  - For sub-clusters, allows tables to be created within the sub-cluster.

- **CONNECT**

  Allows the grantee to connect to the database.

- **EXECUTE**

  Allows calling a function, including use of any operators that are implemented on top of the function.

- **USAGE**
  - For procedural languages, allows use of the language for the creation of functions in that language.
  - For schemas, allows access to objects contained in the schema. Without this permission, it is still possible to see the object names.
  - For sequences, allows use of the **nextval** function.
  - For sub-clusters, allows users who can access objects contained in the schema to access tables in the sub-cluster.
  - For data sources, specifies access permissions or is used as **ALL PRIVILEGES**.
  - For a key object, **USAGE** is the permission to use the key.

- **COMPUTE**

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For computing sub-clusters, allows users to perform elastic computing in the sub-cluster that they have the compute permission on.

- **ALTER**

  Allows users to modify the attributes of a specified object, excluding the owner and schema of the object.

- **DROP**

  Allows users to delete specified objects.

- **COMMENT**

  Allows users to define or modify comments of a specified object.

- **INDEX**

  Allows users to create indexes on specified tables, manage indexes on the tables, and perform REINDEX and CLUSTER operations on the tables.

- **VACUUM**

  Allows users to perform ANALYZE and VACUUM operations on specified tables.

- **ALL PRIVILEGES**

  Grants all available permissions to a user or role at a time. Only a system administrator has the **GRANT ALL PRIVILEGES** permission.

**GRANT** parameters are as follows:

- **role_name**

  Specifies the username.

- **table_name**

  Specifies the table name.

- **column_name**

  Specifies the column name.

- **schema_name**

  Specifies the schema name.

- **database_name**

  Specifies the database name.

- **function_name**

  Specifies the function name.

- **sequence_name**

  Specifies the sequence name.

- **domain_name**

  Specifies the domain type name.

- **fdw_name**

  Specifies the foreign data wrapper name.

- **lang_name**

  Specifies the language name.

- **type_name**

  Specifies the type name.

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- **group_name**
  Specifies the sub-cluster name.
- **src_name**
  Specifies the data source name.
- **argmode**
  Specifies the parameter mode.
  Value range: a string. It must comply with the naming convention.
- **arg_name**
  Specifies the parameter name.
  Value range: a string. It must comply with the naming convention.
- **arg_type**
  Specifies the parameter type.
  Value range: a string. It must comply with the naming convention.
- **loid**
  Specifies the identifier of the large object that includes this page.
  Value range: a string. It must comply with the identifier naming convention.
- **tablespace_name**
  Specifies the tablespace name.
- client_master_key
  Name of the CMK.
  Value range: a string. It must comply with the identifier naming convention.
- column_encryption_key
  Name of the column encryption key.
  Value range: a string. It must comply with the identifier naming convention.
- **directory_name**
  Specifies the directory name.
  Value range: a string. It must comply with the identifier naming convention.
- **WITH GRANT OPTION**
  If **WITH GRANT OPTION** is specified, the recipient of the permission can in turn grant it to others. Without a grant option, the recipient cannot do that. Grant options cannot be granted to **PUBLIC**.

When a non-owner of an object attempts to GRANT permissions on the object:

- The statement will fail outright if the user has no permissions whatsoever on the object.
- As long as some permission is available, the statement will proceed, but it will grant only those permissions for which the user has grant options.
- The **GRANT ALL PRIVILEGES** forms will issue a warning message if no grant options are held, while the other forms will issue a warning if grant options for any of the permissions specifically named in the statement are not held.

**NOTE**

Database administrators can access all objects, regardless of object permission settings. It is unwise to operate as a system administrator except when necessary.

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- WITH ADMIN OPTION

  If **WITH ADMIN OPTION** is specified for a role, the grantee can grant the role to other roles or users or revoke the role from other roles or users.

  For the ANY permissions, if **WITH ADMIN OPTION** is specified, the grantee can grant the ANY permissions to or revoke them from other roles or users.

**Table 12-124** ANY permissions

| Permission | Description |
| --- | --- |
| CREATE ANY TABLE | Users can create tables or views in the public and user schemas. The users must be granted with the permission to create sequences to create a table that contains serial columns. |
| ALTER ANY TABLE | Users' **ALTER** permission on tables or views in the public and user schemas. If the users want to modify the unique index of a table to add a primary key constraint or unique constraint to the table, the users must be granted with the index permission on the table. |
| DROP ANY TABLE | Users' **DROP** permission on tables or views in the public and user schemas. |
| SELECT ANY TABLE | Users' **SELECT** permission on tables or views in the public and user schemas, which is still subject to row-level access control. |
| UPDATE ANY TABLE | Users' **UPDATE** permission on tables or views in the public and user schemas, which is still subject to row-level access control. |
| INSERT ANY TABLE | Users' **INSERT** permission on tables or views in the public and user schemas. |
| DELETE ANY TABLE | Users' **DELETE** permission on tables or views in the public and user schemas, which is still subject to row-level access control. |
| CREATE ANY FUNCTION | Users can create functions or stored procedures in the user schemas. |
| EXECUTE ANY FUNCTION | Users' **EXECUTE** permission on functions or stored procedures in the public and user schemas. |
| CREATE ANY PACKAGE | In the current version, the package access permission cannot be granted. |
| EXECUTE ANY PACKAGE | In the current version, the package access permission cannot be granted. |
| CREATE ANY TYPE | Users can create types in the public and user schemas. |
| CREATE ANY SEQUENCE | Users can create sequences in the public and user schemas. |
| CREATE ANY INDEX | Users can create indexes in the public and user schemas. The users must be granted with the permission to create tablespaces to create a partitioned table index in a tablespace. |

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NOTE

If a user is granted with any ANY permission, the user has the USAGE permission on the public and user schemas but does not have the USAGE permission on the system schemas except **public** listed in **Table 16-1**.

## Examples

**Example: Granting system permissions to a user or role**

Create the **joe** user and grant the **sysadmin** permission to it.

```
openGauss=# CREATE USER joe PASSWORD 'xxxxxxxxxx';
openGauss=# GRANT ALL PRIVILEGES TO joe;
```

Then **joe** has the **sysadmin** permission.

**Example: Granting object permissions to a user or role**

1. Revoke the **sysadmin** permission from the **joe** user. Grant the usage permission of the **tpcds** schema and all permissions on the **tpcds.reason** table to **joe**.

   ```
   openGauss=# REVOKE ALL PRIVILEGES FROM joe;
   openGauss=# GRANT USAGE ON SCHEMA tpcds TO joe;
   openGauss=# GRANT ALL PRIVILEGES ON tpcds.reason TO joe;
   ```

   Then **joe** has all permissions on the **tpcds.reason** table, including create, retrieve, update, and delete.

2. Grant the retrieve permission of **r_reason_sk**, **r_reason_id**, and **r_reason_desc** columns and the update permission of the **r_reason_desc** column in the **tpcds.reason** table to **joe**.

   ```
   openGauss=# GRANT select (r_reason_sk,r_reason_id,r_reason_desc),update (r_reason_desc) ON tpcds.reason TO joe;
   ```

   Then **joe** has the retrieve permission of **r_reason_sk** and **r_reason_id** columns in the **tpcds.reason** table. To enable **joe** to grant these permissions to other users, execute the following statement:

   ```
   openGauss=# GRANT select (r_reason_sk, r_reason_id) ON tpcds.reason TO joe WITH GRANT OPTION;
   ```

   Grant the connection and schema creation permissions of the **postgres** database to **joe**, and allow **joe** to grant these permissions to other users.

   ```
   openGauss=# GRANT create,connect on database postgres TO joe WITH GRANT OPTION;
   ```

   Create the **tpcds_manager** role, grant the access and object creation permissions of the **tpcds** schema to **tpcds_manager**, but do not allow **tpcds_manager** to grant these permissions to others.

   ```
   openGauss=# CREATE ROLE tpcds_manager PASSWORD 'xxxxxxxxxx';
   openGauss=# GRANT USAGE,CREATE ON SCHEMA tpcds TO tpcds_manager;
   ```

   Grant all permissions on the **tpcds_tbspc** tablespace to **joe**, but do not allow **joe** to grant these permissions to others.

   ```
   openGauss=# CREATE TABLESPACE tpcds_tbspc RELATIVE LOCATION 'tablespace/tablespace_1';
   openGauss=# GRANT ALL ON TABLESPACE tpcds_tbspc TO joe;
   ```

**Example: Granting the permissions of one user or role to others**

1. Create the **manager** role, grant **joe**'s permissions to **manager**, and allow **manager** to grant these permissions to others.

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```
openGauss=# CREATE ROLE manager PASSWORD 'xxxxxxxxxx';
openGauss=# GRANT joe TO manager WITH ADMIN OPTION;
```

2. Create the **senior_manager** user and grant **manager**'s permissions to it.

```
openGauss=# CREATE ROLE senior_manager PASSWORD 'xxxxxxxxxx';
openGauss=# GRANT manager TO senior_manager;
```

3. Revoke permissions and delete users.

```
openGauss=# REVOKE manager FROM joe;
openGauss=# REVOKE senior_manager FROM manager;
openGauss=# DROP USER manager;
```

**Example: Granting the CMK or CEK permission to other user or role**

1. Connect to an encrypted database.

```
gsql -p 57101 postgres -r -C
openGauss=# \! gs_ktool -g
GENERATE
1
openGauss=#  CREATE CLIENT MASTER KEY MyCMK1 WITH ( KEY_STORE = gs_ktool , KEY_PATH =
"gs_ktool/1" , ALGORITHM = AES_256_CBC);
CREATE CLIENT MASTER KEY
openGauss=# CREATE COLUMN ENCRYPTION KEY MyCEK1 WITH VALUES (CLIENT_MASTER_KEY =
MyCMK1, ALGORITHM = AEAD_AES_256_CBC_HMAC_SHA256);
CREATE COLUMN ENCRYPTION KEY
```

2. Create a role **newuser** and grant the key permission to **newuser**.

```
openGauss=# CREATE USER newuser PASSWORD 'xxxxxxxxx';
CREATE ROLE
openGauss=# GRANT ALL ON SCHEMA public TO newuser;
GRANT
openGauss=# GRANT USAGE ON COLUMN_ENCRYPTION_KEY MyCEK1 to newuser;
GRANT
openGauss=# GRANT USAGE ON CLIENT_MASTER_KEY MyCMK1 to newuser;
GRANT
```

3. Set the user to connect to a database and use a CEK to create an encrypted table.

```
openGauss=# SET SESSION AUTHORIZATION newuser PASSWORD 'xxxxxxxxx';
openGauss=>  CREATE TABLE acltest1 (x int, x2 varchar(50) ENCRYPTED WITH
(COLUMN_ENCRYPTION_KEY = MyCEK1, ENCRYPTION_TYPE = DETERMINISTIC));
NOTICE:  The 'DISTRIBUTE BY' clause is not specified. Using 'x' as the distribution column by default.
HINT:  Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
CREATE TABLE
openGauss=> SELECT has_cek_privilege('newuser', 'MyCEK1', 'USAGE');
 has_cek_privilege
-------------------
 t
(1 row)
```

4. Revoke permissions and delete users.

```
openGauss=# REVOKE USAGE ON COLUMN_ENCRYPTION_KEY MyCEK1 FROM newuser;
openGauss=# REVOKE USAGE ON CLIENT_MASTER_KEY MyCMK1 FROM newuser;
openGauss=# DROP TABLE newuser.acltest1;
openGauss=# DROP COLUMN ENCRYPTION KEY MyCEK1;
openGauss=# DROP CLIENT MASTER KEY MyCMK1;
openGauss=# DROP SCHEMA IF EXISTS newuser CASCADE;
openGauss=# REVOKE ALL ON SCHEMA public FROM newuser;
openGauss=# DROP ROLE IF EXISTS newuser;
```

**Example: Revoking permissions and deleting roles and users**

```
openGauss=# REVOKE ALL PRIVILEGES ON tpcds.reason FROM joe;
openGauss=# REVOKE ALL PRIVILEGES ON SCHEMA tpcds FROM joe;
openGauss=# REVOKE ALL ON TABLESPACE tpcds_tbspc FROM joe;
openGauss=# DROP TABLESPACE tpcds_tbspc;
openGauss=# REVOKE USAGE,CREATE ON SCHEMA tpcds FROM tpcds_manager;
openGauss=# DROP ROLE tpcds_manager;
openGauss=# DROP ROLE senior_manager;
openGauss=# DROP USER joe CASCADE;
```

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## Helpful Links

12.14.154 REVOKE and 12.14.7 ALTER DEFAULT PRIVILEGES

# 12.14.141 INSERT

## Function

**INSERT** inserts new rows into a table.

## Precautions

- The owner of a table, users granted with the **INSERT** permission on the table, or users granted with the **INSERT ANY TABLE** permission can insert data into the table. The system administrator has the permission to insert data into the table by default.
- Use of the **RETURNING** clause requires the **SELECT** permission on all columns mentioned in **RETURNING**.
- For column-store tables, the **RETURNING** clause is currently not supported.
- If **ON DUPLICATE KEY UPDATE** is used, you must have the **SELECT** and **UPDATE** permissions on the table and the **SELECT** permission on the unique constraint (primary key or unique index).
- If you use the **query** clause to insert rows from a query, you need to have the **SELECT** permission on any table or column used in the query.
- If you use the query clause to insert data from the dynamic data anonymization column, the inserted result is the anonymized value and cannot be restored.
- When you connect to a database compatible to Teradata and **td_compatible_truncation** is **on**, a long string will be automatically truncated. If later **INSERT** statements (not involving foreign tables) insert long strings to columns of char- and varchar-typed columns in the target table, the system will truncate the long strings to ensure no strings exceed the maximum length defined in the target table.

  NOTE

  If inserting multi-byte character data (such as Chinese characters) to a database with the character set byte encoding (SQL_ASCII, LATIN1), and the character data crosses the truncation position, the string is truncated based on its bytes instead of characters. Unexpected result will occur in tail after the truncation. If you want correct truncation result, you are advised to adopt encoding set such as UTF8, which has no character data crossing the truncation position.

## Syntax

```
[ WITH [ RECURSIVE ] with_query [, ...] ]
INSERT [/*+ plan_hint */] INTO table_name [ AS alias ] [ ( column_name [, ...] ) ]
    { DEFAULT VALUES
    | VALUES {( { expression | DEFAULT } [, ...] ) }[, ...]
    | query }
    [ ON DUPLICATE KEY UPDATE { NOTHING | { column_name = { expression | DEFAULT } } [, ...] [ WHERE
condition ] } ]
    [ RETURNING {* | {output_expression [ [ AS ] output_name ] }[, ...]} ];
```

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## Parameter Description

- **WITH [ RECURSIVE ] with_query [, ...]**

  Specifies one or more subqueries that can be referenced by name in the main query, which is equivalent to a temporary table.

  If **RECURSIVE** is specified, it allows a **SELECT** subquery to reference itself by name.

  Format of **with_query**:

  ```
  with_query_name [ ( column_name [, ...] ) ] AS [ [ NOT ] MATERIALIZED ]
  ( {select | values | insert | update | delete} )
  ```

  – **with_query_name** specifies the name of the result set generated by a subquery. Such names can be used to access the result sets of subqueries in a query.

  -- **column_name** specifies the column name displayed in the subquery result set.

  Each subquery can be a **SELECT**, **VALUES**, **INSERT**, **UPDATE** or **DELETE** statement.

  – You can use **MATERIALIZED** or **NOT MATERIALIZED** to modify the CTE.

  – If **MATERIALIZED** is specified, the WITH query will be materialized, and a copy of the subquery result set is generated. The copy is directly queried at the reference point. Therefore, the WITH subquery cannot be jointly optimized with the SELECT statement trunk (for example, predicate pushdown and equivalence class transfer). In this scenario, you can use **NOT MATERIALIZED** for modification. If the WITH query can be executed as a subquery inline, the preceding optimization can be performed.

  – If the user does not explicitly declare the materialized attribute, comply with the following rules: If the CTE is referenced only once in the trunk statement to which it belongs and semantically supports inline execution, it will be rewritten as subquery inline execution. Otherwise, the materialized execution will be performed in CTE Scan mode.

  NOTE

  **INSERT ON DUPLICATE KEY UPDATE** does not support the **WITH** and **WITH RECURSIVE** clauses.

- **plan_hint** clause

  Follows the **INSERT** keyword in the **/*+ */** format. It is used to optimize the plan of an **INSERT** statement block. For details, see **10.3.9 Hint-based Tuning**. In each statement, only the first **/*+** *plan_hint* ***/** comment block takes effect as a hint. Multiple hints can be written.

- **table_name**

  Specifies the name of the target table where data will be inserted.

  Value range: an existing table name

- **column_name**

  Specifies the name of a column in a table.

  – The column name can be qualified with a subfield name or array subscript, if needed.

  – Each column not present in the explicit or implicit column list will be filled with a default value, either its declared default value or **NULL** if

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there is none. Inserting into only some fields of a composite column leaves the other fields null.

- The target column names **column_name** can be listed in any order. If no list of column names is given at all, the default is all the columns of the table in their declared order.
- The target columns are the first *N* column names, if there are only *N* columns supplied by the **value** clause or **query**.
- The values provided by the **value** clause and query are associated with the corresponding columns from left to right in the table.

Value range: an existing column

- **expression**

  Specifies an expression or a value to assign to the corresponding column.

  - In the **INSERT ON DUPLICATE KEY UPDATE** statement, expression can be **VALUES(***column_name***)** or **EXCLUDED.***column_name*, indicating that the value of **column_name** corresponding to the conflict row is referenced. Note that **VALUES(***column_name***)** cannot be nested in an expression (for example, **VALUES(***column_name***)+1**). **EXCLUDED** is not subject to this restriction.
  - If single-quotation marks are inserted in a column, the single-quotation marks need to be used for escape.
  - If the expression for any column is not of the correct data type, automatic type conversion will be attempted. If the attempt fails, data insertion fails, and the system returns an error message.

- **DEFAULT**

  Specifies the default value of a field. The value is **NULL** if no default value is assigned to it.

- **query**

  Specifies a query statement (SELECT statement) that uses the query result as the inserted data.

- **RETURNING**

  Returns the inserted rows. The syntax of the **RETURNING** list is identical to that of the output list of **SELECT**. Note that **INSERT ON DUPLICATE KEY UPDATE** does not support the **RETURNING** clause.

- **output_expression**

  Specifies an expression used to calculate the output result of the **INSERT** statement after each row is inserted.

  Value range: The expression can use any field in the table. You can use the asterisk (*) to return all fields of the inserted row.

- **output_name**

  Specifies a name to use for a returned column.

  Value range: a string. It must comply with the naming convention.

- **ON DUPLICATE KEY UPDATE**

  For a table with a unique constraint (**UNIQUE INDEX** or **PRIMARY KEY**), if the inserted data violates the unique constraint, the **UPDATE** clause is executed to update the conflicting rows. If the clause of **UPDATE** is **NOTHING**, no operation will be performed.

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For a table without a unique constraint, only insert is performed.

- Triggers are not supported. The **INSERT** or **UPDATE** trigger of the target table is not fired.
- The unique constraint or primary key of **DEFERRABLE** is not supported.
- If a table has multiple unique constraints and the inserted data violates multiple unique constraints, only the first row that has a conflict is updated. (The check sequence is closely related to index maintenance. Generally, the conflict check is performed on the index that is created first.)
- Distribution columns and unique index columns cannot be updated.
- Column-store tables do not support this operation.
- The **WHERE** clause of **UPDATE** does not contain sublinks.

## Examples

```
-- Create the tpcds. reason_t2 table:
openGauss=# CREATE TABLE tpcds.reason_t2
(
  r_reason_sk    integer,
  r_reason_id    character(16),
  r_reason_desc  character(100)
);

-- Insert a record into a table:
openGauss=# INSERT INTO tpcds.reason_t2(r_reason_sk, r_reason_id, r_reason_desc) VALUES (1,
'AAAAAAAABAAAAAAA', 'reason1');

-- Insert a record into the table, which is equivalent to the previous syntax:
openGauss=# INSERT INTO tpcds.reason_t2 VALUES (2, 'AAAAAAAABAAAAAAA', 'reason2');

-- Insert multiple records into the table.
openGauss=# INSERT INTO tpcds.reason_t2 VALUES (3, 'AAAAAAAACAAAAAAA','reason3'),(4,
'AAAAAAAADAAAAAAA', 'reason4'),(5, 'AAAAAAAAEAAAAAAA','reason5');

-- Insert records whose r_reason_sk in the tpcds.reason table is less than 5:
openGauss=# INSERT INTO tpcds.reason_t2 SELECT * FROM tpcds.reason WHERE r_reason_sk <5;

-- Create a unique index for the table:
openGauss=# CREATE UNIQUE INDEX reason_t2_u_index ON tpcds.reason_t2(r_reason_sk);

-- Insert multiple records into the table. If the records conflict, update the r_reason_id field in the conflict
data row to BBBBBBBBCAAAAAAA.
openGauss=# INSERT INTO tpcds.reason_t2 VALUES (5, 'BBBBBBBBCAAAAAAA','reason5'),(6,
'AAAAAAAADAAAAAAA', 'reason6') ON DUPLICATE KEY UPDATE r_reason_id = 'BBBBBBBBCAAAAAAA';

-- Delete the tpcds.reason_t2 table.
openGauss=# DROP TABLE tpcds.reason_t2;
```

## Suggestions

VALUES

When you run the **INSERT** statement to insert data in batches, you are advised to combine multiple records into one statement to improve data loading performance. Example: **INSERT INTO sections VALUES (30, 'Administration', 31, 1900),(40, 'Development', 35, 2000), (50, 'Development' , 60 , 2001);**

If values of an insert statement are distributed on a DN, GaussDB can push the statement down to the corresponding DN for execution. Currently, only constants, simple expressions, and pushdown functions (**provolatile** in **pg_proc** is set to **'i'**)

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are supported. If a column in the table has a default value, the value must be a constant or a simple expression. Neither a single-value statement nor a multi-value statement can be pushed down to a single DN.

# 12.14.142 LOCK

## Function

**LOCK TABLE** obtains a table-level lock.

GaussDB always tries to select the lock mode with minimum constraints when automatically requesting a lock for a statement referenced by a table. Use **LOCK** if users need a more strict lock mode. For example, suppose an application runs a transaction at the Read Committed isolation level and needs to ensure that data in a table remains stable in the duration of the transaction. To achieve this, you could obtain **SHARE** lock mode over the table before the query. This will prevent concurrent data changes and ensure subsequent reads of the table see a stable view of committed data. It is because the **SHARE** lock mode conflicts with the **ROW EXCLUSIVE** lock acquired by writers, and your **LOCK TABLE name IN SHARE MODE** statement will wait until any concurrent holders of **ROW EXCLUSIVE** mode locks commit or roll back. Therefore, once you obtain the lock, there are no uncommitted writes outstanding; furthermore none can begin until you release the lock.

The kernel can automatically cancel services when the scale-out redistribution tool waits for a lock.

## Precautions

- **LOCK TABLE** is useless outside a transaction block: the lock would remain held only to the completion of the statement. If **LOCK TABLE** is out of any transaction block, an error is reported.
- If no lock mode is specified, then **ACCESS EXCLUSIVE**, the most restrictive mode, is used.
- LOCK TABLE ... **IN ACCESS SHARE MODE** requires the **SELECT** permission on the target table. All other forms of **LOCK** require table-level **UPDATE** and/or the **DELETE** permission.
- There is no **UNLOCK TABLE** statement. Locks are always released at transaction end.
- **LOCK TABLE** only deals with table-level locks, and so the mode names involving **ROW** are all misnomers. These mode names should generally be read as indicating the intention of the user to acquire row-level locks within the locked table. Also, **ROW EXCLUSIVE** mode is a shareable table lock. Note that all lock modes have the same semantics as long as LOCK TABLE is involved. The only difference lies in whether locks conflict with each other. For details about the rules, see **Table 12-125**.
- If the xc_maintenance_mode parameter is not enabled, an error is reported when an ACCESS EXCLUSIVE lock is applied for a system catalog.
- Only the redistribution tool can use the automatic CANCEL service interface.

## Syntax

```
LOCK [ TABLE ] {[ ONLY ] name [, ...]| {name [ * ]} [, ...]}
    [ IN {ACCESS SHARE | ROW SHARE | ROW EXCLUSIVE | SHARE UPDATE EXCLUSIVE | SHARE | SHARE
```

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```
ROW EXCLUSIVE | EXCLUSIVE | ACCESS EXCLUSIVE} MODE ]
    [ NOWAIT ][CANCELABLE];
```

## Parameter Description

**Table 12-125** Lock mode conflicts

| Requested Lock Mode/ Current Lock Mode | ACCESS SHARE | ROW SHARE | ROW EXCLUSIVE | SHARE UPDATE EXCLUSIVE | SHARE | SHARE ROW EXCLUSIVE | EXCLUSIVE | ACCESS EXCLUSIVE |
|---|---|---|---|---|---|---|---|---|
| ACCESS SHARE | - | - | - | - | - | - | - | X |
| ROW SHARE | - | - | - | - | - | - | X | X |
| ROW EXCLUSIVE | - | - | - | - | X | X | X | X |
| SHARE UPDATE EXCLUSIVE | - | - | - | X | X | X | X | X |
| SHARE | - | - | X | X | - | X | X | X |
| SHARE ROW EXCLUSIVE | - | - | X | X | X | X | X | X |
| EXCLUSIVE | - | X | X | X | X | X | X | X |
| ACCESS EXCLUSIVE | X | X | X | X | X | X | X | X |

**LOCK** parameters are as follows:

- **name**

  Specifies the name (optionally schema-qualified) of an existing table to lock.

  Tables are locked one-by-one in the order specified in the **LOCK TABLE** statement.

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Value range: an existing table name

- **ONLY**

  If **ONLY** is specified, only that table is locked. If **ONLY** is not specified, the table and all its sub-tables are locked.

- **ACCESS SHARE**

  Allows only read operations on a table. In general, any SQL statements that only read a table and do not modify it will acquire this lock mode. The **SELECT** statement acquires a lock of this mode on referenced tables.

- **ROW SHARE**

  Allows concurrent read of a table but does not allow any other operations on the table.

  **SELECT FOR UPDATE** and **SELECT FOR SHARE** automatically acquire the **ROW SHARE** lock on the target table and add the **ACCESS SHARE** lock to other referenced tables except **FOR SHARE** and **FOR UPDATE**.

  For a partitioned table, **SELECT FOR SHARE** obtains the **ROW EXCLUSIVE** lock of the partition object on the DN for concurrency control. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

- **ROW EXCLUSIVE**

  Allows concurrent read of a table but does not allow modification of data in the table like **ROW SHARE**. **UPDATE**, **DELETE**, and **INSERT** automatically acquire the **ROW SHARE** lock on the target table and add the **ACCESS SHARE** lock to other referenced tables. Generally, all statements that modify table data acquire the **ROW EXCLUSIVE** lock for tables.

- **SHARE UPDATE EXCLUSIVE**

  Protects a table against concurrent schema changes and **VACUUM** runs.

  The VACUUM (without FULL), ANALYZE, and CREATE INDEX CONCURRENTLY statements automatically request this lock.

- **SHARE**

  Allows concurrent queries of a table but does not allow modification of the table.

  The CREATE INDEX (without CONCURRENTLY) statement automatically requests this lock.

- **SHARE ROW EXCLUSIVE**

  Protects a table against concurrent data changes, and is self-exclusive so that only one session can hold it at a time.

  No SQL statements automatically acquire this lock mode.

- **EXCLUSIVE**

  Allows concurrent queries of the target table but does not allow any other operations.

  This mode allows only concurrent **ACCESS SHARE** locks; that is, only reads from the table can proceed in parallel with a transaction holding this lock mode.

  No SQL statements automatically acquire this lock mode on user tables. However, it will be acquired on some system catalogs in case of some operations.

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- **ACCESS EXCLUSIVE**

  Guarantees that the holder is the only transaction accessing the table in any way.

  Acquired by the **ALTER TABLE**, **DROP TABLE**, **TRUNCATE**, **REINDEX**, **CLUSTER**, and **VACUUM FULL** statements.

  This is also the default lock mode for **LOCK TABLE** statements that do not specify a mode explicitly.

- **NOWAIT**

  Specifies that LOCK TABLE does not wait for any conflicting locks to be released. If the lock cannot be obtained immediately, the command exits and an error message is displayed.

  If **NOWAIT** is not specified, **LOCK TABLE** obtains a table-level lock, waiting if necessary for any conflicting locks to be released.

- **CANCELABLE**

  Allows the waiting thread to send CANCEL signals to the holding threads and waiting threads.

  Only the redistribution tool can use this parameter. An error message is displayed when the parameter is used by users.

## Example

```
-- Obtain a SHARE lock on a primary key table when going to perform inserts into a foreign key table:
openGauss=# START TRANSACTION;

openGauss=# LOCK TABLE tpcds.reason IN SHARE MODE;

openGauss=# SELECT r_reason_desc FROM tpcds.reason WHERE r_reason_sk=5;
r_reason_desc
-----------
 Parts missing
(1 row)

openGauss=# COMMIT;

-- Obtain a SHARE ROW EXCLUSIVE lock on a primary key table when going to perform a delete operation.
openGauss=# CREATE TABLE tpcds.reason_t1 AS TABLE tpcds.reason;

openGauss=# START TRANSACTION;

openGauss=# LOCK TABLE tpcds.reason_t1 IN SHARE ROW EXCLUSIVE MODE;

openGauss=# DELETE FROM tpcds.reason_t1 WHERE r_reason_desc IN(SELECT r_reason_desc FROM
tpcds.reason_t1 WHERE r_reason_sk < 6 );

openGauss=# DELETE FROM tpcds.reason_t1 WHERE r_reason_sk = 7;

openGauss=# COMMIT;

-- Delete the tpcds.reason_t1 table.
openGauss=# DROP TABLE tpcds.reason_t1;
```

# 12.14.143 MOVE

## Function

Repositions a cursor without retrieving any data. **MOVE** works exactly like the **12.14.139 FETCH** statement, except it only repositions the cursor and does not return rows.

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## Precautions

None

## Syntax

```
MOVE [ direction [ FROM | IN ] ] cursor_name;
```

The **direction** clause specifies optional parameters.

```
NEXT
  | PRIOR
  | FIRST
  | LAST
  | ABSOLUTE count
  | RELATIVE count
  | count
  | ALL
  | FORWARD
  | FORWARD count
  | FORWARD ALL
  | BACKWARD
  | BACKWARD count
  | BACKWARD ALL
```

## Parameter Description

**MOVE** statement parameters are the same as **FETCH** statement parameters. For details, see **Parameter Description** in **FETCH**.

NOTE

On successful completion, a **MOVE** statement returns a tag of the form **MOVE count**. The **count** is the number of rows that a **FETCH** statement with the same parameters would have returned (possibly zero).

## Examples

```
-- Start a transaction.
openGauss=# START TRANSACTION;

-- Define a cursor named cursor1.
openGauss=# CURSOR cursor1 FOR SELECT * FROM tpcds.reason;

-- Skip the first three rows of cursor1:
openGauss=# MOVE FORWARD 3 FROM cursor1;

-- Fetch the first four rows from cursor1:
openGauss=# FETCH 4 FROM cursor1;
 r_reason_sk |   r_reason_id    |                                r_reason_desc
-------------+------------------
+-----------------------------------------------------------------------------------------------------
           4 | AAAAAAAAEAAAAAAA | Not the product that was
ordred
           5 | AAAAAAAAFAAAAAAA | Parts missing
           6 | AAAAAAAAGAAAAAAA | Does not work with a product that I
have
           7 | AAAAAAAAHAAAAAAA | Gift
exchange
(4 rows)

-- Close the cursor.
openGauss=# CLOSE cursor1;

-- End the transaction.
openGauss=# END;
```

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## Helpful Links

12.14.45 CLOSE and 12.14.139 FETCH

# 12.14.144 MERGE INTO

## Function

**MERGE INTO** conditionally matches data in a target table with that in a source table. If data matches, **UPDATE** is executed on the target table; if data does not match, **INSERT** is executed. You can use this syntax to run **UPDATE** and **INSERT** at a time for convenience

## Precautions

- You have the **INSERT** and **UPDATE** permissions for the target table and the **SELECT** permission for the source table.
- **MERGE INTO** cannot be executed during redistribution.
- If the source table of the **MERGE INTO** operation contains data columns that are dynamically anonymized, the result of inserting data to or updating data in the target table is the anonymized value and cannot be restored.

## Syntax

```
MERGE [/*+ plan_hint */] INTO table_name [ [ AS ] alias ]
USING { { table_name | view_name } | subquery } [ [ AS ] alias ]
ON ( condition )
[
  WHEN MATCHED THEN
  UPDATE SET { column_name = { expression | subquery | DEFAULT } |
         ( column_name [, ...] ) = ( { expression | subquery | DEFAULT } [, ...] ) } [, ...]
  [ WHERE condition ]
]
[
  WHEN NOT MATCHED THEN
  INSERT { DEFAULT VALUES |
  [ ( column_name [, ...] ) ] VALUES ( { expression | subquery | DEFAULT } [, ...] ) [, ...] [ WHERE condition ] }
];
NOTICE: 'subquery' in the UPDATE and INSERT clauses are only avaliable in CENTRALIZED mode!
```

## Parameter Description

- **plan_hint** clause

  Follows the **MERGE** keyword in the **/*+ */** format. It is used to optimize the plan of a **MERGE** statement block. For details, see **10.3.9 Hint-based Tuning**. In each statement, only the first **/*+** *plan_hint* ***/** comment block takes effect as a hint. Multiple hints can be written.

- **INTO** clause

  Specifies the target table that is being updated or has data being inserted. If the target table is a replication table, the default value of a column (such as auto-increment column) in the target table cannot be the **volatile** function. If **enable_stream_operator** is set to **off**, the target table must contain a primary key or **UNIQUE** and **NOT NULL** constraints.

  - **talbe_name**

    Specifies the name of the target table.

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  - **alias**

    Specifies the alias of the target table.

    Value range: a string. It must comply with the naming convention.

- **USING** clause

  Specifies the source table, which can be a table, view, or subquery. If the target table is a replication table, the **USING** clause cannot contain non-replication tables.

- **ON** clause

  Specifies the condition used to match data between the source and target tables. Columns in the condition cannot be updated.

- **WHEN MATCHED** clause

  Performs **UPDATE** if data in the source table matches that in the target table based on the condition.

  Distribution keys cannot be updated. System catalogs and system columns cannot be updated.

- **WHEN NOT MATCHED** clause

  Performs **INSERT** if data in the source table does not match that in the target table based on the condition.

  An **INSERT** clause can contain only one **VALUES**.

  The order of **WHEN MATCHED** and **WHEN NOT MATCHED** clauses can be reversed. One of them can be used by default, but they cannot be both used at one time. Two **WHEN MATCHED** or **WHEN NOT MATCHED** clauses cannot be specified at the same time.

- **DEFAULT**

  Specifies the default value of a column.

  The value is **NULL** if no default value is assigned to it.

- **WHERE condition**

  Specifies the conditions for the **UPDATE** and **INSERT** clauses. The two clauses will be executed only when the conditions are met. The default value can be used. System columns cannot be referenced in **WHERE condition**. You are not advised to use numeric types such as int for **condition**, because such types can be implicitly converted to bool values (non-zero values are implicitly converted to **true** and **0** is implicitly converted to **false**), which may cause unexpected results.

## Examples

```
-- Create the target table products and source table newproducts, and insert data to them.
openGauss=# CREATE TABLE products
(
product_id INTEGER,
product_name VARCHAR2(60),
category VARCHAR2(60)
);

openGauss=# INSERT INTO products VALUES (1501, 'vivitar 35mm', 'electrncs');
openGauss=# INSERT INTO products VALUES (1502, 'olympus is50', 'electrncs');
openGauss=# INSERT INTO products VALUES (1600, 'play gym', 'toys');
openGauss=# INSERT INTO products VALUES (1601, 'lamaze', 'toys');
openGauss=# INSERT INTO products VALUES (1666, 'harry potter', 'dvd');
```

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```
openGauss=# CREATE TABLE newproducts
(
product_id INTEGER,
product_name VARCHAR2(60),
category VARCHAR2(60)
);

openGauss=# INSERT INTO newproducts VALUES (1502, 'olympus camera', 'electrncs');
openGauss=# INSERT INTO newproducts VALUES (1601, 'lamaze', 'toys');
openGauss=# INSERT INTO newproducts VALUES (1666, 'harry potter', 'toys');
openGauss=# INSERT INTO newproducts VALUES (1700, 'wait interface', 'books');

-- Run MERGE INTO.
openGauss=# MERGE INTO products p
USING newproducts np
ON (p.product_id = np.product_id)
WHEN MATCHED THEN
  UPDATE SET p.product_name = np.product_name, p.category = np.category WHERE p.product_name !=
'play gym'
WHEN NOT MATCHED THEN
  INSERT VALUES (np.product_id, np.product_name, np.category) WHERE np.category = 'books';
MERGE 4

-- Query updates.
openGauss=# SELECT * FROM products ORDER BY product_id;
 product_id |  product_name  | category
------------+----------------+-----------
       1501 | vivitar 35mm   | electrncs
       1502 | olympus camera | electrncs
       1600 | play gym       | toys
       1601 | lamaze         | toys
       1666 | harry potter   | toys
       1700 | wait interface | books
(6 rows)

-- Delete the table.
openGauss=# DROP TABLE products;
openGauss=# DROP TABLE newproducts;
```

# 12.14.145 PREDICT BY

This syntax is not supported in distributed scenarios.

# 12.14.146 PREPARE

## Function

**PREPARE** creates a prepared statement.

A prepared statement is a performance optimizing object on the server. When the **PREPARE** statement is executed, the specified query is parsed, analyzed, and rewritten. When **EXECUTE** is executed, the prepared statement is planned and executed. This avoids repetitive parsing and analysis. After the **PREPARE** statement is created, it exists throughout the database session. Once it is created (even if in a transaction block), it will not be deleted when a transaction is rolled back. It can only be deleted by explicitly invoking **12.14.93 DEALLOCATE** or automatically deleted when the session ends.

## Precautions

None

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## Syntax

```
PREPARE name [ ( data_type [, ...] ) ] AS statement;
```

## Parameter Description

- **name**

  Specifies the name of a prepared statement. It must be unique in the session.

- **data_type**

  Specifies the type of an argument.

- **statement**

  Specifies a **SELECT**, **INSERT**, **UPDATE**, **DELETE**, **MERGE INTO**, or **VALUES** statement.

## Examples

See **Examples** in **EXECUTE**.

## Helpful Links

**12.14.93 DEALLOCATE**

# 12.14.147 PREPARE TRANSACTION

## Function

Prepares the current transaction for two-phase commit.

After this statement, the transaction is no longer associated with the current session; instead, its state is fully stored on disk, and there is a high probability that it can be committed successfully, even if a database crash occurs before the commit is requested.

Once prepared, a transaction can later be committed or rolled back with **12.14.49 COMMIT PREPARED** or **12.14.156 ROLLBACK PREPARED**, respectively. Those statements can be issued from any session, not only the one that executed the original transaction.

From the point of view of the issuing session, **PREPARE TRANSACTION** is not unlike a **ROLLBACK** statement: after executing it, there is no active current transaction, and the effects of the prepared transaction are no longer visible. (The effects will become visible again if the transaction is committed.)

If the **PREPARE TRANSACTION** statement fails for any reason, it becomes a **ROLLBACK** and the current transaction is canceled.

## Precautions

- The transaction function is maintained automatically by the database, and should be not visible to users.
- The distributed system does not allow users to call the customized PREPARE TRANSACTION operation.
- When running the **PREPARE TRANSACTION** statement, increase the value of **max_prepared_transactions** in configuration file **postgresql.conf**. You are

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advised to set **max_prepared_transactions** to a value not less than that of **max_connections** so that one pending prepared transaction is available for each session.

## Syntax

```
PREPARE TRANSACTION transaction_id;
```

## Parameter Description

**transaction_id**

Specifies an arbitrary identifier that later identifies this transaction for **COMMIT PREPARED** or **ROLLBACK PREPARED**. The identifier must be different from those for current prepared transactions.

Value range: The identifier must be written as a string literal, and must be less than 200 bytes long.

## Helpful Links

**12.14.49 COMMIT PREPARED** and **12.14.156 ROLLBACK PREPARED**

# 12.14.148 REASSIGN OWNED

## Function

Changes the owner of the database object.

**REASSIGN OWNED** requires that the system change owners of all the database objects owned by **old_roles** to **new_role**.

## Precautions

- **REASSIGN OWNED** is often executed before role deletion.
- To run the REASSIGN OWNED statement, you must have the permissions of the original and target roles.

## Syntax

```
REASSIGN OWNED BY old_role [, ...] TO new_role;
```

## Parameter Description

- **old_role**

  Specifies the role name of the old owner.
- **new_role**

  Specifies the role name of the new owner.

## Examples

None

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# 12.14.149 REINDEX

## Function

**REINDEX** rebuilds an index using the data stored in the index's table, replacing the old copy of the index.

There are several scenarios in which **REINDEX** can be used:

- An index has become corrupted, and no longer contains valid data.
- An index has become "bloated", that is, it contains many empty or nearly-empty pages.
- You have altered a storage parameter (such as a fill factor) for an index, and wish that the change takes full effect.

## Precautions

**REINDEX DATABASE** and **REINDEX SYSTEM** type cannot be performed in transaction blocks.

## Syntax

- Rebuild a general index.
```
REINDEX { INDEX | [INTERNAL] TABLE | DATABASE | SYSTEM } name [ FORCE ];
```
- Rebuild an index partition.
```
REINDEX  { INDEX|  [INTERNAL] TABLE} name
   PARTITION partition_name [ FORCE  ];
```

## Parameter Description

- **INDEX**

  Recreates the specified index.

- **INTERNAL TABLE**

  Recreates the Desc table index of a column-store table. The TOAST table (if any) of the table is reindexed as well.

- **TABLE**

  Recreates all indexes of a specified table. If a table has a TOAST table, the table will also be reindexed. If an index on the table has been invalidated by running **alter unusable**, the index cannot be recreated.

- **DATABASE**

  Recreates all indexes within the current database.

- **SYSTEM**

  Recreates all indexes on system catalogs within the current database. Indexes on user tables are not processed.

- **name**

  Specifies the name of the index, table, or database whose index needs to be recreated. Tables and indexes can be schema-qualified.

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> **NOTE**
>
> **REINDEX DATABASE** and **SYSTEM** can create indexes for only the current database. Therefore, **name** must be the same as the current database name.

- **FORCE**

  Discarded parameter. It is currently reserved for compatibility with earlier versions.

- **partition_name**

  Specifies the name of the partition or index partition to be recreated.

  Value range:

  - If **REINDEX INDEX** is used, specify the name of an index partition.
  - If it is **REINDEX TABLE**, specify the name of a partition.
  - If it is **REINDEX INTERNAL TABLE**, specify the name of a partition in a column-store partitioned table.

**NOTICE**

**REINDEX DATABASE** and **REINDEX SYSTEM** type cannot be performed in transaction blocks.

## Examples

```
-- Create a row-store table tpcds.customer_t1 and create an index on the c_customer_sk column in the table.
openGauss=# CREATE TABLE tpcds.customer_t1
(
    c_customer_sk             integer               not null,
    c_customer_id             char(16)              not null,
    c_current_cdemo_sk        integer                       ,
    c_current_hdemo_sk        integer                       ,
    c_current_addr_sk         integer                       ,
    c_first_shipto_date_sk    integer                       ,
    c_first_sales_date_sk     integer                       ,
    c_salutation              char(10)                      ,
    c_first_name              char(20)                      ,
    c_last_name               char(30)                      ,
    c_preferred_cust_flag     char(1)                       ,
    c_birth_day               integer                       ,
    c_birth_month             integer                       ,
    c_birth_year              integer                       ,
    c_birth_country           varchar(20)                   ,
    c_login                   char(13)                      ,
    c_email_address           char(50)                      ,
    c_last_review_date        char(10)
)
WITH (orientation = row);
DISTRIBUTE BY HASH (c_customer_sk);

openGauss=# CREATE INDEX tpcds_customer_index1 ON tpcds.customer_t1 (c_customer_sk);

openGauss=# INSERT INTO tpcds.customer_t1 SELECT * FROM tpcds.customer WHERE c_customer_sk < 10;

-- Rebuild a single index:
openGauss=# REINDEX INDEX tpcds.tpcds_customer_index1;

-- Rebuild all indexes in the tpcds.customer_t1 table:
openGauss=# REINDEX TABLE tpcds.customer_t1;
```

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```
-- Delete the tpcds.customer_t1 table:
openGauss=# DROP TABLE tpcds.customer_t1;
```

### Suggestions

- INTERNAL TABLE

  This scenario is used for fault recovery. You are not advised to perform concurrent operations.

- DATABASE

  You are not advised to reindex a database in a transaction.

- SYSTEM

  You are not advised to reindex system catalogs in transactions.

## 12.14.150 REFRESH INCREMENTAL MATERIALIZED VIEW

### Function

**REFRESH INCREMENTAL MATERIALIZED VIEW** refreshes a materialized view in materialized mode.

### Precautions

- Incremental refresh supports only incremental materialized views.
- To refresh a materialized view, you must have the SELECT permission on the base table.

### Syntax

```
REFRESH INCREMENTAL MATERIALIZED VIEW mv_name;
```

### Parameter Description

- **mv_name**

  Name of the materialized view to be refreshed.

### Examples

```
-- Create an ordinary table.
openGauss=# CREATE TABLE my_table (c1 int, c2 int);
-- Create an incremental materialized view.
openGauss=# CREATE INCREMENTAL MATERIALIZED VIEW my_imv AS SELECT * FROM my_table;
-- Write data to the base table.
openGauss=# INSERT INTO my_table VALUES(1,1),(2,2);
-- Incrementally refresh the incremental materialized view my_imv.
openGauss=# REFRESH INCREMENTAL MATERIALIZED VIEW my_imv;
```

### Helpful Links

**12.14.17 ALTER MATERIALIZED VIEW**, **12.14.63 CREATE INCREMENTAL MATERIALIZED VIEW**, **12.14.67 CREATE MATERIALIZED VIEW**, **12.14.80 CREATE TABLE**, **12.14.111 DROP MATERIALIZED VIEW**, and **12.14.151 REFRESH MATERIALIZED VIEW**

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# 12.14.151 REFRESH MATERIALIZED VIEW

## Function

**REFRESH MATERIALIZED VIEW** refreshes materialized views in full refresh mode.

## Precautions

- Full refreshing can be performed on both full and incremental materialized views.
- To refresh a materialized view, you must have the SELECT permission on the base table.

## Syntax

```
REFRESH MATERIALIZED VIEW mv_name;
```

## Parameter Description

- **mv_name**

  Name of the materialized view to be refreshed.

## Examples

```
-- Create an ordinary table.
openGauss=# CREATE TABLE my_table (c1 int, c2 int);
-- Create a full materialized view.
openGauss=# CREATE MATERIALIZED VIEW my_mv AS SELECT * FROM my_table;
-- Create an incremental materialized view.
openGauss=# CREATE INCREMENTAL MATERIALIZED VIEW my_imv AS SELECT * FROM my_table;
-- Write data to the base table.
openGauss=# INSERT INTO my_table VALUES(1,1),(2,2);
-- Fully refresh the full materialized view my_mv.
openGauss=# REFRESH MATERIALIZED VIEW my_mv;
-- Fully refresh the incremental materialized view my_imv.
openGauss=# REFRESH MATERIALIZED VIEW my_imv;
```

## Helpful Links

**12.14.17 ALTER MATERIALIZED VIEW**, **12.14.63 CREATE INCREMENTAL MATERIALIZED VIEW**, **12.14.67 CREATE MATERIALIZED VIEW**, **12.14.80 CREATE TABLE**, **12.14.111 DROP MATERIALIZED VIEW**, and **12.14.150 REFRESH INCREMENTAL MATERIALIZED VIEW**

# 12.14.152 RELEASE SAVEPOINT

## Function

Destroys a savepoint previously defined in the current transaction.

Destroying a savepoint makes it unavailable as a rollback point, but it has no other user visible behavior. It does not undo the effects of statements executed after the savepoint was established. To do that, use **ROLLBACK TO SAVEPOINT**. Destroying a savepoint when it is no longer needed allows the system to reclaim some resources earlier than transaction end.

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**RELEASE SAVEPOINT** also destroys all savepoints that were established after the named savepoint was established.

## Precautions

- Specifying a savepoint name that was not previously defined causes an error.
- It is not possible to release a savepoint when the transaction is in an aborted state.
- If multiple savepoints have the same name, only the one that was most recently defined is released.

## Syntax

```
RELEASE [ SAVEPOINT ] savepoint_name;
```

## Parameter Description

**savepoint_name**

Specifies the name of the savepoint you want to destroy.

## Examples

```
-- Create a table.
openGauss=# CREATE TABLE tpcds.table1(a int);

-- Start a transaction.
openGauss=# START TRANSACTION;

-- Insert data.
openGauss=# INSERT INTO tpcds.table1 VALUES (3);

-- Establish a savepoint.
openGauss=# SAVEPOINT my_savepoint;

-- Insert data.
openGauss=# INSERT INTO tpcds.table1 VALUES (4);

-- Delete the savepoint.
openGauss=# RELEASE SAVEPOINT my_savepoint;

-- Commit the transaction.
openGauss=# COMMIT;

-- Query the table content, which should contain both 3 and 4.
openGauss=# SELECT * FROM tpcds.table1;

-- Delete the table.
openGauss=# DROP TABLE tpcds.table1;
```

## Helpful Links

**12.14.158 SAVEPOINT** and **12.14.157 ROLLBACK TO SAVEPOINT**

# 12.14.153 RESET

## Function

Restores run-time parameters to their default values. The default values are parameter default values complied in the **postgresql.conf** configuration file.

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**RESET** is an alternative spelling for:

SET configuration_parameter TO DEFAULT

## Precautions

**RESET** and **SET** have the same transaction behavior. Their impact will be rolled back.

## Syntax

```
RESET {configuration_parameter | CURRENT_SCHEMA | TIME ZONE | TRANSACTION ISOLATION LEVEL | SESSION AUTHORIZATION | ALL };
```

## Parameter Description

- **configuration_parameter**

  Specifies the name of a settable run-time parameter.

  Value range: run-time parameters. You can view them by running the **SHOW ALL** statement.

  NOTE

  Some parameters that viewed by **SHOW ALL** cannot be set by **SET**. For example, **max_datanodes**.

- **CURRENT_SCHEMA**

  Specifies the current schema.

- **TIME ZONE**

  Specifies the time zone.

- **TRANSACTION ISOLATION LEVEL**

  Specifies the transaction isolation level.

- **SESSION AUTHORIZATION**

  Specifies the session authorization.

- **ALL**

  Resets all settable run-time parameters to default values.

## Examples

```
-- Reset timezone to the default value:
openGauss=# RESET timezone;

-- Set all parameters to their default values:
openGauss=# RESET ALL;
```

## Helpful Links

12.14.161 SET and 12.14.166 SHOW

# 12.14.154 REVOKE

## Function

**REVOKE** revokes permissions from one or more roles.

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## Precautions

If a non-owner user of an object attempts to **REVOKE** permission on the object, the statement is executed based on the following rules:

- If the user has no permissions whatsoever on the object, the statement will fail outright.
- If an authorized user has some permissions, only the permissions with authorization options are revoked.
- If the authorized user does not have the authorization option, the **REVOKE ALL PRIVILEGES** form will issue an error message. For other forms of statements, if the permission specified in the statement does not have the corresponding authorization option, the statement will issue a warning.

## Syntax

- Revoke the permission on a specified table or view.

```
REVOKE [ GRANT OPTION FOR ]
    { { SELECT | INSERT | UPDATE | DELETE | TRUNCATE | REFERENCES | ALTER | DROP | COMMENT |
INDEX | VACUUM }[, ...]
    | ALL [ PRIVILEGES ] }
    ON { [ TABLE ] table_name [, ...]
        | ALL TABLES IN SCHEMA schema_name [, ...] }
    FROM { [ GROUP ] role_name | PUBLIC } [, ...]
    [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified field in a table.

```
REVOKE [ GRANT OPTION FOR ]
    { {{ SELECT | INSERT | UPDATE | REFERENCES | COMMENT } ( column_name [, ...] )}[, ...]
    | ALL [ PRIVILEGES ] ( column_name [, ...] ) }
    ON [ TABLE ] table_name [, ...]
    FROM { [ GROUP ] role_name | PUBLIC } [, ...]
    [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified sequence.

```
REVOKE [ GRANT OPTION FOR ]
    { { SELECT | UPDATE | ALTER | DROP | COMMENT }[, ...]
    | ALL [ PRIVILEGES ] }
    ON { [ SEQUENCE ] sequence_name [, ...]
        | ALL SEQUENCES IN SCHEMA schema_name [, ...] }
    FROM { [ GROUP ] role_name | PUBLIC } [, ...]
    [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified database.

```
REVOKE [ GRANT OPTION FOR ]
    { { CREATE | CONNECT | TEMPORARY | TEMP | ALTER | DROP | COMMENT } [, ...]
    | ALL [ PRIVILEGES ] }
    ON DATABASE database_name [, ...]
    FROM { [ GROUP ] role_name | PUBLIC } [, ...]
    [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified domain.

```
REVOKE [ GRANT OPTION FOR ]
    { USAGE | ALL [ PRIVILEGES ] }
    ON DOMAIN domain_name [, ...]
    FROM { [ GROUP ] role_name | PUBLIC } [, ...]
    [ CASCADE | RESTRICT ];
```

- Revoke the specified CMK permission.

```
REVOKE [ GRANT OPTION FOR ]
    { { USAGE | DROP } [, ...] | ALL [PRIVILEGES] }
    ON CLIENT_MASTER_KEYS client_master_keys_name [, ...]
    FROM { [ GROUP ] role_name | PUBLIC } [, ...]
    [ CASCADE | RESTRICT ];
```

- Revoke the specified CEK permission.

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```
REVOKE [ GRANT OPTION FOR ]
  { { USAGE | DROP } [, ...] | ALL [PRIVILEGES]}
  ON COLUMN_ENCRYPTION_KEYS column_encryption_keys_name [, ...]
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified directory.

```
REVOKE [ GRANT OPTION FOR ]
  { { READ | WRITE | ALTER | DROP } [, ...] | ALL [ PRIVILEGES ] }
  ON DIRECTORY directory_name [, ...]
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified external data source.

```
REVOKE [ GRANT OPTION FOR ]
  { USAGE | ALL [ PRIVILEGES ] }
  ON FOREIGN DATA WRAPPER fdw_name [, ...]
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified external server.

```
REVOKE [ GRANT OPTION FOR ]
  { { USAGE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON FOREIGN SERVER server_name [, ...]
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified function.

```
REVOKE [ GRANT OPTION FOR ]
  { { EXECUTE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON { FUNCTION {function_name ( [ {[ argmode ] [ arg_name ] arg_type} [, ...] ] )} [, ...]
    | ALL FUNCTIONS IN SCHEMA schema_name [, ...] }
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified stored procedure.

```
REVOKE [ GRANT OPTION FOR ]
  { { EXECUTE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON { PROCEDURE {proc_name ( [ {[ argmode ] [ arg_name ] arg_type} [, ...] ] )} [, ...]
    | ALL PROCEDURE IN SCHEMA schema_name [, ...] }
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified procedural language.

```
REVOKE [ GRANT OPTION FOR ]
  { USAGE | ALL [ PRIVILEGES ] }
  ON LANGUAGE lang_name [, ...]
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified large object.

```
REVOKE [ GRANT OPTION FOR ]
  { { SELECT | UPDATE } [, ...] | ALL [ PRIVILEGES ] }
  ON LARGE OBJECT loid [, ...]
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified schema.

```
REVOKE [ GRANT OPTION FOR ]
  { { CREATE | USAGE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON SCHEMA schema_name [, ...]
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified tablespace.

```
REVOKE [ GRANT OPTION FOR ]
  { { CREATE  | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
  ON TABLESPACE tablespace_name [, ...]
  FROM { [ GROUP ] role_name | PUBLIC } [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified type.

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```
REVOKE [ GRANT OPTION FOR ]
  { { USAGE | ALTER | DROP | COMMENT } [, ...] | ALL [ PRIVILEGES ] }
   ON TYPE type_name [, ...]
   FROM { [ GROUP ] role_name | PUBLIC } [, ...]
   [ CASCADE | RESTRICT ];
```

- Revoke the permission on a specified sub-cluster.

```
REVOKE [ GRANT OPTION FOR ]
   { { CREATE | USAGE | COMPUTE  | ALTER | DROP } [, ...] | ALL [ PRIVILEGES ] }
   ON NODE GROUP group_name [, ...]
   FROM { [ GROUP ] role_name | PUBLIC } [, ...]
   [ CASCADE | RESTRICT ];
```

  NOTE

  When the **create** permission on a sub-cluster is revoked, the **usage** and **compute** permissions are revoked by default.

- Revoke the permission on a data source object.

```
REVOKE [ GRANT OPTION FOR ]
  { USAGE | ALL [PRIVILEGES] }
   ON DATA SOURCE src_name [, ...]
   FROM {[GROUP] role_name | PUBLIC} [, ...]
   [ CASCADE | RESTRICT ];
```

- Revoke the permission on a directory object.

```
REVOKE [ GRANT OPTION FOR ]
  { { READ | WRITE } [, ...] | ALL [PRIVILEGES] }
  ON DIRECTORY directory_name [, ...]
  FROM {[GROUP] role_name | PUBLIC} [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke the permission on a package object.

```
REVOKE [ GRANT OPTION FOR ]
  { { EXECUTE | ALTER | DROP | COMMENT } [, ...] | ALL [PRIVILEGES] }
  ON PACKAGE package_name [, ...]
  FROM {[GROUP] role_name | PUBLIC} [, ...]
  [ CASCADE | RESTRICT ];
```

- Revoke permissions from a role.

```
REVOKE [ ADMIN OPTION FOR ]
   role_name [, ...] FROM role_name [, ...]
   [ CASCADE | RESTRICT ];
```

- Revoke the sysadmin permission from a role.

```
REVOKE ALL { PRIVILEGES | PRIVILEGE } FROM role_name;
```

- Revoke the ANY permissions.

```
REVOKE [ ADMIN OPTION FOR ]
 { CREATE ANY TABLE | ALTER ANY TABLE | DROP ANY TABLE | SELECT ANY TABLE | INSERT ANY
TABLE | UPDATE ANY TABLE |
 DELETE ANY TABLE | CREATE ANY SEQUENCE | CREATE ANY INDEX | CREATE ANY FUNCTION |
EXECUTE ANY FUNCTION |
 CREATE ANY PACKAGE | EXECUTE ANY PACKAGE | CREATE ANY TYPE } [, ...]
 FROM [ GROUP ] role_name [, ...];
```

## Parameter Description

The keyword **PUBLIC** indicates an implicitly defined group that has all roles.

For details about permission types and parameters, see section "GRANT".

Permissions of a role include the permissions directly granted to the role, permissions inherited from the parent role, and permissions granted to **PUBLIC**. Therefore, revoking the **SELECT** permission for an object from **PUBLIC** does not necessarily mean that the **SELECT** permission for the object has been revoked from all roles, because the **SELECT** permission directly granted to roles and inherited from parent roles remains. Similarly, if the **SELECT** permission is revoked

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from a user but is not revoked from **PUBLIC**, the user can still run the **SELECT** statement.

If **GRANT OPTION FOR** is specified, the permission cannot be granted to others, but permission itself is not revoked.

If user A holds the **UPDATE** permissions on a table and the **WITH GRANT OPTION** and has granted them to user B, the permissions that user B holds are called dependent permissions. If the permissions or the grant option held by user A is revoked, the dependent permissions still exist. Those dependent permissions are also revoked if **CASCADE** is specified.

A user can only revoke permissions that were granted directly by that user. For example, if user A has granted permission with grant option (**WITH ADMIN OPTION**) to user B, and user B has in turn granted it to user C, then user A cannot revoke the permission directly from C. However, user A can revoke the grant option held by user B and use **CASCADE**. In this way, the permission of user C is automatically revoked. For another example, if both user A and user B have granted the same permission to C, A can revoke his own grant but not B's grant, so C will still effectively have the permission.

If the role executing **REVOKE** holds permissions indirectly via more than one role membership path, it is unspecified which containing role will be used to execute the statement. In such cases, you are advised to use **SET ROLE** to become the specific role you want to do the **REVOKE** as, and then execute REVOKE. Failure to do so may lead to deleting permissions not intended to delete, or not deleting any permissions at all.

## Examples

See **Examples** in section "GRANT".

## Helpful Links

**12.14.140 GRANT**

# 12.14.155 ROLLBACK

## Function

**ROLLBACK** rolls back the current transaction and backs out all updates in the transaction.

**ROLLBACK** backs out of all changes that a transaction makes to a database if the transaction fails to be executed due to a fault.

## Precautions

If a **ROLLBACK** statement is executed out of a transaction, no error occurs, but a notice is displayed.

## Syntax

```
ROLLBACK [ WORK | TRANSACTION ];
```

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## Parameter Description

**WORK | TRANSACTION**

Specifies the optional keyword that more clearly illustrates the syntax.

## Examples

```
-- Start a transaction.
openGauss=# START TRANSACTION;

-- Back out all changes.
openGauss=# ROLLBACK;
```

## Helpful Links

**12.14.48 COMMIT | END**

# 12.14.156 ROLLBACK PREPARED

## Function

Cancels a transaction ready for two-phase committing.

## Precautions

- The function is only available in maintenance mode (when GUC parameter **xc_maintenance_mode** is **on**). Exercise caution when enabling the mode. It is used by maintenance engineers for troubleshooting. Common users should not use the mode.
- Only the user that initiates a transaction or the system administrator can roll back the transaction.
- The transaction function is maintained automatically by the database, and should be not visible to users.

## Syntax

```
ROLLBACK PREPARED transaction_id ;
```

## Parameter Description

**transaction_id**

Specifies the identifier of the transaction to be committed. The identifier must be different from those for current prepared transactions.

## Helpful Links

**12.14.49 COMMIT PREPARED** and **12.14.147 PREPARE TRANSACTION**

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# 12.14.157 ROLLBACK TO SAVEPOINT

## Function

Rolls back to a savepoint. It implicitly destroys all savepoints that were established after the named savepoint.

Rolls back all statements that were executed after the savepoint was established. The savepoint remains valid and can be rolled back to again later, if needed.

## Precautions

- Specifying a savepoint name that has not been established is an error.
- Cursors have somewhat non-transactional behavior with respect to savepoints. Any cursor that is opened inside a savepoint will be closed when the savepoint is rolled back. If a previously opened cursor is affected by a **FETCH** or **MOVE** statement inside a savepoint that is later rolled back, the cursor remains at the position that **FETCH** left it pointing to (that is, the cursor motion caused by **FETCH** is not rolled back). Closing a cursor is not undone by rolling back, either. A cursor whose execution causes a transaction to abort is put in a cannot-execute state, so while the transaction can be restored using **ROLLBACK TO SAVEPOINT**, the cursor can no longer be used.
- Use **ROLLBACK TO SAVEPOINT** to roll back to a savepoint. Use **RELEASE SAVEPOINT** to destroy a savepoint but keep the effects of the statements executed after the savepoint was established.

## Syntax

```
ROLLBACK [ WORK | TRANSACTION ] TO [ SAVEPOINT ] savepoint_name;
```

## Parameter Description

savepoint_name

Rolls back to a savepoint.

## Examples

```
-- Undo the effects of the statements executed after my_savepoint was established:
openGauss=# START TRANSACTION;
openGauss=# SAVEPOINT my_savepoint;
openGauss=# ROLLBACK TO SAVEPOINT my_savepoint;
-- Cursor positions are not affected by savepoint rollback.
openGauss=# DECLARE foo CURSOR FOR SELECT 1 UNION SELECT 2;
openGauss=# SAVEPOINT foo;
openGauss=# FETCH 1 FROM foo;
 ?column?
----------
        1
openGauss=# ROLLBACK TO SAVEPOINT foo;
openGauss=# FETCH 1 FROM foo;
 ?column?
----------
        2
openGauss=# RELEASE SAVEPOINT my_savepoint;
openGauss=# COMMIT;
```

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## Helpful Links

12.14.158 SAVEPOINT and 12.14.152 RELEASE SAVEPOINT

# 12.14.158 SAVEPOINT

## Function

**SAVEPOINT** establishes a new savepoint within the current transaction.

A savepoint is a special mark inside a transaction. It allows all statements that are executed after it was established to be rolled back, restoring the transaction state to what it was at the time of the savepoint.

## Precautions

- Use **ROLLBACK TO SAVEPOINT** to roll back to a savepoint. Use **RELEASE SAVEPOINT** to destroy a savepoint but keep the effects of the statements executed after the savepoint was established.
- Savepoints can only be established when inside a transaction block. Multiple savepoints can be defined in a transaction.
- In the case of an unexpected termination of a distributed thread or process caused by a node or connection failure, or of an error caused by the inconsistency between source and destination table structures in a COPY FROM operation, the transaction cannot be rolled back to the established savepoint. Instead, the entire transaction will be rolled back.
- According to the SQL standard, when a savepoint with the same name is created, the previous savepoint with the same name is automatically deleted. In GaussDB, the old savepoint is retained, but only the latest one is used during rollback or release. Releasing the newer savepoint with **RELEASE SAVEPOINT** will cause the older one to again become accessible to **ROLLBACK TO SAVEPOINT** and **RELEASE SAVEPOINT**. In addition, **SAVEPOINT** fully complies with the SQL standard.

## Syntax

```
SAVEPOINT savepoint_name;
```

## Parameter Description

savepoint_name

Specifies the name of the new savepoint.

## Examples

```
-- Create a table.
openGauss=# CREATE TABLE table1(a int);

-- Start a transaction.
openGauss=# START TRANSACTION;

-- Insert data.
openGauss=# INSERT INTO table1 VALUES (1);

-- Create a savepoint.
```

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```
openGauss=# SAVEPOINT my_savepoint;

-- Insert data.
openGauss=# INSERT INTO table1 VALUES (2);

-- Roll back the savepoint.
openGauss=# ROLLBACK TO SAVEPOINT my_savepoint;

-- Insert data.
openGauss=# INSERT INTO table1 VALUES (3);

-- Commit the transaction.
openGauss=# COMMIT;

-- Query the content of the table. You can see 1 and 3 at the same time, but cannot see 2 because 2 is
rolled back.
openGauss=# SELECT * FROM table1;

-- Delete the table.
openGauss=# DROP TABLE table1;

-- Create a table.
openGauss=# CREATE TABLE table2(a int);

-- Start a transaction.
openGauss=# START TRANSACTION;

-- Insert data.
openGauss=# INSERT INTO table2 VALUES (3);

-- Create a savepoint.
openGauss=# SAVEPOINT my_savepoint;

-- Insert data.
openGauss=# INSERT INTO table2 VALUES (4);

-- Roll back the savepoint.
openGauss=# RELEASE SAVEPOINT my_savepoint;

-- Commit the transaction.
openGauss=# COMMIT;

-- Query the table content. You can see 3 and 4 at the same time.
openGauss=# SELECT * FROM table2;

-- Delete the table.
openGauss=# DROP TABLE table2;
```

## Helpful Links

**12.14.152 RELEASE SAVEPOINT** and **12.14.157 ROLLBACK TO SAVEPOINT**

# 12.14.159 SELECT

## Function

**SELECT** retrieves data from a table or view.

Serving as an overlaid filter for a database table, **SELECT** filters required data from the table using SQL keywords.

## Precautions

- The owner of a table, users granted with the **SELECT** permission on the table, or users granted with the **SELECT ANY TABLE** permission can read data in the

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table or view. The system administrator has the permission to read data in the table or view by default.

- Using **SELECT** can join ordinary tables, but cannot join ordinary and GDS foreign tables. That is, the **SELECT** statement cannot contain both an ordinary table and a GDS foreign table.
- You must have the **SELECT** permission on each field used in the SELECT statement.
- **UPDATE** permission is required when **FOR UPDATE** or **FOR SHARE** is used.

## Syntax

- Querying Data

```
[ WITH [ RECURSIVE ] with_query [, ...] ]
SELECT [/*+ plan_hint */] [ ALL | DISTINCT [ ON ( expression [, ...] ) ] ]
   { * | {expression [ [ AS ] output_name ]} [, ...] }
   [ FROM from_item [, ...] ]
   [ WHERE condition ]
   [ GROUP BY grouping_element [, ...] ]
   [ HAVING condition [, ...] ]
   [ WINDOW {window_name AS ( window_definition )} [, ...] ]
   [ { UNION | INTERSECT | EXCEPT | MINUS } [ ALL | DISTINCT ] select ]
   [ ORDER BY {expression [ [ ASC | DESC | USING operator ] | nlssort_expression_clause ] [ NULLS { FIRST |
LAST } ]} [, ...] ]
   [ LIMIT { [offset,] count | ALL } ]
   [ OFFSET start [ ROW | ROWS ] ]
   [ FETCH { FIRST | NEXT } [ count ] { ROW | ROWS } ONLY ]
   [ {FOR { UPDATE | SHARE } [ OF table_name [, ...] ] [ NOWAIT | WAIT N]} [...] ]
TABLE { ONLY { (table_name) | table_name } | table_name [ * ]};
```

**NOTE**

In condition and expression, you can use the aliases of expressions in **targetlist** in compliance with the following rules:

- Reference only within the same level.
- Only reference aliases in **targetlist**.
- Reference a prior expression in a subsequent expression.
- The **volatile** function cannot be used.
- The **Window** function cannot be used.
- Aliases cannot be referenced in the **join on** condition.
- An error is reported if **targetlist** contains multiple referenced aliases.

- The subquery **with_query** is as follows:

```
with_query_name [ ( column_name [, ...] ) ]
   AS [ [ NOT ] MATERIALIZED ] ( {select | values | insert | update | delete} )
```

- The specified query source **from_item** is as follows:

```
{[ ONLY ] table_name [ * ] [ partition_clause ] [ [ AS ] alias [ ( column_alias [, ...] ) ] ]
[ TABLESAMPLE sampling_method ( argument [, ...] ) [ REPEATABLE ( seed ) ] ]
|( select ) [ AS ] alias [ ( column_alias [, ...] ) ]
|with_query_name [ [ AS ] alias [ ( column_alias [, ...] ) ] ]
|function_name ( [ argument [, ...] ] ) [ AS ] alias [ ( column_alias [, ...] | column_definition [, ...] ) ]
|function_name ( [ argument [, ...] ] ) AS ( column_definition [, ...] )
|from_item [ NATURAL ] join_type from_item [ ON join_condition | USING ( join_column [, ...] ) ]}
```

- The **group** clause is as follows:

```
( )
| expression
| ( expression [, ...] )
| ROLLUP ( { expression | ( expression [, ...] ) } [, ...] )
| CUBE ( { expression | ( expression [, ...] ) } [, ...] )
| GROUPING SETS ( grouping_element [, ...] )
```

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- The specified partition **partition_clause** is as follows:
```
PARTITION { ( partition_name ) |
      FOR (  partition_value [, ...] ) }
```

  NOTE

  The specified partition applies only to ordinary tables.

- The sorting order **nlssort_expression_clause** is as follows:
```
NLSSORT ( column_name, ' NLS_SORT = { SCHINESE_PINYIN_M | generic_m_ci } ' )
```
  The second parameter can be **generic_m_ci**, which supports only the case-insensitive order for English characters.
- Simplified query syntax, equivalent to **select * from table_name**.
```
TABLE { ONLY {(table_name)| table_name} | table_name [ * ]};
```

## Parameter Description

- **WITH [ RECURSIVE ] with_query [, ...]**

  Specifies one or more subqueries that can be referenced by name in the main query, which is equivalent to a temporary table.

  If **RECURSIVE** is specified, it allows a **SELECT** subquery to reference itself by name.

  The detailed format of **with_query** is as follows: **with_query_name [ ( column_name [, ...] ) ] AS [ [ NOT ] MATERIALIZED ] ( {select | values | insert | update | delete} )**

  - **with_query_name** specifies the name of the result set generated by a subquery. Such names can be used to access the result sets of subqueries in a query.
  - **column_name** specifies the column name displayed in the subquery result set.
  - Each subquery can be a **SELECT**, **VALUES**, **INSERT**, **UPDATE** or **DELETE** statement.
  - You can use **MATERIALIZED** or **NOT MATERIALIZED** to modify the CTE. Currently, only inline execution is supported for stream plans. In this case, this syntax does not take effect.
    - If **MATERIALIZED** is specified, the WITH query will be materialized, and a copy of the subquery result set is generated. The copy is directly queried at the reference point. Therefore, the WITH subquery cannot be jointly optimized with the SELECT statement trunk (for example, predicate pushdown and equivalence class transfer). In this scenario, you can use **NOT MATERIALIZED** for modification. If the WITH query can be executed as a subquery inline, the preceding optimization can be performed.
    - If the user does not explicitly declare the materialized attribute, comply with the following rules: If the CTE is referenced only once in the SELECT statement trunk to which it belongs and semantically supports inline execution, it will be rewritten as subquery inline execution. Otherwise, the materialized execution will be performed in CTE Scan mode.
- **plan_hint** clause

  Follows the **SELECT** keyword in the /*+<*Plan hint*> */ format. It is used to optimize the plan of a **SELECT** statement block. For details, see **10.3.9 Hint-**

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based Tuning. In each statement, only the first **/*+** *plan_hint* ***/** comment block takes effect as a hint. Multiple hints can be written.

- **ALL**

  Specifies that all rows that meet the conditions are returned. This is the default behavior and can be omitted.

- **DISTINCT [ ON ( expression [, ...] ) ]**

  Removes all duplicate rows from the **SELECT** result set so one row is kept from each group of duplicates.

  Retains only the first row in the set of rows that have the same result calculated on the given expression.

  **NOTICE**

  **DISTINCT ON** expression is explained with the same rule of **ORDER BY**. Unless you use **ORDER BY** to ensure that the required row appears first, you cannot know what the first row is.

- **SELECT list**

  Specifies the name of a column in the table to be queried. The value can be a part of the column name or all of the column names. The wildcard (*) is used to represent the column name.

  You may use the **AS output_name** clause to give an alias for an output column. The alias is used for the displaying of the output column. The name, value, and type keywords can be used as column aliases.

  Column names can be expressed in the following formats:

  – Manually input column names which are spaced using commas (,).
  – Columns computed in the **FROM** clause.

- **FROM clause**

  Specifies one or more source tables for **SELECT**.

  The **FROM** clause can contain the following elements:

  – table_name

    Specifies the name of a table or view. The schema name can be added before the table name or view name, for example, schema_name.table_name.

  – alias

    Gives a temporary alias to a table to facilitate the quotation by other queries.

    An alias is used for brevity or to eliminate ambiguity for self-joins. If an alias is provided, it completely replaces the actual name of the table.

  – TABLESAMPLE *sampling_method* ( *argument* [, ...] ) [ REPEATABLE ( *seed* ) ]

    The **TABLESAMPLE** clause following *table_name* specifies that the specified *sampling_method* should be used to retrieve the subset of rows in the table.

    The optional **REPEATABLE** clause specifies the number of seeds used to generate random numbers in the sampling method. The seed value can

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be any non-null constant value. If the table was not changed during the query, the two queries having the same seed and *argument* values will select the same sampling in this table. However, different seed values usually generate different samples. If **REPEATABLE** is not specified, a new random sample will be selected for each query based on the seed generated by the system.

- column_alias

  Specifies the column alias.

- PARTITION

  Queries data in the specified partition in a partitioned table.

- partition_name

  Specifies the name of a partition.

- partition_value

  Specifies the value of the specified partition key. If there are many partition keys, use the **PARTITION FOR** clause to specify the value of the only partition key you want to use.

- subquery

  Performs a subquery in the **FROM** clause. A temporary table is created to save subquery results.

- with_query_name

  Specifies that the **WITH** clause can also be used as the source of the **FROM** clause and can be referenced by the name of the **WITH** query.

- function_name

  Function name Function calls can appear in the **FROM** clause.

- join_type

  The options are as follows:

  - [ INNER ] JOIN

    A **JOIN** clause combines two **FROM** items. You can use parentheses to determine the order of nesting. In the absence of parentheses, **JOIN** nests left-to-right.

    In any case, **JOIN** binds more tightly than the commas separating **FROM** items.

  - LEFT [ OUTER ] JOIN

    Returns all rows that meet join conditions in the Cartesian product, plus those rows that do not match the right table rows in the left table by join conditions. This left-hand row is extended to the full width of the joined table by inserting **NULL** values for the right-hand columns. Note that only the **JOIN** clause's own condition is considered while the system decides which rows have matches. Outer conditions are applied afterward.

  - RIGHT [ OUTER ] JOIN

    Returns all the joined rows, plus one row for each unmatched right-hand row (extended with **NULL** on the left).

    This is just a notational convenience, since you could convert it to a **LEFT OUTER JOIN** by switching the left and right inputs.

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- FULL [ OUTER ] JOIN

  Returns all the joined rows, pluses one row for each unmatched left-hand row (extended with **NULL** on the right), and pluses one row for each unmatched right-hand row (extended with **NULL** on the left).

- CROSS JOIN

  Is equivalent to **INNER JOIN ON (TRUE)**, which means no rows are removed by qualification. These join types are just a notational convenience, since they do nothing you could not do with plain **FROM** and **WHERE**.

  NOTE

  For the **INNER** and **OUTER** join types, a join condition must be specified, namely exactly one of **NATURAL ON**, **join_condition**, or **USING (join_column [, ...])**. For **CROSS JOIN**, none of these clauses can appear.

**CROSS JOIN** and **INNER JOIN** produce a simple Cartesian product, the same result as you get from listing the two items at the top level of **FROM**.

– ON join_condition

  Defines which rows have matches in joins. Example: ON left_table.a = right_table.a You are not advised to use numeric types such as int for **join_condition**, because such types can be implicitly converted to bool values (non-zero values are implicitly converted to **true** and **0** is implicitly converted to **false**), which may cause unexpected results.

– USING(join_column[, ...])

  ON left_table.a = right_table.a AND left_table.b = right_table.b ... abbreviation. Corresponding columns must have the same name.

– NATURAL

  Is a shorthand for a **USING** list that mentions all columns in the two tables that have the same names.

– from item

  Specifies the name of the query source object connected.

- **WHERE clause**

  Forms an expression for row selection to narrow down the query range of **SELECT**. **condition** indicates any expression that returns a value of Boolean type. Rows that do not meet this condition will not be retrieved. You are not advised to use numeric types such as int for **condition**, because such types can be implicitly converted to bool values (non-zero values are implicitly converted to **true** and **0** is implicitly converted to **false**), which may cause unexpected results.

  In the **WHERE** clause, you can use the operator (+) to convert a table join to an outer join. However, this method is not recommended because it is not the standard SQL syntax and may raise syntax compatibility issues during platform migration. There are many restrictions on using the operator (+):

  a. It can appear only in the **WHERE** clause.
  b. If a table join has been specified in the **FROM** clause, the operator (+) cannot be used in the **WHERE** clause.

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c. The operator (+) can work only on columns of tables or views, instead of on expressions.

d. If table A and table B have multiple join conditions, the operator (+) must be specified in all the conditions. Otherwise, the operator (+) will not take effect, and the table join will be converted into an inner join without any prompt information.

e. Tables specified in a join condition where the operator (+) works cannot cross queries or subqueries. If tables where the operator (+) works are not in the **FROM** clause of the current query or subquery, an error will be reported. If a peer table for the operator (+) does not exist, no error will be reported and the table join will be converted into an inner join.

f. Expressions where the operator (+) is used cannot be directly connected through **OR**.

g. If a column where the operator (+) works is compared with a constant, the expression becomes a part of the join condition.

h. A table cannot have multiple foreign tables.

i. The operator (+) can appear only in the following expressions: comparison, NOT, ANY, ALL, IN, NULLIF, IS DISTINCT FROM, and IS OF. It is not allowed in other types of expressions. In addition, these expressions cannot be connected through **AND** or **OR**.

j. The operator (+) can be used to convert a table join only to a left or right outer join, instead of a full join. That is, the operator (+) cannot be specified on both tables of an expression.

**NOTICE**

For the **WHERE** clause, if special character "%", "_", or "\" is queried in **LIKE**, add the slash "\" before each character.

- **GROUP BY clause**

  Condenses query results into a single row all selected rows that share the same values for the grouped expressions.

  – CUBE ( { expression | ( expression [, ...] ) } [, ...] )

    A CUBE grouping is an extension to the GROUP BY clause that creates subtotals for all of the possible combinations of the given list of grouping columns (or expressions). In terms of multidimensional analysis, CUBE generates all the subtotals that could be calculated for a data cube with the specified dimensions. Notice that n elements of a CUBE translate to 2n grouping sets. For example, if the CUBE clause contains three expressions (n = 3), the number of result sets = $2^n = 2^3 = 8$ groups. Rows grouped on the values of *n* expressions are called regular rows, and the rest are called superaggregate rows.

  – GROUPING SETS ( grouping_element [, ...] )

    Is another extension to the **GROUP BY** clause. It allows users to specify multiple **GROUP BY** clauses. This improves efficiency by trimming away unnecessary data. After you specify the set of groups that you want to create using a **GROUPING SETS** expression within a **GROUP BY** clause, the database does not need to compute a whole **ROLLUP** or **CUBE**.

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NOTICE

If the **SELECT** list expression quotes some ungrouped fields and no aggregate function is used, an error is displayed. This is because multiple values may be returned for ungrouped fields.

- **HAVING clause**

  Selects special groups by working with the **GROUP BY** clause. The **HAVING** clause compares some attributes of groups with a constant. Only groups that matching the logical expression in the **HAVING** clause are extracted.

- **WINDOW clause**

  The general format is **WINDOW window_name AS ( window_definition ) [, ...]**. **window_name** is a name can be referenced by **window_definition**. **window_definition** can be expressed in the following forms:

  [ existing_window_name ]

  [ PARTITION BY expression [, ...] ]

  [ ORDER BY expression [ ASC | DESC | USING operator ] [ NULLS { FIRST | LAST } ] [, ...] ]

  [ frame_clause ]

  **frame_clause** defines a **window frame** for the window function. The window function (not all window functions) depends on **window frame** and **window frame** is a set of relevant rows of the current query row. **frame_clause** can be expressed in the following forms:

  [ RANGE | ROWS ] frame_start

  [ RANGE | ROWS ] BETWEEN frame_start AND frame_end

  **frame_start** and **frame_end** can be expressed in the following forms:

  UNBOUNDED PRECEDING

  value PRECEDING

  CURRENT ROW

  value FOLLOWING

  UNBOUNDED FOLLOWING

NOTICE

For the query of column storage table, only **row_number** window function is supported, and **frame_clause** is not supported.

- **UNION clause**

  Computes the set union of the rows returned by the involved **SELECT** statements.

  The **UNION** clause has the following constraints:

  – By default, the result of **UNION** does not contain any duplicate rows unless the **ALL** clause is declared.

  – Multiple **UNION** operators in the same **SELECT** statement are evaluated left to right, unless otherwise specified by parentheses.

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  - **FOR UPDATE** cannot be specified either for a **UNION** result or for any input of a **UNION**.

  General format:

  select_statement UNION [ALL] select_statement

  - **select_statement** can be any **SELECT** statement without an **ORDER BY**, **LIMIT**, or **FOR UPDATE** statement.
  - **ORDER BY** and **LIMIT** can be attached to the subexpression if it is enclosed in parentheses.

- **INTERSECT clause**

  Computes the set intersection of rows returned by the involved **SELECT** statements. The result of **INTERSECT** does not contain any duplicate rows.

  The **INTERSECT** clause has the following constraints:

  - Multiple **INTERSECT** operators in the same **SELECT** statement are evaluated left to right, unless otherwise specified by parentheses.
  - Processing **INTERSECT** preferentially when **UNION** and **INTERSECT** operations are executed for results of multiple **SELECT** statements.

  General format:

  select_statement INTERSECT select_statement

  **select_statement** can be any **SELECT** statement without a **FOR UPDATE** clause.

- **EXCEPT clause**

  Has the following common form:

  select_statement EXCEPT [ ALL ] select_statement

  **select_statement** can be any **SELECT** statement without a **FOR UPDATE** clause.

  The **EXCEPT** operator computes the set of rows that are in the result of the left **SELECT** statement but not in the result of the right one.

  The result of **EXCEPT** does not contain any duplicate rows unless the **ALL** clause is declared. To execute **ALL**, a row that has *m* duplicates in the left table and *n* duplicates in the right table will appear MAX(*m*–*n*, 0) times in the result set.

  Multiple **EXCEPT** operators in the same **SELECT** statement are evaluated left to right, unless parentheses dictate otherwise. **EXCEPT** binds at the same level as **UNION**.

  Currently, **FOR UPDATE** cannot be specified either for an **EXCEPT** result or for any input of an **EXCEPT**.

- **MINUS clause**

  Has the same function and syntax as **EXCEPT** clause.

- **ORDER BY clause**

  Sorts data retrieved by **SELECT** in descending or ascending order. If the **ORDER BY** expression contains multiple columns:

  - If two columns are equal according to the leftmost expression, they are compared according to the next expression and so on.
  - If they are equal according to all specified expressions, they are returned in an implementation-dependent order.

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  - When used with the **DISTINCT** keyword, the columns to be sorted in **ORDER BY** must be included in the columns of the result set retrieved by the SELECT statement.
  - When used with the **GROUP BY** clause, the columns to be sorted in **ORDER BY** must be included in the columns of the result set retrieved by the SELECT statement.

**NOTICE**

To support Chinese pinyin order, specify the **UTF-8**, **GB18030**, or **GBK** encoding mode during database initiation. The statements are as follows:

initdb –E UTF8 –D ../data –locale=zh_CN.UTF-8, initdb -E GB18030 -D ../data -locale=zh_CN.GB18030, or initdb –E GBK –D ../data –locale=zh_CN.GBK.

- **LIMIT clause**

  Consists of two independent sub-clauses:

  LIMIT { count | ALL }

  **OFFSET start count** specifies the maximum number of rows to return, while **start** specifies the number of rows to skip before starting to return rows. When both are specified, **start** rows are skipped before starting to count the **count** rows to be returned.

- **OFFSET clause**

  The SQL: 2008 standard has introduced a different clause:

  OFFSET start { ROW | ROWS }

  **start** specifies the number of rows to skip before starting to return rows.

- **FETCH { FIRST | NEXT } [ count ] { ROW | ROWS } ONLY**

  If **count** is omitted in a **FETCH** clause, it defaults to **1**.

- **FOR UPDATE clause**

  Locks rows retrieved by **SELECT**. This ensures that the rows cannot be modified or deleted by other transactions until the current transaction ends. That is, other transactions that attempt **UPDATE**, **DELETE**, or **SELECT FOR UPDATE** of these rows will be blocked until the current transaction ends.

  To prevent the operation from waiting for the commit of other transactions, you can use **NOWAIT**. If the selected row cannot be locked immediately, an error is reported immediately when you execute **SELECT FOR UPDATE NOWAIT**. If you use **WAIT N** and the selected row cannot be locked immediately, the operation needs to wait for *N* seconds (the value of *N* is of the int type with a range of $0 \leq N \leq 2147483$). If the lock is obtained within *N* seconds, the operation is performed normally. Otherwise, an error is reported.

  **FOR SHARE** behaves similarly, except that it acquires a shared rather than exclusive lock on each retrieved row. A share lock blocks other transaction from performing **UPDATE**, **DELETE**, or **SELECT FOR UPDATE** on these rows, but it does not prevent them from performing **SELECT FOR SHARE**.

  If specified tables are named in **FOR UPDATE** or **FOR SHARE**, then only rows coming from those tables are locked. Any other tables used in **SELECT** are simply read as usual. Otherwise, locking all tables in the statement.

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If **FOR UPDATE** or **FOR SHARE** is applied to a view or sub-query, it affects all tables used in the view or sub-query.

Multiple **FOR UPDATE** and **FOR SHARE** clauses can be written if it is necessary to specify different locking behaviors for different tables.

If the same table is mentioned (or implicitly affected) by both **FOR UPDATE** and **FOR SHARE** clauses, it is processed as **FOR UPDATE**. Similarly, a table is processed as **NOWAIT** if that is specified in any of the clauses affecting it.

**NOTICE**

- For SQL statements containing **FOR UPDATE** or **FOR SHARE**, their execution plans will be pushed down to DNs. If the pushdown fails, an error will be reported.
- The query of column-store tables does not support **for update/share**.

- **NLS_SORT**

  Specifies that a field is sorted in a special order. Currently, only Chinese Pinyin and case-insensitive sorting are supported. To support this sorting mode, you need to set the encoding format to UTF8, GB18030, or GBK when creating a database. If you set the encoding format to another format, for example, SQL_ASCII, an error may be reported or the sorting mode may be invalid.

  Value range:

  – **SCHINESE_PINYIN_M**, sorted by Pinyin order.

  – **generic_m_ci**: sorted in case-insensitive order (optional; only English characters are supported in the case-insensitive order.)

- **PARTITION clause**

  Queries data in the specified partition in a partitioned table.

## Example

```
-- Obtain the temp_t temporary table by a subquery and query all records in this table.
openGauss=# WITH temp_t(name,isdba) AS (SELECT usename,usesuper FROM pg_user) SELECT * FROM
temp_t;

-- Query all r_reason_sk records in the tpcds.reason table and delete duplicate records:
openGauss=# SELECT DISTINCT(r_reason_sk) FROM tpcds.reason;

-- Example of a LIMIT clause: Obtain a record from the table.
openGauss=# SELECT * FROM tpcds.reason LIMIT 1;

-- Query all records and sort them in alphabetic order.
openGauss=# SELECT r_reason_desc FROM tpcds.reason ORDER BY r_reason_desc;

-- Use table aliases to obtain data from the pg_user and pg_user_status tables:
openGauss=# SELECT a.usename,b.locktime FROM pg_user a,pg_user_status b WHERE a.usesysid=b.roloid;

-- Example of the FULL JOIN clause: Join data in the pg_user and pg_user_status tables.
openGauss=# SELECT a.usename,b.locktime,a.usesuper FROM pg_user a FULL JOIN pg_user_status b on
a.usesysid=b.roloid;

-- Example of the GROUP BY clause: Filter data based on query conditions, and group the results.
openGauss=# SELECT r_reason_id, AVG(r_reason_sk) FROM tpcds.reason GROUP BY r_reason_id HAVING
AVG(r_reason_sk) > 25;

-- Example of the GROUP BY CUBE clause: Filter data based on query conditions, and group the results.
openGauss=# SELECT r_reason_id,AVG(r_reason_sk) FROM tpcds.reason GROUP BY
```

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```
CUBE(r_reason_id,r_reason_sk);

-- Example of the GROUP BY GROUPING SETS clause: Filter data based on query conditions, and group the
results.
openGauss=# SELECT r_reason_id,AVG(r_reason_sk) FROM tpcds.reason GROUP BY GROUPING
SETS((r_reason_id,r_reason_sk),r_reason_sk);

-- Example of the UNION clause: Merge the names started with W and N in the r_reason_desc column in
the tpcds.reason table.
openGauss=# SELECT r_reason_sk, tpcds.reason.r_reason_desc
    FROM tpcds.reason
    WHERE tpcds.reason.r_reason_desc LIKE 'W%'
UNION
SELECT r_reason_sk, tpcds.reason.r_reason_desc
    FROM tpcds.reason
    WHERE tpcds.reason.r_reason_desc LIKE 'N%';

-- Example of the NLS_SORT clause: Sort by Chinese Pinyin.
openGauss=# SELECT * FROM tpcds.reason ORDER BY NLSSORT( r_reason_desc, 'NLS_SORT =
SCHINESE_PINYIN_M');


-- sorting by case-insensitive order (optional; only English characters are supported in the case-insensitive
order.)
openGauss=# SELECT * FROM tpcds.reason ORDER BY NLSSORT( r_reason_desc, 'NLS_SORT =
generic_m_ci');

-- Create a partitioned table tpcds.reason_p:
openGauss=# CREATE TABLE tpcds.reason_p
(
  r_reason_sk integer,
  r_reason_id character(16),
  r_reason_desc character(100)
)
PARTITION BY RANGE (r_reason_sk)
(
  partition P_05_BEFORE values less than (05),
  partition P_15 values less than (15),
  partition P_25 values less than (25),
  partition P_35 values less than (35),
  partition P_45_AFTER values less than (MAXVALUE)
)
;

-- Insert data.
openGauss=# INSERT INTO tpcds.reason_p values(3,'AAAAAAAABAAAAAAA','reason 1'),
(10,'AAAAAAAABAAAAAAA','reason 2'),(4,'AAAAAAAABAAAAAAA','reason 3'),
(10,'AAAAAAAABAAAAAAA','reason 4'),(10,'AAAAAAAABAAAAAAA','reason 5'),
(20,'AAAAAAAACAAAAAAA','reason 6'),(30,'AAAAAAAACAAAAAAA','reason 7');

-- Example of the PARTITION clause: Obtain data from the P_05_BEFORE partition in the tpcds.reason_p
table.
openGauss=#  SELECT * FROM tpcds.reason_p PARTITION (P_05_BEFORE);
 r_reason_sk |   r_reason_id    |   r_reason_desc
-------------+------------------+----------------------------------
           3 | AAAAAAAABAAAAAAA | reason 1
           4 | AAAAAAAABAAAAAAA | reason 3
(2 rows)

-- Example of the GROUP BY clause: Group records in the tpcds.reason_p table by r_reason_id, and count
the number of records in each group.
openGauss=# SELECT COUNT(*),r_reason_id FROM tpcds.reason_p GROUP BY r_reason_id;
 count |   r_reason_id
-------+------------------
     2 | AAAAAAAACAAAAAAA
     5 | AAAAAAAABAAAAAAA
(2 rows)

-- Example of the GROUP BY CUBE clause: Filter data based on query conditions, and group the results.
```

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```
openGauss=# SELECT * FROM tpcds.reason GROUP BY  CUBE (r_reason_id,r_reason_sk,r_reason_desc);

-- Example of the GROUP BY GROUPING SETS clause: Filter data based on query conditions, and group the results.
openGauss=# SELECT * FROM tpcds.reason GROUP BY  GROUPING SETS
((r_reason_id,r_reason_sk),r_reason_desc);

-- Example of the HAVING clause: Group records in the tpcds.reason_p table by r_reason_id, count the number of records in each group, and display only values whose number of r_reason_id is greater than 2.
openGauss=# SELECT COUNT(*) c,r_reason_id FROM tpcds.reason_p GROUP BY r_reason_id HAVING c>2;
 c |   r_reason_id
---+------------------
 5 | AAAAAAAABAAAAAAA
(1 row)

-- Example of the IN clause: Group records in the tpcds.reason_p table by r_reason_id, count the number of records in each group, and display only the numbers of records whose r_reason_id is AAAAAAAABAAAAAAA or AAAAAAAADAAAAAAA.
openGauss=# SELECT COUNT(*),r_reason_id FROM tpcds.reason_p GROUP BY r_reason_id HAVING
r_reason_id IN('AAAAAAAABAAAAAAA','AAAAAAAADAAAAAAA');
count |   r_reason_id
-------+------------------
     5 | AAAAAAAABAAAAAAA
(1 row)

-- Example of the INTERSECT clause: Query records whose r_reason_id is AAAAAAAABAAAAAAA and whose r_reason_sk is smaller than 5.
openGauss=# SELECT * FROM tpcds.reason_p WHERE r_reason_id='AAAAAAAABAAAAAAA' INTERSECT
SELECT * FROM tpcds.reason_p WHERE r_reason_sk<5;
 r_reason_sk |   r_reason_id    |      r_reason_desc
-------------+------------------+----------------------------------
           4 | AAAAAAAABAAAAAAA | reason 3
           3 | AAAAAAAABAAAAAAA | reason 1
(2 rows)

-- Example of the EXCEPT clause: Query records whose r_reason_id is AAAAAAAABAAAAAAA and whose r_reason_sk is greater than or equal to 4.
openGauss=# SELECT * FROM tpcds.reason_p WHERE r_reason_id='AAAAAAAABAAAAAAA' EXCEPT SELECT *
FROM tpcds.reason_p WHERE r_reason_sk<4;
r_reason_sk |   r_reason_id    |      r_reason_desc
-------------+------------------+----------------------------------
          10 | AAAAAAAABAAAAAAA | reason 5
          10 | AAAAAAAABAAAAAAA | reason 4
           4 | AAAAAAAABAAAAAAA | reason 3
          10 | AAAAAAAABAAAAAAA | reason 2
(4 rows)

-- Specify the operator (+) in the WHERE clause to indicate a left join.
openGauss=# select t1.sr_item_sk ,t2.c_customer_id from store_returns t1, customer t2 where
t1.sr_customer_sk  = t2.c_customer_sk(+)
order by 1 desc limit 1;
 sr_item_sk | c_customer_id
------------+---------------
      18000 |
(1 row)

-- Specify the operator (+) in the WHERE clause to indicate a right join.
openGauss=# select t1.sr_item_sk ,t2.c_customer_id from store_returns t1, customer t2 where
t1.sr_customer_sk(+)  = t2.c_customer_sk
order by 1 desc limit 1;
 sr_item_sk |  c_customer_id
------------+------------------
            | AAAAAAAAJNGEBAAA
(1 row)

-- Specify the operator (+) in the WHERE clause to indicate a left join and add a join condition.
openGauss=# select t1.sr_item_sk ,t2.c_customer_id from store_returns t1, customer t2 where
t1.sr_customer_sk  = t2.c_customer_sk(+) and t2.c_customer_sk(+) < 1 order by 1  limit 1;
 sr_item_sk | c_customer_id
```

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```
------------+---------------
          1 |
(1 row)

-- If the operator (+) is specified in the WHERE clause, do not use expressions connected through AND/OR.
openGauss=# select t1.sr_item_sk ,t2.c_customer_id from store_returns t1, customer t2 where
not(t1.sr_customer_sk  = t2.c_customer_sk(+) and t2.c_customer_sk(+) < 1);
ERROR:  Operator "(+)" can not be used in nesting expression.
LINE 1: ...tomer_id from store_returns t1, customer t2 where not(t1.sr_...
                                                             ^
-- If the operator (+) is specified in the WHERE clause which does not support expression macros, an error
will be reported.
openGauss=# select t1.sr_item_sk ,t2.c_customer_id from store_returns t1, customer t2 where
(t1.sr_customer_sk  = t2.c_customer_sk(+))::bool;
ERROR:  Operator "(+)" can only be used in common expression.

-- If the operator (+) is specified on both sides of an expression in the WHERE clause, an error will be
reported.
openGauss=# select t1.sr_item_sk ,t2.c_customer_id from store_returns t1, customer t2 where
t1.sr_customer_sk(+)  = t2.c_customer_sk(+);
ERROR:  Operator "(+)" can't be specified on more than one relation in one join condition
HINT:  "t1", "t2"...are specified Operator "(+)" in one condition.

-- Delete the table.
openGauss=# DROP TABLE tpcds.reason_p;
```

# 12.14.160 SELECT INTO

## Function

Defines a new table based on a query result and inserts data obtained by query to the new table.

Different from **SELECT**, data found by **SELECT INTO** is not returned to the client. The table columns have the same names and data types as the output columns of the **SELECT**.

## Precautions

**CREATE TABLE AS** provides functions similar to **SELECT INTO** in functions and provides a superset of functions provided by **SELECT INTO**. You are advised to use **CREATE TABLE AS**, because **SELECT INTO** cannot be used in a stored procedure.

## Syntax

```
[ WITH [ RECURSIVE ] with_query [, ...] ]
SELECT [ ALL | DISTINCT [ ON ( expression [, ...] ) ] ]
    { * | {expression [ [ AS ] output_name ]} [, ...] }
    INTO [ UNLOGGED ] [ TABLE ] new_table
    [ FROM from_item [, ...] ]
    [ WHERE condition ]
    [ GROUP BY expression [, ...] ]
    [ HAVING condition [, ...] ]
    [ WINDOW {window_name AS ( window_definition )} [, ...] ]
    [ { UNION | INTERSECT | EXCEPT | MINUS } [ ALL | DISTINCT ] select ]
    [ ORDER BY {expression [ [ ASC | DESC | USING operator ] | nlssort_expression_clause ] [ NULLS { FIRST |
LAST } ]} [, ...] ]
    [ LIMIT { count | ALL } ]
    [ OFFSET start [ ROW | ROWS ] ]
    [ FETCH { FIRST | NEXT } [ count ] { ROW | ROWS } ONLY ]
    [ {FOR { UPDATE | SHARE } [ OF table_name [, ...] ] [ NOWAIT | WAIT N]} [...] ];
```

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## Parameter Description

**INTO [ UNLOGGED ] [ TABLE ] new_table**

Specifies that the table is created as an unlogged table. Data written to unlogged tables is not written to the WALs, which makes them considerably faster than ordinary tables. However, they are not crash-safe: an unlogged table is automatically truncated after a crash or unclean shutdown. The contents of an unlogged table are also not replicated to standby servers. Any indexes created on an unlogged table are automatically unlogged as well.

**new_table** specifies the name of the new table.

NOTE

For details about other **SELECT INTO** parameters, see **Parameter Description** in SELECT.

## Examples

```
-- Add the values that are less than 5 in the r_reason_sk field in the tpcds.reason table to the new table.
openGauss=# SELECT * INTO tpcds.reason_t1 FROM tpcds.reason WHERE r_reason_sk < 5;
INSERT 0 6

-- Delete the tpcds.reason_t1 table.
openGauss=# DROP TABLE tpcds.reason_t1;
```

## Helpful Links

**12.14.159 SELECT**

## Suggestions

- **DATABASE**

  You are not advised to reindex a database in a transaction.
- **SYSTEM**

  You are not advised to reindex system catalogs in transactions.

# 12.14.161 SET

## Function

Modifies a run-time parameter.

## Precautions

Most run-time parameters can be modified by executing **SET**. Some parameters cannot be modified after a server or session starts.

## Syntax

- Set the system time zone.

  ```
  SET [ SESSION | LOCAL ] TIME ZONE { timezone | LOCAL | DEFAULT };
  ```
- Set the schema of the table.

  ```
  SET [ SESSION | LOCAL ]
    {CURRENT_SCHEMA { TO | = } { schema | DEFAULT }
    | SCHEMA 'schema'};
  ```

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- Set client encoding.
  ```
  SET [ SESSION | LOCAL ] NAMES encoding_name;
  ```
- Set XML parsing mode.
  ```
  SET [ SESSION | LOCAL ] XML OPTION { DOCUMENT | CONTENT };
  ```
- Set other running parameters.
  ```
  SET [ LOCAL | SESSION ]
    { {config_parameter { { TO | = } { value | DEFAULT }
                        | FROM CURRENT }}};
  ```

## Parameter Description

- **SESSION**

  Specifies that the specified parameters take effect for the current session. This is the default value if neither **SESSION** nor **LOCAL** appears.

  If **SET** or **SET SESSION** is executed within a transaction that is later aborted, the effects of the **SET** statement disappear when the transaction is rolled back. Once the surrounding transaction is committed, the effects will persist until the end of the session, unless overridden by another **SET**.

- **LOCAL**

  Specifies that the specified parameters take effect for the current transaction. After **COMMIT** or **ROLLBACK**, the session-level setting takes effect again.

  The effects of **SET LOCAL** last only till the end of the current transaction, whether committed or not. A special case is **SET** followed by **SET LOCAL** within a single transaction: the **SET LOCAL** value will be seen until the end of the transaction, but afterward (if the transaction is committed) the **SET** value will take effect.

- **TIME ZONE timezone**

  Specifies the local time zone for the current session.

  Value range: a valid local time zone. The corresponding run-time parameter is **TimeZone**. The default value is **PRC**.

- **CURRENT_SCHEMA**

  **schema**

  Specifies the current schema.

  Value range: an existing schema name

- **SCHEMA schema**

  Specifies the current schema. Here the schema is a string.

  Example: set schema 'public';

- **NAMES encoding_name**

  Specifies the client character encoding. This statement is equivalent to **set client_encoding to encoding_name**.

  Value range: a valid character encoding name. The run-time parameter corresponding to this option is **client_encoding**. The default encoding is **UTF8**.

- **XML OPTION option**

  Specifies the XML parsing mode.

  Value range: **CONTENT** (default), **DOCUMENT**

- **config_parameter**

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Specifies the name of a configurable run-time parameter. You can use **SHOW ALL** to view available run-time parameters.

NOTE

Some parameters that viewed by **SHOW ALL** cannot be set by **SET**. For example, **max_datanodes**.

- **value**

  Specifies the new value of **config_parameter**. This parameter can be specified as string constants, identifiers, numbers, or comma-separated lists of these. **DEFAULT** can be written to indicate resetting the parameter to its default value.

## Examples

```
-- Set the search path of a schema.
openGauss=# SET search_path TO tpcds, public;

-- Set the date style to the traditional POSTGRES style (date placed before month):
openGauss=# SET datestyle TO postgres;
```

## Helpful Links

**12.14.153 RESET** and **12.14.166 SHOW**

# 12.14.162 SET CONSTRAINTS

## Function

Sets the behavior of constraint checking within the current transaction.

**IMMEDIATE** constraints are checked at the end of each statement. **DEFERRED** constraints are not checked until transaction commit. Each constraint has its own **IMMEDIATE** or **DEFERRED** mode.

Upon creation, a constraint is given one of three characteristics **DEFERRABLE INITIALLY DEFERRED**, **DEFERRABLE INITIALLY IMMEDIATE**, or **NOT DEFERRABLE**. The third class is always **IMMEDIATE** and is not affected by the **SET CONSTRAINTS** statement. The first two classes start every transaction in specified modes, but its behaviors can be changed within a transaction by **SET CONSTRAINTS**.

**SET CONSTRAINTS** with a list of constraint names changes the mode of just those constraints (which must all be deferrable). If multiple constraints match a name, the name is affected by all of these constraints. **SET CONSTRAINTS ALL** changes the modes of all deferrable constraints.

When **SET CONSTRAINTS** changes the mode of a constraint from **DEFERRED** to **IMMEDIATE**, the new mode takes effect retroactively: any outstanding data modifications that would have been checked at the end of the transaction are instead checked during the execution of the **SET CONSTRAINTS** statement. If any such constraint is violated, the **SET CONSTRAINTS** fails (and does not change the constraint mode). Therefore, **SET CONSTRAINTS** can be used to force checking of constraints to occur at a specific point in a transaction.

Only foreign key constraints are affected by this setting. Check and unique constraints are always checked immediately when a row is inserted or modified.

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## Precautions

**SET CONSTRAINTS** sets the behavior of constraint checking only within the current transaction. Therefore, if you execute this statement outside of a transaction block (**START TRANSACTION/COMMIT** pair), it will not appear to have any effect.

## Syntax

```
SET CONSTRAINTS { ALL | { name } [, ...] } { DEFERRED | IMMEDIATE };
```

## Parameter Description

- **name**

  Specifies the constraint name.

  Value range: an existing table name, which can be found in the system catalog **pg_constraint**.

- **ALL**

  Specifies all constraints.

- **DEFERRED**

  Specifies that constraints are not checked until transaction commit.

- **IMMEDIATE**

  Specifies that constraints are checked at the end of each statement.

## Examples

```
-- Set that constraints are checked when a transaction is committed.
openGauss=# SET CONSTRAINTS ALL DEFERRED;
```

# 12.14.163 SET ROLE

## Function

Sets the current user identifier of the current session.

## Precautions

- Users of the current session must be members of specified **rolename**, but the system administrator can choose any roles when separation of duties is disabled.
- Executing this statement may add rights of a user or restrict rights of a user. If the role of a session user has the **INHERITS** attribute, it automatically has all rights of roles that **SET ROLE** enables the role to be. In this case, **SET ROLE** physically deletes all rights directly granted to session users and rights of its belonging roles and only leaves rights of the specified roles. If the role of the session user has the **NOINHERITS** attribute, **SET ROLE** deletes rights directly granted to the session user and obtains rights of the specified role.

## Syntax

- Set the current user identifier of the current session.

  ```
  SET [ SESSION | LOCAL ] ROLE role_name PASSWORD 'password';
  ```

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- Reset the current user identifier to that of the current session.
  ```
  RESET ROLE;
  ```

## Parameter Description

- **SESSION**

  Specifies that the statement takes effect only for the current session. This parameter is used by default.

  Value range: a string. It must comply with the naming convention.

- **LOCALE**

  Specifies that the specified statement takes effect only for the current transaction.

- **role_name**

  Indicates the role name.

  Value range: a string. It must comply with the naming convention.

- **password**

  Specifies the password of a role. It must comply with the password convention.

- **RESET ROLE**

  Resets the current user identifier.

## Examples

```
-- Create a role paul.
openGauss=# CREATE ROLE paul IDENTIFIED BY 'xxxxxxxxxx';

-- Set the current user to paul.
openGauss=# SET ROLE paul PASSWORD 'xxxxxxxxxx';

-- View the current session user and the current user.
openGauss=# SELECT SESSION_USER, CURRENT_USER;

-- Reset the current user.
openGauss=# RESET role;

-- Delete the user.
openGauss=# DROP USER paul;
```

# 12.14.164 SET SESSION AUTHORIZATION

## Function

Sets the session user identifier and the current user identifier of the current SQL session to a specified user.

## Precautions

The session identifier can be changed only when the initial session user has the system administrator rights. Otherwise, the system supports the statement only when the authenticated user name is specified.

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## Syntax

- Set the session user identifier and the current user identifier of the current session.

```
SET [ SESSION | LOCAL ] SESSION AUTHORIZATION role_name PASSWORD 'password';
```

- Reset the identifiers of the session and current users to the initially authenticated user names.

```
{SET [ SESSION | LOCAL ] SESSION AUTHORIZATION DEFAULT
    | RESET SESSION AUTHORIZATION};
```

## Parameter Description

- **SESSION**

  Specifies that the specified parameters take effect for the current session.

  Value range: a string. It must comply with the naming convention.

- **LOCALE**

  Specifies that the specified statement takes effect only for the current transaction.

- **role_name**

  Username

  Value range: a string. It must comply with the naming convention.

- **password**

  Specifies the password of a role. It must comply with the password convention.

- **DEFAULT**

  Resets the identifiers of the session and current users to the initially authenticated user names.

## Examples

```
-- Create a role paul.
openGauss=# CREATE ROLE paul IDENTIFIED BY 'xxxxxxxxx';

-- Set the current user to paul.
openGauss=# SET SESSION AUTHORIZATION paul password 'xxxxxxxxxx';

-- View the current session user and the current user.
openGauss=# SELECT SESSION_USER, CURRENT_USER;

-- Reset the current user.
openGauss=# RESET SESSION AUTHORIZATION;

-- Delete the user.
openGauss=# DROP USER paul;
```

## Reference

12.14.163 SET ROLE

# 12.14.165 SET TRANSACTION

## Function

**SET TRANSACTION** sets characteristics of a transaction. Available transaction characteristics include the transaction separation level and transaction access

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mode (read/write or read only). You can set the current transaction characteristics using **LOCAL** or the default transaction characteristics of a session using **SESSION**.

## Precautions

The current transaction characteristics must be set in a transaction, that is, **START TRANSACTION** or **BEGIN** must be executed before **SET TRANSACTION** is executed. Otherwise, the setting does not take effect.

## Syntax

Set the isolation level and access mode of the transaction.

```
{ SET [ LOCAL ] TRANSACTION|SET SESSION CHARACTERISTICS AS TRANSACTION }
  { ISOLATION LEVEL { READ COMMITTED | READ UNCOMMITTED | SERIALIZABLE | REPEATABLE READ }
  | { READ WRITE | READ ONLY } } [, ...]
```

## Parameter Description

- **LOCAL**

  Specifies that the specified statement takes effect only for the current transaction.

- **SESSION**

  Specifies that the specified parameters take effect for the current session.

  Value range: a string. It must comply with the naming convention.

- **ISOLATION_LEVEL_CLAUSE**

  Specifies the transaction isolation level that determines the data that a transaction can view if other concurrent transactions exist.

  NOTE

  - The isolation level cannot be changed after data is modified using **INSERT**, **DELETE**, **UPDATE**, **FETCH**, or **COPY** in the current transaction.

  Value range:

  - **READ COMMITTED**: Only committed data is read. It is the default value.
  - **READ UNCOMMITTED**: Uncommitted data is probably read. This isolation level is provided to handle CN breakdown emergencies. On this isolation level, you are advised to only read data to prevent inconsistency.
  - **REPEATABLE READ**: Only the data committed before transaction start is read. Uncommitted data or data committed in other concurrent transactions cannot be read.
  - **SERIALIZABLE**: Currently, this isolation level is not supported in GaussDB. It is equivalent to **REPEATABLE READ**.

- **READ WRITE | READ ONLY**

  Specifies the transaction access mode (read/write or read only).

  NOTE

  The access mode of the default transaction feature of the session can be set only when the database is started or by sending the HUP signal.

## Examples

```
-- Start a transaction and set its isolation level to READ COMMITTED and access mode to READ ONLY.
openGauss=# START TRANSACTION;
```

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```
openGauss=# SET LOCAL TRANSACTION ISOLATION LEVEL READ COMMITTED READ ONLY;
openGauss=# COMMIT;
```

# 12.14.166 SHOW

## Function

Shows the current value of a run-time parameter.

## Precautions

None

## Syntax

```
SHOW
 {
   [VARIABLES LIKE] configuration_parameter |
   CURRENT_SCHEMA |
   TIME ZONE |
   TRANSACTION ISOLATION LEVEL |
   SESSION AUTHORIZATION |
   ALL
 };
```

## Parameter Description

See **Parameter Description** in RESET.

## Examples

```
-- Show the value of timezone.
openGauss=# SHOW timezone;

-- Show all parameters.
openGauss=# SHOW ALL;

-- Show all parameters whose names contain var.
openGauss=# SHOW VARIABLES LIKE var;
```

## Helpful Links

**12.14.161 SET** and **12.14.153 RESET**

# 12.14.167 SHUTDOWN

## Function

**SHUTDOWN** shuts down the currently connected database node.

## Precautions

Only the administrator can run this command.

## Syntax

```
SHUTDOWN
 {
```

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```
      |
  fast  |
  immediate
};
```

## Parameter Description

- ""

  If the shutdown mode is not specified, the default mode **fast** is used.

- **fast**

  Rolls back all active transactions, forcibly disconnects the client, and shuts down the database node without waiting for the client to disconnect.

- **immediate**

  Shuts down the server forcibly. Fault recovery will occur on the next startup.

## Examples

```
-- Shut down the current database node.
openGauss=# SHUTDOWN;

-- Shut down the current database node in fast mode.
openGauss=# SHUTDOWN FAST;
```

# 12.14.168 START TRANSACTION

## Function

Starts a transaction. If the isolation level or read/write mode is specified, a new transaction will have those characteristics. You can also specify them using **12.14.165 SET TRANSACTION**.

## Precautions

None

## Syntax

Format 1: START TRANSACTION

```
START TRANSACTION
 [
   {
     ISOLATION LEVEL { READ COMMITTED | READ UNCOMMITTED | SERIALIZABLE | REPEATABLE READ }
     | { READ WRITE | READ ONLY }
   } [, ...]
 ];
```

Format 2: BEGIN

```
BEGIN [ WORK | TRANSACTION ]
 [
   {
     ISOLATION LEVEL { READ COMMITTED | READ UNCOMMITTED | SERIALIZABLE | REPEATABLE READ }
     | { READ WRITE | READ ONLY }
    } [, ...]
 ];
```

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## Parameter Description

- **WORK | TRANSACTION**

  Specifies the optional keyword in BEGIN format without functions.

- **ISOLATION LEVEL**

  Specifies the transaction isolation level that determines the data that a transaction can view if other concurrent transactions exist.

  NOTE

  The isolation level of a transaction cannot be reset after the first clause (**INSERT**, **DELETE**, **UPDATE**, **FETCH**, **COPY**) for modifying data is executed in the transaction.

  Value range:

  - READ COMMITTED: Only committed data is read. It is the default value.
  - **READ UNCOMMITTED**: Uncommitted data is probably read. This isolation level is provided to handle CN breakdown emergencies. On this isolation level, you are advised to only read data to prevent inconsistency.
  - **REPEATABLE READ**: Only the data committed before transaction start is read. Uncommitted data or data committed in other concurrent transactions cannot be read.
  - **SERIALIZABLE**: Currently, this isolation level is not supported in GaussDB. It is equivalent to **REPEATABLE READ**.

- **READ WRITE | READ ONLY**

  Specifies the transaction access mode (read/write or read only).

## Examples

```
-- Start a transaction in default mode.
openGauss=# START TRANSACTION;
openGauss=# SELECT * FROM tpcds.reason;
openGauss=# END;

-- Start a transaction in default mode.
openGauss=# BEGIN;
openGauss=# SELECT * FROM tpcds.reason;
openGauss=# END;

-- Start a transaction with the isolation level being READ COMMITTED and the access mode being READ WRITE:
openGauss=# START TRANSACTION ISOLATION LEVEL READ COMMITTED READ WRITE;
openGauss=# SELECT * FROM tpcds.reason;
openGauss=# COMMIT;
```

## Helpful Links

12.14.48 COMMIT | END, 12.14.155 ROLLBACK, 12.14.165 SET TRANSACTION

# 12.14.169 TRUNCATE

## Function

Quickly removes all rows from a database table.

It has the same effect as an unqualified **DELETE** on each table, but it is faster since it does not actually scan the tables. This is most useful on large tables.

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## Precautions

- **TRUNCATE TABLE** has the same function as a **DELETE** statement with no **WHERE** clause, emptying a table.
- **TRUNCATE TABLE** uses less system and transaction log resources as compared with **DELETE**.
  - **DELETE** deletes a row each time, and records the deletion of each row in the transaction log.
  - **TRUNCATE TABLE** deletes all rows in a table by releasing the data page storing the table data, and records the releasing of the data page only in the transaction log.
- The differences between **TRUNCATE**, **DELETE**, and **DROP** are as follows:
  - **TRUNCATE TABLE** deletes content, releases space, but does not delete definitions.
  - **DELETE TABLE** deletes content, but does not delete definitions nor release space.
  - **DROP TABLE** deletes content and definitions, and releases space.

## Syntax

- Delete data from a table.

```
TRUNCATE [ TABLE ] [ ONLY ] {table_name [ * ]} [, ... ]
    [ CONTINUE IDENTITY ] [ CASCADE | RESTRICT ];
```

- Truncate the data in a partition.

```
ALTER TABLE [ IF EXISTS  ] { [ ONLY  ] table_name
                           | table_name *
                           | ONLY ( table_name )  }
    TRUNCATE PARTITION { partition_name
                       | FOR (  partition_value  [, ...] )  } [ UPDATE GLOBAL INDEX ];
```

## Parameter Description

- **ONLY**

  Specifies that if **ONLY** is specified, only the specified table is cleared. Otherwise, the table and all its subtables (if any) are cleared.

- **table_name**

  Specifies the name (optionally schema-qualified) of the table to delete rows from.

  Value range: an existing table name

- **CONTINUE IDENTITY**

  Does not change the values of sequences. It is the default value.

- **CASCADE | RESTRICT**
  - **CASCADE**: automatically truncates all tables that have foreign-key references to any of the named tables, or to any tables added to the group due to **CASCADE**.
  - **RESTRICT** (default): refuses to truncate if any of the tables have foreign-key references from tables that are not listed in the statement.

- **partition_name**

  Specifies the partition in the target partitioned table.

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Value range: an existing table name

- **partition_value**

  Specifies the value of the specified partition key.

  The value specified by **PARTITION FOR** can uniquely identify a partition.

  Value range: value range of the partition key for the partition to be renamed

  **NOTICE**

  When the **PARTITION FOR** clause is used, the entire partition where **partition_value** is located is cleared.

- **UPDATE GLOBAL INDEX**

  If this parameter is used, all global indexes in a partitioned table are updated to ensure that correct data can be queried using global indexes.

  If this parameter is not used, all global indexes in a partitioned table will become invalid.

## Examples

```
-- Create a table.
openGauss=# CREATE TABLE tpcds.reason_t1 AS TABLE tpcds.reason;

-- Clear the tpcds.reason_t1 table.
openGauss=# TRUNCATE TABLE tpcds.reason_t1;

-- Delete the table.
openGauss=# DROP TABLE tpcds.reason_t1;
-- Create a partitioned table.
openGauss=# CREATE TABLE tpcds.reason_p
(
  r_reason_sk integer,
  r_reason_id character(16),
  r_reason_desc character(100)
)PARTITION BY RANGE (r_reason_sk)
(
  partition p_05_before values less than (05),
  partition p_15 values less than (15),
  partition p_25 values less than (25),
  partition p_35 values less than (35),
  partition p_45_after values less than (MAXVALUE)
);

-- Insert data.
openGauss=# INSERT INTO tpcds.reason_p SELECT * FROM tpcds.reason;

-- Clear the p_05_before partition.
openGauss=# ALTER TABLE tpcds.reason_p TRUNCATE PARTITION p_05_before;

-- Clear the p_15 partition.
openGauss=# ALTER TABLE tpcds.reason_p TRUNCATE PARTITION for (13);

-- Clear the partitioned table.
openGauss=# TRUNCATE TABLE tpcds.reason_p;

-- Delete the table.
openGauss=# DROP TABLE tpcds.reason_p;
```

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# 12.14.170 UPDATE

## Function

Updates data in a table. Changes the values of the specified columns in all rows that satisfy the condition. The WHERE clause clarifies conditions. The SET clause specifies the columns to be modified and columns that not specified in the SET clause retain their previous values.

## Precautions

- The owner of a table, users granted with the UPDATE permission on the table, or users granted with the UPDATE ANY TABLE permission can update data in the table. The system administrator has the permission to update data in the table by default.
- You must have the SELECT permission on all tables involved in the expressions or conditions.
- The distribution key (or column) of a table cannot be modified.
- For column-store tables, the RETURNING clause is currently not supported.
- Column-store tables do not support non-deterministic update. If you update data in one row with multiple rows of data in a column-store table, an error will be reported.
- Memory space that records update operations in column-store tables is not recycled. You need to clean it by executing **VACUUM FULL table_name**.
- Currently, UPDATE cannot be used in column-store replication tables.

## Syntax

```
[ WITH [ RECURSIVE ] with_query [, ...] ]
UPDATE [/*+ plan_hint */] [ ONLY ] table_name [ * ] [ [ AS ] alias ]
SET {column_name = { expression | DEFAULT }
   |( column_name [, ...] ) = {( { expression | DEFAULT } [, ...] ) |sub_query }}[, ...]
   [ FROM from_list] [ WHERE condition ]
   [ RETURNING {*
            | {output_expression [ [ AS ] output_name ]} [, ...] }];

where sub_query can be:
SELECT [ ALL | DISTINCT [ ON ( expression [, ...] ) ] ]
{ * | {expression [ [ AS ] output_name ]} [, ...] }
[ FROM from_item [, ...] ]
[ WHERE condition ]
[ GROUP BY grouping_element [, ...] ]
[ HAVING condition [, ...] ]
[ ORDER BY {expression [ [ ASC | DESC | USING operator ] | nlssort_expression_clause ] [ NULLS { FIRST |
LAST } ]} [, ...] ]
[ LIMIT { [offset,] count | ALL } ]
```

## Parameter Description

- **WITH [ RECURSIVE ] with_query [, ...]**

  Specifies one or more subqueries that can be referenced by name in the main query, which is equivalent to a temporary table.

  If **RECURSIVE** is specified, it allows a **SELECT** subquery to reference itself by name.

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The detailed format of **with_query** is as follows: **with_query_name [ ( column_name [, ...] ) ] AS [ [ NOT ] MATERIALIZED ] ( {select | values | insert | update | delete} )**

- **with_query_name** specifies the name of the result set generated by a subquery. Such names can be used to access the result sets of subqueries in a query.
- **column_name** specifies the column name displayed in the subquery result set.
- Each subquery can be a **SELECT**, **VALUES**, **INSERT**, **UPDATE** or **DELETE** statement.
- You can use **MATERIALIZED** or **NOT MATERIALIZED** to modify the CTE.
  - If **MATERIALIZED** is specified, the WITH query will be materialized, and a copy of the subquery result set is generated. The copy is directly queried at the reference point. Therefore, the WITH subquery cannot be jointly optimized with the SELECT statement trunk (for example, predicate pushdown and equivalence class transfer). In this scenario, you can use **NOT MATERIALIZED** for modification. If the WITH query can be executed as a subquery inline, the preceding optimization can be performed.
  - If the user does not explicitly declare the materialized attribute, comply with the following rules: If the CTE is referenced only once in the SELECT statement trunk to which it belongs and semantically supports inline execution, it will be rewritten as subquery inline execution. Otherwise, the materialized execution will be performed in CTE Scan mode.

- **plan_hint** clause

  Follows the UPDATE keyword in the **/*+ */** format. It is used to optimize the plan of an UPDATE statement block. For details, see **10.3.9 Hint-based Tuning**. In each statement, only the first **/*+** *plan_hint* ***/** comment block takes effect as a hint. Multiple hints can be written.

- **table_name**

  Specifies the name (optionally schema-qualified) of the table to be updated.

  Value range: an existing table name

- **alias**

  Specifies the alias of the target table.

  Value range: a string. It must comply with the naming convention.

- **column_name**

  Specifies the name of the column to be modified.

  You can refer to this column by specifying the target table alias and the column name. For example:

  UPDATE foo AS f SET f.col_name = 'postgres';

  Value range: an existing column

- **expression**

  Specifies a value assigned to a column or an expression that assigns the value.

- **DEFAULT**

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Specifies the default value of a column.

The value is **NULL** if no default value is assigned to it.

- **sub_query**

  Specifies a subquery.

  This statement can be executed to update a table with information for other tables in the same database. For details about clauses in the SELECT statement, see **12.14.159 SELECT**.

  When a single column is updated, the ORDER BY and LIMIT clauses can be used. When multiple columns are updated, the ORDER BY and LIMIT clauses cannot be used.

- **from_list**

  Specifies a list of table expressions, allowing columns from other tables to appear in the WHERE condition. This is similar to the list of tables that can be specified in the FROM clause of a SELECT statement.

  **NOTICE**

  Note that the target table cannot appear in the **from_list**, unless you intend a self-join (in which case it must appear with an alias in the **from_list**).

- **condition**

  Specifies an expression that returns a value of type Boolean. Only rows for which this expression returns **true** are updated. You are not advised to use numeric types such as int for **condition**, because such types can be implicitly converted to bool values (non-zero values are implicitly converted to **true** and **0** is implicitly converted to **false**), which may cause unexpected results.

- **output_expression**

  Specifies an expression to be computed and returned by the UPDATE statement after each row is updated.

  Value range: any table and table columns listed in FROM. The asterisk (*) indicates that all fields are returned.

- **output_name**

  Specifies a name to use for a returned column.

## Examples

```
-- Create the student1 table.
openGauss=# CREATE TABLE student1
(
  stuno    int,
  classno  int
)
DISTRIBUTE BY hash(stuno);

-- Insert data.
openGauss=# INSERT INTO student1 VALUES(1,1);
openGauss=# INSERT INTO student1 VALUES(2,2);
openGauss=# INSERT INTO student1 VALUES(3,3);

-- View data.
openGauss=# SELECT * FROM student1;
```

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```
-- Update the values of all records.
openGauss=# UPDATE student1 SET classno = classno*2;

-- View data.
openGauss=# SELECT * FROM student1;

-- Delete the table.
openGauss=# DROP TABLE student1;
```

# 12.14.171 VACUUM

## Function

**VACUUM** recycles storage space occupied by tables or **B-Tree** indexes. In normal database operation, rows that have been deleted are not physically removed from their table; they remain present until a **VACUUM** is done. Therefore, it is necessary to do **VACUUM** periodically, especially on frequently-updated tables.

## Precautions

- With no table specified, **VACUUM** processes all the tables that the current user has permission to vacuum in the current database. With a parameter, **VACUUM** processes only that table.
- To perform **VACUUM** operation to a table, you must be a table owner or a user granted the **VACUUM** permission on the table. By default, the system administrator has this permission. However, database owners are allowed to **VACUUM** all tables in their databases, except shared catalogs. (The restriction for shared catalogs means that a true database-wide **VACUUM** can only be executed by the system administrator). **VACUUM** skips over any tables that the calling user does not have the permission to vacuum.
- **VACUUM** cannot be executed inside a transaction block.
- It is recommended that active production databases be vacuumed frequently (at least nightly), in order to remove dead rows. After adding or deleting a large number of rows, it might be a good idea to run **VACUUM ANALYZE** for the affected table. This will update the system catalogs with the results of all recent changes, and allow the query planner to make better choices in planning queries.
- **FULL** is recommended only in special scenarios. For example, you wish to physically narrow the table to decrease the occupied disk space after deleting most rows of a table. **VACUUM FULL** usually shrinks a table more than **VACUUM** does. The **FULL** option does not clear indexes. You are advised to periodically run the **12.14.149 REINDEX** statement. Deleting all indexes, running **VACUUM FULL**, and rebuilding indexes is usually a faster choice. If the physical space usage does not decrease after you run the statement, check whether there are other active transactions (that have started before you delete data transactions and not ended before you run **VACUUM FULL**). If there are such transactions, run this statement again when the transactions quit.
- **VACUUM** causes a substantial increase in I/O traffic, which might cause poor performance for other active sessions. Therefore, it is sometimes advisable to use the cost-based VACUUM delay feature.
- When **VERBOSE** is specified, **VACUUM** prints progress messages to indicate which table is currently being processed. Various statistics about the tables

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are printed as well. However, if you execute **VACUUM** and specify the **VERBOSE** option for column-store tables, no information is returned.

- When the option list is surrounded by parentheses, the options can be written in any order. If there are no brackets, the options must be given in the order displayed in the syntax.
- **VACUUM** and **VACUUM FULL** clear deleted tuples after the delay specified by **vacuum_defer_cleanup_age**.
- **VACUUM ANALYZE** executes a VACUUM operation and then an ANALYZE operation for each selected table. This is a handy combination form for routine maintenance scripts.
- Plain **VACUUM** (without **FULL**) simply reclaims space and makes it available for reuse. This form of statement can operate in parallel with normal reading and writing of the table, as an exclusive lock is not obtained. **VACUUM FULL** executes wider processing, including moving rows across blocks to compress tables so they occupy the minimum number of disk blocks. This form is much slower and requires an exclusive lock on each table while it is being processed.
- When you do **VACUUM** to a column-store table, the following operations are internally performed: data in the delta table is migrated to the primary table, and the delta and desc tables of the primary table are vacuumed. **VACUUM** does not reclaim the storage space of the delta table. To reclaim it, do **VACUUM DELTAMERGE** to the column-store table.
- The function of **VACUUM FULL** is the same as that of **Compaction**. Therefore, **VACUUM FULL** can be executed only when the **Compaction** function is disabled.
- If the **xc_maintenance_mode** parameter is not enabled, **VACUUM FULL** skips all system catalogs.
- If you run **VACUUM FULL** immediately after running **DELETE**, the space will not be reclaimed. After executing **DELETE**, execute 1000 non-**SELECT** transactions, or wait for 1s and then execute one transaction. Then, run **VACUUM FULL** to reclaim the space.

## Syntax

- Reclaim space and update statistics information, no requirements for keyword orders.

```
VACUUM [ ( { FULL | FREEZE | VERBOSE | {ANALYZE | ANALYSE }} [,...] ) ]
    [ table_name [ (column_name [, ...] ) ] ] [ PARTITION ( partition_name ) ];
```

- Reclaim space, without updating statistics information.

```
VACUUM [ FULL [COMPACT] ] [ FREEZE ] [ VERBOSE ] [ table_name ] [ PARTITION
( partition_name ) ];
```

- Reclaim space and update statistics information, and require keywords in order.

```
VACUUM [ FULL ] [ FREEZE ] [ VERBOSE ] { ANALYZE | ANALYSE } [ VERBOSE ]
    [ table_name [ (column_name [, ...] ) ] ] [ PARTITION ( partition_name ) ];
```

## Parameter Description

- **FULL**

  Selects "FULL" vacuum, which can reclaim more space, but takes much longer and exclusively locks the table.

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> NOTE
>
> Using **FULL** will cause statistics missing. To collect statistics, add the keyword **ANALYZE** to **VACUUM FULL**.

- **FREEZE**

  Is equivalent to running **VACUUM** with the **vacuum_freeze_min_age** parameter set to **zero**.

- **VERBOSE**

  Prints a detailed VACUUM activity report for each table.

- **ANALYZE | ANALYSE**

  Updates statistics used by the planner to determine the most efficient way to execute a query.

- **table_name**

  Specifies the name (optionally schema-qualified) of a specific table to vacuum.

  Value range: name of a specific table to vacuum Defaults are all tables in the current database.

- **column_name**

  Specifies the name of the column to be analyzed. This parameter must be used together with **ANALYZE**.

  Value range: name of a specific field to analyze Defaults are all columns.

- **PARTITION**

  **COMPACT** and **PARTITION** cannot be used at the same time.

- **partition_name**

  Specifies the partition name of the table to be cleared. Defaults are all partitions.

- **DELTAMERGE**

  (For column-store tables) Migrates data from the delta table to primary tables. For a column-store table, this operation is controlled by **deltarow_threshold**. For details, see **enable_delta_store** and **Parameter Description**.

  > NOTE
  >
  > The following DFX functions are provided to return the data storage in the delta table of a column-store table:
  >
  > - **pgxc_get_delta_info(TEXT)**: The input parameter is a column-store table name. The delta table information on each node is collected and displayed, including the number of active tuples, table size, and maximum block ID.
  > - **get_delta_info(TEXT)**: The input parameter is a column-store table name. The system summarizes the results returned from pgxc_get_delta_info and returns the total number of active tuples, total table size, and maximum block ID in the delta table.

## Examples

```
-- Create an index in the tpcds.reason table:
CREATE UNIQUE INDEX ds_reason_index1 ON tpcds.reason(r_reason_sk);

-- Do VACUUM to the tpcds.reason table that has indexes:
```

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```
openGauss=# VACUUM (VERBOSE, ANALYZE) tpcds.reason;

-- Drop an index.
openGauss=# DROP INDEX ds_reason_index1 CASCADE;
openGauss=# DROP TABLE tpcds.reason;
```

## Suggestions

- vacuum
  - **VACUUM** cannot be executed inside a transaction block.
  - It is recommended that active production databases be vacuumed frequently (at least nightly), in order to remove dead rows. It is strongly recommended that you run **VACUUM ANALYZE** after adding or deleting a large number of records.
  - **FULL** is recommended only in special scenarios. For example, you wish to physically narrow the table to decrease the occupied disk space after deleting most rows of a table.
  - Before performing the VACUUM FULL operation, you are advised to delete all indexes in related tables, run **VACUUM FULL**, and then re-create the index.

# 12.14.172 VALUES

## Function

Computes a row or a set of rows based on given values. It is most commonly used to generate a constant table within a large statement.

## Precautions

- **VALUES** lists with large numbers of rows should be avoided, as you might encounter out-of-memory failures or poor performance. **VALUES** appearing within **INSERT** is a special case, because the desired column types are known from the **INSERT**'s target table, and need not be inferred by scanning the **VALUES** list. In this case, **VALUE** can handle larger lists than are practical in other contexts.
- If more than one row is specified, all the rows must have the same number of elements.

## Syntax

```
VALUES {( expression [, ...] )} [, ...]
  [ ORDER BY { sort_expression [ ASC | DESC | USING operator ] } [, ...] ]
  [ LIMIT { count | ALL } ]
  [ OFFSET start [ ROW | ROWS ] ]
  [ FETCH { FIRST | NEXT } [ count ] { ROW | ROWS } ONLY ];
```

## Parameter Description

- **expression**

  Specifies a constant or expression to compute and insert at the indicated place in the resulting table or set of rows.

  In a **VALUES** list appearing at the top level of an **INSERT**, an expression can be replaced by **DEFAULT** to indicate that the destination column's default

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value should be inserted. **DEFAULT** cannot be used when **VALUES** appears in other contexts.

- **sort_expression**

  Specifies an expression or integer constant indicating how to sort the result rows.

- **ASC**

  Specifies an ascending sort order.

- **DESC**

  Specifies a descending sort order.

- **operator**

  Specifies a sorting operator.

- **count**

  Specifies the maximum number of rows to return.

- **OFFSET start { ROW | ROWS }**

  Specifies the maximum number of returned rows, whereas **start** specifies the number of rows to skip before starting to return rows.

- **FETCH { FIRST | NEXT } [ count ] { ROW | ROWS } ONLY**

  The **FETCH** clause restricts the total number of rows starting from the first row of the return query result, and the default value of **count** is **1**.

### Examples

See **Examples** in INSERT.

# 12.15 Appendix

## 12.15.1 GIN Indexes

### 12.15.1.1 Introduction

Generalized Inverted Index (GIN) is designed for handling cases where the items to be indexed are composite values, and the queries to be handled by the index need to search for element values that appear within the composite items. For example, the items could be documents, and the queries could be searches for documents containing specific words.

We use the word "item" to refer to a composite value that is to be indexed, and the word "key" to refer to an element value. GIN stores and searches for keys, not item values.

A GIN index stores a set of (key, posting list) key-value pairs, where a posting list is a set of row IDs in which the key occurs. The same row ID can appear in multiple posting lists, since an item can contain more than one key. Each key value is stored only once, so a GIN index is very compact for cases where the same key appears many times.

GIN is generalized in the sense that the GIN access method code does not need to know the specific operations that it accelerates. Instead, it uses custom strategies

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defined for particular data types. The strategy defines how keys are extracted from indexed items and query conditions, and how to determine whether a row that contains some of the key values in a query actually satisfies the query.

## 12.15.1.2 Scalability

The GIN interface has a high level of abstraction, requiring the access method implementer only to implement the semantics of the data type being accessed. The GIN layer itself takes care of concurrency, logging and searching the tree structure.

All it takes to get a GIN access method working is to implement multiple user-defined methods, which define the behavior of keys in the tree and the relationships between keys, indexed items, and indexable queries. In short, GIN combines extensibility with generality, code reuse, and a clean interface.

There are four methods that an operator class for GIN must provide:

- int compare(Datum a, Datum b)

  Compares two keys (not indexed items) and returns an integer less than zero, zero, or greater than zero, indicating whether the first key is less than, equal to, or greater than the second. Null keys are never passed to this function.

- Datum *extractValue(Datum itemValue, int32 *nkeys, bool **nullFlags)

  Returns an array of keys given an item to be indexed. The number of returned keys must be stored into ***nkeys**. If any of the keys can be null, also palloc an array of ***nkeys** bool fields, store its address at ***nullFlags**, and set these null flags as needed. ***nullFlags** can be left **NULL** (its initial value) if all keys are not-null. The returned value can be **NULL** if the item contains no keys.

- Datum *extractQuery(Datum query, int32 *nkeys, StrategyNumber n, bool **pmatch, Pointer **extra_data, bool **nullFlags, int32 *searchMode)

  Returns a palloc'd array of keys given a value to be queried; that is, query is the value on the right-hand side of an indexable operator whose left-hand side is the indexed column. n is the strategy number of the operator within the operator class. Often, **extractQuery** will need to consult n to determine the data type of query and the method it should use to extract key values. The number of returned keys must be stored into ***nkeys**. If any of the keys can be null, also palloc an array of ***nkeys** bool fields, store its address at ***nullFlags**, and set these null flags as needed. ***nullFlags** can be left NULL (its initial value) if all keys are non-null. The returned value can be NULL if the query contains no keys.

  **searchMode** is an output argument that allows **extractQuery** to specify details about how the search will be done. If ***searchMode** is set to **GIN_SEARCH_MODE_DEFAULT** (which is the value it is initialized to before call), only items that match at least one of the returned keys are considered candidate matches. If ***searchMode** is set to **GIN_SEARCH_MODE_INCLUDE_EMPTY**, then in addition to items containing at least one matching key, items that contain no keys at all are considered candidate matches. (This mode is useful for implementing is-subset-of operators, for example.) If ***searchMode** is set to **GIN_SEARCH_MODE_ALL**, then all non-null items in the index are considered candidate matches, whether they match any of the returned keys or not.

  **pmatch** is an output argument for use when partial match is supported. To use it, **extractQuery** must allocate an array of *nkeys Booleans and store its

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address at ***pmatch**. Each element of the array should be set to **TRUE** if the corresponding key requires partial match, **FALSE** if not. If ***pmatch** is set to **NULL** then GIN assumes partial match is not required. The variable is initialized to NULL before call, so this argument can simply be ignored by operator classes that do not support partial match.

**extra_data** is an output argument that allows **extractQuery** to pass additional data to the **consistent** and **comparePartial** methods. To use it, **extractQuery** must allocate an array of ***nkeys** pointers and store its address at ***extra_data**, then store whatever it wants to into the individual pointers. The variable is initialized to **NULL** before call, so this argument can simply be ignored by operator classes that do not require extra data. If ***extra_data** is set, the whole array is passed to the **consistent** method, and the appropriate element to the **comparePartial** method.

- bool consistent(bool check[], StrategyNumber n, Datum query, int32 nkeys, Pointer extra_data[], bool *recheck, Datum queryKeys[], bool nullFlags[])

  Returns **TRUE** if an indexed item satisfies the query operator with StrategyNumber **n** (or might satisfy it, if the recheck indication is returned). This function does not have direct access to the indexed item's value, since GIN does not store items explicitly. Rather, what is available is knowledge about which key values extracted from the query appear in a given indexed item. The check array has length **nkeys**, which is the same as the number of keys previously returned by **extractQuery** for this query datum. Each element of the check array is **TRUE** if the indexed item contains the corresponding query key, for example, if (check[i] == TRUE), the i-th key of the **extractQuery** result array is present in the indexed item. The original query datum is passed in case the **consistent** method needs to consult it, and so are the **queryKeys[]** and **nullFlags[]** arrays previously returned by **extractQuery**. **extra_data** is the extra-data array returned by **extractQuery**, or **NULL** if none.

  When **extractQuery** returns a null key in **queryKeys[]**, the corresponding **check[]** element is **TRUE** if the indexed item contains a null key; that is, the semantics of **check[]** are like **IS NOT DISTINCT FROM**. The **consistent** function can examine the corresponding **nullFlags[]** element if it needs to tell the difference between a regular value match and a null match.

  On success, ***recheck** should be set to **TRUE** if the heap tuple needs to be rechecked against the query operator, or **FALSE** if the index test is exact. That is, a **FALSE** return value guarantees that the heap tuple does not match the query; a **TRUE** return value with ***recheck** set to **FALSE** guarantees that the heap tuple matches the query; and a **TRUE** return value with ***recheck** set to **TRUE** means that the heap tuple might match the query, so it needs to be fetched and rechecked by evaluating the query operator directly against the originally indexed item.

Optionally, an operator class for GIN can supply the following method:

- int comparePartial(Datum partial_key, Datum key, StrategyNumber n, Pointer extra_data)

  Compares a partial-match query key to an index key. Returns an integer whose sign indicates the result: less than zero means the index key does not match the query, but the index scan should continue; zero means that the index key matches the query; greater than zero indicates that the index scan should stop because no more matches are possible. The strategy number **n** of

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the operator that generated the partial match query is provided, in case its semantics are needed to determine when to end the scan. Also, **extra_data** is the corresponding element of the extra-data array made by **extractQuery**, or **NULL** if none. Null keys are never passed to this function.

To support "partial match" queries, an operator class must provide the **comparePartial** method, and its **extractQuery** method must set the **pmatch** parameter when a partial-match query is encountered. For details, see **Partial Match Algorithm**.

The actual data types of the various Datum values mentioned in this section vary depending on the operator class. The item values passed to **extractValue** are always of the operator class's input type, and all key values must be of the class's **STORAGE** type. The type of the query argument passed to **extractQuery**, consistent and **triConsistent** is whatever is specified as the right-hand input type of the class member operator identified by the strategy number. This need not be the same as the item type, so long as key values of the correct type can be extracted from it.

### 12.15.1.3 Implementation

Internally, a GIN index contains a B-tree index constructed over keys, where each key is an element of one or more indexed items (a member of an array, for example) and where each tuple in a leaf page contains either a pointer to a B-tree of heap pointers (a "posting tree"), or a simple list of heap pointers (a "posting list") when the list is small enough to fit into a single index tuple along with the key value.

Multi-column GIN indexes are implemented by building a single B-tree over composite values (column number, key value). The key values for different columns can be of different types.

## GIN Fast Update Technique

Updating a GIN index tends to be slow because of the intrinsic nature of inverted indexes: inserting or updating one heap row can cause many inserts into the index. After the table is vacuumed or if the pending list becomes larger than **work_mem**, the entries are moved to the main GIN data structure using the same bulk insert techniques used during initial index creation. This greatly increases the GIN index update speed, even counting the additional vacuum overhead. Moreover the overhead work can be done by a background process instead of in foreground query processing.

The main disadvantage of this approach is that searches must scan the list of pending entries in addition to searching the regular index, and so a large list of pending entries will slow searches significantly. Another disadvantage is that, while most updates are fast, an update that causes the pending list to become "too large" will incur an immediate cleanup cycle and be much slower than other updates. Proper use of autovacuum can minimize both of these problems.

If consistent response time (of entity cleanup and of update) is more important than update speed, use of pending entries can be disabled by turning off the **fastupdate** storage parameter for a GIN index. For details, see **12.14.64 CREATE INDEX**.

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### Partial Match Algorithm

GIN can support "partial match" queries, in which the query does not determine an exact match for one or more keys, but the possible matches fall within a narrow range of key values (within the key sorting order determined by the **compare** support method). The **extractQuery** method, instead of returning a key value to be matched exactly, returns a key value that is the lower bound of the range to be searched, and sets the **pmatch** flag true. The key range is then scanned using the **comparePartial** method. **comparePartial** must return zero for a matching index key, less than zero for a non-match that is still within the range to be searched, or greater than zero if the index key is past the range that could match.

## 12.15.1.4 GIN Tips and Tricks

Create vs. Insert

Insertion into a GIN index can be slow due to the likelihood of many keys being inserted for each item. So, for bulk insertions into a table it is advisable to drop the GIN index and recreate it after finishing bulk insertion. GUC parameters related to GIN index creation and query performance as follows:

- maintenance_work_mem

  Build time for a GIN index is very sensitive to the **maintenance_work_mem** setting;

- work_mem

  During a series of insertions into an existing GIN index that has **fastupdate** enabled, the system will clean up the pending-entry list whenever the list grows larger than **work_mem**. To avoid fluctuations in observed response time, it is desirable to have pending-list cleanup occur in the background (that is, via autovacuum). Foreground cleanup operations can be avoided by increasing **work_mem** or making **autovacuum** more aggressive. However, increasing **work_mem** means that if a foreground cleanup occurs, it will take even longer.

- gin_fuzzy_search_limit

  The primary goal of developing GIN indexes was to support highly scalable full-text search in GaussDB. A full-text search often returns a very large set of results. This often happens when the query contains very frequent words, so that the large result set is not even useful. Since reading many tuples from the disk and sorting them could take a lot of time, this is unacceptable for production.

  To facilitate controlled execution of such queries, GIN has a configurable soft upper limit on the number of rows returned: the **gin_fuzzy_search_limit** configuration parameter. The default value **0** indicates that there is no limit on the returned set. If a non-zero limit is set, then the returned set is a subset of the whole result set, chosen at random.

# 12.15.2 Extended Functions

The following table lists the extended functions supported by GaussDB and they are for reference only.

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| Type | Name | Description |
| --- | --- | --- |
| Trigger function | pg_get_triggerdef(trigger_oid) | Gets **CREATE** [ **CONSTRAINT** ] **TRIGGER** command for triggers. |
| | pg_get_triggerdef(trigger_oid, pretty_bool) | Gets **CREATE** [ **CONSTRAINT** ] **TRIGGER** command for triggers. |

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# 13 Stored Procedures

## 13.1 Overview

In GaussDB, business rules and logics are saved as stored procedures.

A stored procedure is a combination of SQL, PL/SQL, and Java statements. Stored procedures can move the code that executes business rules from applications to databases. Therefore, the code storage can be used by multiple programs at a time.

For details about how to create and call a stored procedure, see **12.14.71 CREATE PROCEDURE**.

## 13.2 Data Types

A data type refers to a value set and an operation set defined on the value set. The GaussDB database consists of tables, each of which is defined by its own columns. Each column corresponds to a data type. GaussDB uses corresponding functions to perform operations on data based on data types. For example, GaussDB can perform addition, subtraction, multiplication, and division operations on data of numeric values.

## 13.3 Data Type Conversion

Certain data types in the database support implicit data type conversions, such as assignments and parameters called by functions. For other data types, you can use the type conversion functions provided by GaussDB, such as the **CAST** function, to forcibly convert them.

**Table 13-1** lists common implicit data type conversions in GaussDB.

NOTICE

The valid value range of **DATE** supported by GaussDB is from 4713 B.C. to 294276 A.D.

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**Table 13-1** Implicit data type conversions

| Raw Data Type | Target Data Type | Remarks |
| --- | --- | --- |
| CHAR | VARCHAR2 | - |
| CHAR | NUMBER | Raw data must consist of digits. |
| CHAR | DATE | Raw data cannot exceed the valid date range. |
| CHAR | RAW | - |
| CHAR | CLOB | - |
| VARCHAR2 | CHAR | - |
| VARCHAR2 | NUMBER | Raw data must consist of digits. |
| VARCHAR2 | DATE | Raw data cannot exceed the valid date range. |
| VARCHAR2 | CLOB | - |
| NUMBER | CHAR | - |
| NUMBER | VARCHAR2 | - |
| DATE | CHAR | - |
| DATE | VARCHAR2 | - |
| RAW | CHAR | - |
| RAW | VARCHAR2 | - |
| CLOB | CHAR | - |
| CLOB | VARCHAR2 | - |
| CLOB | NUMBER | Raw data must consist of digits. |
| INT4 | CHAR | - |

# 13.4 Arrays and Records

## 13.4.1 Arrays

### Use of Array Types

Before the use of arrays, an array type needs to be defined:

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Define an array type immediately after the **AS** keyword in a stored procedure. Run the following statement:

```
TYPE array_type IS VARRAY(size) OF data_type;
```

Related parameters are as follows:

- **array_type**: indicates the name of the array type to be defined.
- **VARRAY**: indicates the array type to be defined.
- **size**: indicates the maximum number of members in the array type to be defined. The value is a positive integer.
- **data_type**: indicates the types of members in the array type to be created.

NOTE

- In GaussDB, an array automatically increases. If an access violation occurs, a **NULL** value will be returned, and no error message will be reported.
- The scope of an array type defined in a stored procedure takes effect only in this storage process.
- It is recommended that you use one of the preceding methods to define an array type. If both methods are used to define the same array type, GaussDB prefers the array type defined in a stored procedure to declare array variables.

GaussDB supports the access of content in an array by using parentheses, and the **extend**, **count**, **first**, **last prior**, **next**, **exists**, **trim**, and **delete** functions.

NOTE

If the stored procedure contains DML statements (**SELECT**, **UPDATE**, **INSERT**, or **DELETE**), DML statements can access array elements only using brackets. In this way, it may be separated from the function expression area.

## Examples

```
-- Perform array operations in the stored procedure.
openGauss=# CREATE OR REPLACE PROCEDURE array_proc AS
DECLARE
    TYPE ARRAY_INTEGER IS VARRAY(1024) OF INTEGER;--Define the array type.
    ARRINT ARRAY_INTEGER: = ARRAY_INTEGER();  --Declare the variable of the array type.
BEGIN
    ARRINT.EXTEND(10);
    FOR I IN 1..10 LOOP
        ARRINT(I) := I;
    END LOOP;
    DBE_OUTPUT.PRINT_LINE(ARRINT.COUNT);
    DBE_OUTPUT.PRINT_LINE(ARRINT(1));
    DBE_OUTPUT.PRINT_LINE(ARRINT(10));
    DBE_OUTPUT.PRINT_LINE(ARRINT(ARRINT.FIRST));
    DBE_OUTPUT.PRINT_LINE(ARRINT(ARRINT.LAST));
    DBE_OUTPUT.PRINT_LINE(ARRINT(ARRINT.NEXT(ARRINT.FIRST)));
    DBE_OUTPUT.PRINT_LINE(ARRINT(ARRINT.PRIOR(ARRINT.LAST)));
    ARRINT.TRIM();
    IF ARRINT.EXISTS(10) THEN
       DBE_OUTPUT.PRINT_LINE('Exist 10th element');
    ELSE
       DBE_OUTPUT.PRINT_LINE('Not exist 10th element');
    END IF;
    DBE_OUTPUT.PRINT_LINE(ARRINT.COUNT);
    DBE_OUTPUT.PRINT_LINE(ARRINT(ARRINT.FIRST));
    DBE_OUTPUT.PRINT_LINE(ARRINT(ARRINT.LAST));
    ARRINT.DELETE();
END;
/
```

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```
-- Call the stored procedure.
openGauss=# CALL array_proc();

-- Delete the stored procedure.
openGauss=# DROP PROCEDURE array_proc;
```

# 13.4.2 Records

## Record Variables

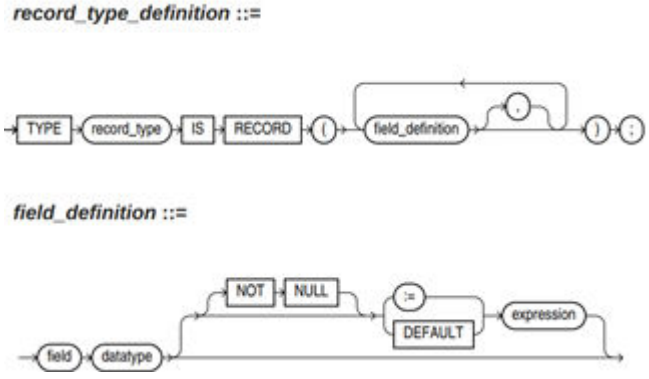
Perform the following operations to create a record variable:

Define a record type and use this type to declare a variable.

## Syntax

For the syntax of the record type, see **Figure 13-1**.

**Figure 13-1** Syntax of the record type




The above syntax diagram is explained as follows:

- *record_type*: specifies the record type.
- *field*: specifies member variables of this type.
- *datatype*: specifies data types for the member variables.
- *expression*: specifies the expression for setting a default value.

NOTE

In GaussDB:

- When assigning values to record variables, you can:
  - Declare a record type and define member variables of this type when you declare a function or stored procedure.
  - Assign the value of a record variable to another record variable.
  - Use **SELECT INTO** or **FETCH** to assign values to record variables.
  - Assign the **NULL** value to a record variable.
- The **INSERT** and **UPDATE** statements cannot use a record variable to insert or update data.
- Just like a variable, a record column of the compound type does not have a default value in the declaration.

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## Examples

```
The table used in the following stored procedure is defined as follows:
openGauss=# \d emp_rec
               Table "public.emp_rec"
  Column  |              Type              | Modifiers
----------+--------------------------------+-----------
 empno    | numeric(4,0)                   | not null
 ename    | character varying(10)          |
 job      | character varying(9)           |
 mgr      | numeric(4,0)                   |
 hiredate | timestamp(0) without time zone |
 sal      | numeric(7,2)                   |
 comm     | numeric(7,2)                   |
 deptno   | numeric(2,0)                   |

-- Perform array operations in the stored procedure.
openGauss=# CREATE OR REPLACE FUNCTION regress_record(p_w VARCHAR2)
RETURNS
VARCHAR2  AS $$
DECLARE

  -- Declare a record type.
  type rec_type is record (name  varchar2(100), epno int);
  employer rec_type;

  -- Use %type to declare a record type.
  type rec_type1 is record (name  emp_rec.ename%type, epno int not null :=10);
  employer1 rec_type1;

  -- Declare a record type with a default value.
  type rec_type2 is record (
        name varchar2 not null := 'SCOTT',
        epno int not null :=10);
   employer2 rec_type2;
   CURSOR C1 IS  select ename,empno from emp_rec order by 1 limit 1;

BEGIN
     -- Assign a value to a member record variable.
    employer.name := 'WARD';
    employer.epno = 18;
    raise info 'employer name: % , epno:%', employer.name, employer.epno;

     -- Assign the value of a record variable to another variable.
    employer1 := employer;
    raise info 'employer1 name: % , epno: %',employer1.name, employer1.epno;

     -- Assign the NULL value to a record variable.
    employer1 := NULL;
    raise info 'employer1 name: % , epno: %',employer1.name, employer1.epno;

     -- Obtain the default value of a record variable.
    raise info 'employer2 name: % ,epno: %', employer2.name, employer2.epno;

     -- Use a record variable in the FOR loop.
     for employer in select ename,empno from emp_rec order by 1  limit 1
         loop
             raise info 'employer name: % , epno: %', employer.name, employer.epno;
         end loop;

     -- Use a record variable in the SELECT INTO statement.
     select ename,empno  into employer2 from emp_rec order by 1 limit 1;
     raise info 'employer name: % , epno: %', employer2.name, employer2.epno;

     -- Use a record variable in a cursor.
     OPEN C1;
     FETCH C1 INTO employer2;
     raise info 'employer name: % , epno: %', employer2.name, employer2.epno;
     CLOSE C1;
     RETURN employer.name;
```

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```
END;
$$
LANGUAGE plpgsql;

-- Call the stored procedure.
openGauss=# CALL regress_record('abc');

-- Delete the stored procedure.
openGauss=# DROP PROCEDURE regress_record;
```

# 13.5 DECLARE Syntax

## 13.5.1 Basic Structure

### Structure

A PL/SQL block can contain a sub-block which can be placed in any section. The following describes the architecture of a PL/SQL block:

- Declaration section: declares variables, types, cursors, and regional stored procedures and functions used in the PL/SQL block.
  ```
  DECLARE
  ```

  NOTE

  This section is optional if no variables need to be declared.

  - An anonymous block may omit the **DECLARE** keyword if no variable needs to be declared.
  - For a stored procedure, **AS** is used, which is equivalent to **DECLARE**. The **AS** keyword must be reserved even if there is no variable declaration section.
- Execution section: specifies procedure and SQL statements. It is the main section of a program and is mandatory.
  ```
  BEGIN
  ```
- Exception-handling section: processes errors. It is optional.
  ```
  EXCEPTION
  ```
- **End**
  ```
  END;
  /
  ```

NOTICE

You are not allowed to use consecutive tabs in the PL/SQL block because they may result in an exception when the **gsql** tool is executed with the **-r** parameter specified.

### Types

PL/SQL blocks are classified into the following types:

- Anonymous block: a dynamic block that can be executed only for once. For details about the syntax, see **Figure 13-2**.

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- Subprogram: a stored procedure, function, operator, or advanced package stored in a database. A subprogram created in a database can be called by other programs.

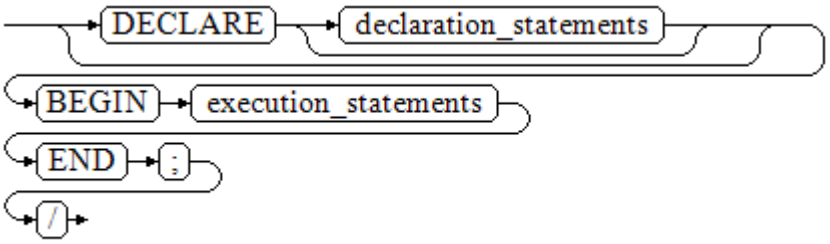
## 13.5.2 Anonymous Blocks

An anonymous block applies to a script infrequently executed or a one-off activity. An anonymous block is executed in a session and is not stored.

### Syntax

Figure 13-2 shows the syntax diagrams for an anonymous block.

**Figure 13-2** anonymous_block::=




Details about the syntax diagram are as follows:

- The execution section of an anonymous block starts with a **BEGIN** statement, has a break with an **END** statement, and ends with a semicolon (;). Type a slash (/) and press **Enter** to execute the statement.

  **NOTICE**

  The terminator "/" must be written in an independent row.

- The declaration section includes the variable definition, type, and cursor definition.
- A simplest anonymous block does not execute any commands. However, at least one statement, even a **NULL** statement, must be presented in any implementation blocks.

### Examples

The following lists basic anonymous block programs:

```
-- Null statement block
openGauss=# BEGIN
    NULL;
END;
/

-- Display information on the console.
openGauss=# BEGIN
    dbe_output.print_line('hello world!');
END;
/
```

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```
-- Display variable content on the console.
openGauss=# DECLARE
    my_var VARCHAR2(30);
BEGIN
    my_var :='world';
    dbe_output.print_line('hello'||my_var);
END;
/
```

## 13.5.3 Subprograms

A subprogram stores stored procedures, functions, operators, and advanced packages. A subprogram created in a database can be called by other programs.

# 13.6 Basic Statements

During PL/SQL programming, you may define some variables, assign values to variables, and call other stored procedures. The following sections describe basic PL/SQL statements, including variable definition statements, value assignment statements, call statements, and return statements.

NOTE

You are not advised to call the SQL statements containing passwords in the stored procedures because authorized users may view the stored procedure file in the database and password information is leaked. If a stored procedure contains other sensitive information, permission to access this procedure must be configured, preventing information leakage.

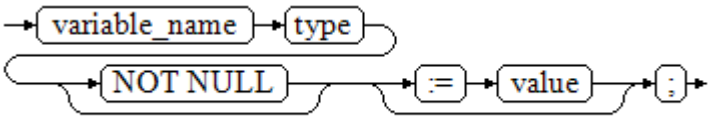
## 13.6.1 Variable Definition Statements

This section describes the declaration of variables in the PL/SQL and the scope of this variable in codes.

### Variable Declaration

For details about the variable declaration syntax, see **Figure 13-3**.

**Figure 13-3** declare_variable::=




The above syntax diagram is explained as follows:

- **variable_name** indicates the name of a variable.
- **type** indicates the type of a variable.
- **value** indicates the initial value of the variable. (If the initial value is not given, NULL is taken as the initial value.) **value** can also be an expression.

**Example**

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```
openGauss=# DECLARE
   emp_id  INTEGER := 7788; -- Define a variable and assign a value to it.
BEGIN
   emp_id := 5*7784; -- Assign a value to the variable.
END;
/
```

In addition to the declaration of basic variable types, **%TYPE** and **%ROWTYPE** can be used to declare variables related to table columns or table structures.

**%TYPE Attribute**

**%TYPE** declares a variable to be of the same data type as a previously declared variable (for example, a column in a table). For example, if you want to define the **my_name** variable whose data type is the same as the data type of the **firstname** column in the **employee** table, you can define the variable as follows:

```
my_name employee.firstname%TYPE
```

In this way, you can declare **my_name** without the need of knowing the data type of **firstname** in **employee**, and the data type of **my_name** can be automatically updated when the data type of **firstname** changes.

**%ROWTYPE Attribute**

**%ROWTYPE** declares data types of a set of data. It stores a row of table data or results fetched from a cursor. For example, if you want to define a set of data with the same column names and column data types as the **employee** table, you can define the data as follows:

```
my_employee employee%ROWTYPE
```

NOTE

In the environment with multiple CNs, the **%ROWTYPE** and **%TYPE** attributes of the temporary table cannot be declared in a stored procedure. The temporary table is valid only in the current session. During compilation, other CNs cannot view the temporary table of the current CN. Therefore, if there are multiple CNs, the system displays a message indicating that the temporary table does not exist.

## Scope of a Variable

The scope of a variable indicates the accessibility and availability of the variable in code block. In other words, a variable takes effect only within its scope.

- To define a function scope, a variable must declare and create a **BEGIN-END** block in the declaration section. The necessity of such declaration is also determined by block structure, which requires that a variable has different scopes and lifetime during a process.
- A variable can be defined multiple times in different scopes, and inner definition can cover outer one.
- A variable defined in an outer block can also be used in a nested block. However, the outer block cannot access variables in the nested block.

**Example**

```
openGauss=# DECLARE
   emp_id  INTEGER :=7788; -- Define a variable and assign a value to it.
   outer_var  INTEGER :=6688; -- Define a variable and assign a value to it.
BEGIN
   DECLARE
```

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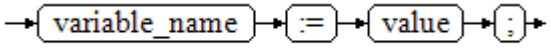
```
    emp_id INTEGER :=7799; -- Define a variable and assign a value to it.
    inner_var  INTEGER :=6688; -- Define a variable and assign a value to it.
  BEGIN
    dbe_output.print_line('inner emp_id ='||emp_id); -- Display the value 7799.
    dbe_output.print_line('outer_var ='||outer_var); -- Reference a variable of an outer block.
  END;
  dbe_output.print_line('outer emp_id ='||emp_id); -- Display the value 7788.
END;
/
```

## 13.6.2 Assignment Statements

### Variable Syntax

Figure 13-4 shows the syntax diagram for assigning a value to a variable.

**Figure 13-4** assignment_value::=




The above syntax diagram is explained as follows:

- *variable_name*: specifies the name of a variable.
- *value* can be a value or an expression. The type of *value* must be compatible with the type of *variable_name*.

### Variable Value Assignment Example

```
openGauss=# DECLARE
  emp_id  INTEGER := 7788; --Assignment
BEGIN
  emp_id := 5; --Assignment
  emp_id := 5*7784;
END;
/
```

### INTO/BULK COLLECT INTO

**INTO** and **BULK COLLECT INTO** store values returned by statements in a stored procedure to variables. **BULK COLLECT INTO** allows some or all returned values to be temporarily stored in an array.

### Example

```
openGauss=# DECLARE
  my_id integer;
BEGIN
  select id into my_id from customers limit 1; -- Assign a value.
END;
/

openGauss=# DECLARE
  type id_list is varray(6) of customers.id%type;
  id_arr id_list;
BEGIN
  select id bulk collect into id_arr from customers order by id DESC limit 20; -- Assign values in batches.
END;
/
```

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NOTICE

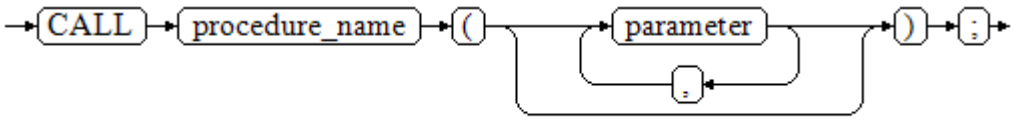
**BULK COLLECT INTO** can only assign values to arrays in batches. Use **LIMIT** properly to prevent performance deterioration caused by excessive operations on data.

## 13.6.3 Call Statements

### Syntax

Figure 13-5 shows the syntax diagram for calling a clause.

**Figure 13-5** call_clause::=




The above syntax diagram is explained as follows:

- *procedure_name*: specifies the name of a stored procedure.
- *parameter*: specifies the parameters for the stored procedure. You can set no parameter or multiple parameters.

### Examples

```
-- Create the stored procedure proc_staffs.
openGauss=# CREATE OR REPLACE PROCEDURE proc_staffs
(
section     NUMBER(6),
salary_sum out NUMBER(8,2),
staffs_count out INTEGER
)
IS
BEGIN
SELECT sum(salary), count(*) INTO salary_sum, staffs_count FROM hr.staffs where section_id = section;
END;
/

-- Create the stored procedure proc_return.
openGauss=# CREATE OR REPLACE PROCEDURE proc_return
AS
v_num NUMBER(8,2);
v_sum INTEGER;
BEGIN
proc_staffs(30, v_sum, v_num);  --Call a statement.
dbe_output.print_line(v_sum||'#'||v_num);
RETURN;  --Return a statement.
END;
/

-- Call the stored procedure proc_return.
openGauss=# CALL proc_return();

-- Delete stored procedures.
openGauss=# DROP PROCEDURE proc_staffs;
openGauss=# DROP PROCEDURE proc_return;
```

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```
--Create the function func_return.
openGauss=# CREATE OR REPLACE FUNCTION func_return returns void
language plpgsql
AS $$
DECLARE
v_num INTEGER := 1;
BEGIN
dbe_output.print_line(v_num);
RETURN;  --Return a statement.
END $$;


-- Call the function func_return.
openGauss=#  CALL func_return();

-- Delete the function.
openGauss=#  DROP FUNCTION func_return;
```

# 13.7 Dynamic Statements

## 13.7.1 Executing Dynamic Query Statements

You can perform dynamic queries using **EXECUTE IMMEDIATE** or **OPEN FOR** in GaussDB. **EXECUTE IMMEDIATE** dynamically executes **SELECT** statements and **OPEN FOR** combines use of cursors. If you need to store query results in a dataset, use **OPEN FOR**.

### EXECUTE IMMEDIATE

**Figure 13-6** shows the syntax diagram.

**Figure 13-6** EXECUTE IMMEDIATE dynamic_select_clause::=

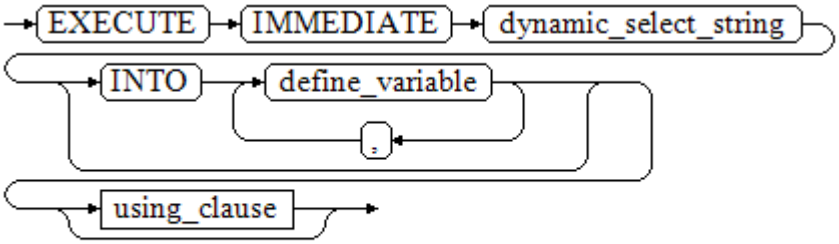
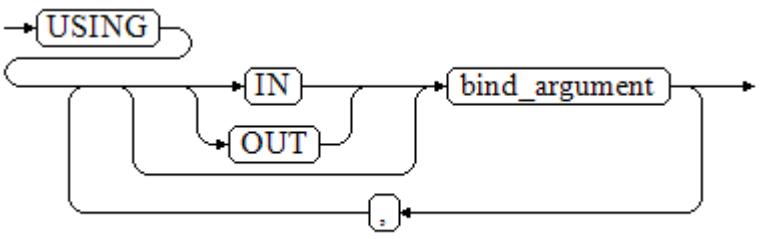



**Figure 13-7** shows the syntax diagram for **using_clause**.

**Figure 13-7** using_clause::=

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The above syntax diagram is explained as follows:

- *define_variable*: specifies a variable to store single-row query results.
- **USING IN** *bind_argument*: specifies the variable whose value is passed to the dynamic SQL statement. The variable is used when a dynamic placeholder exists in *dynamic_select_string*.
- **USING OUT** *bind_argument*: specifies the variable that stores a value returned by the dynamic SQL statement.

**NOTICE**

- In query statements, **INTO** and **OUT** cannot coexist.
- A placeholder name starts with a colon (:) followed by digits, characters, or strings, corresponding to *bind_argument* in the **USING** clause.
- *bind_argument* can only be a value, variable, or expression. It cannot be a database object such as a table name, column name, and data type. That is, *bind_argument* cannot be used to transfer schema objects for dynamic SQL statements. If a stored procedure needs to transfer database objects through *bind_argument* to construct dynamic SQL statements (generally, DDL statements), you are advised to use double vertical bars (||) to concatenate *dynamic_select_clause* with a database object.
- A dynamic PL/SQL block allows duplicate placeholders. That is, a placeholder can correspond to only one *bind_argument* in the **USING** clause.

Example:

```
--Retrieve values from dynamic statements (INTO clause).
openGauss=# DECLARE
  staff_count  VARCHAR2(20);
BEGIN
  EXECUTE IMMEDIATE 'select count(*) from hr.staffs'
    INTO staff_count;
  dbe_output.print_line(staff_count);
END;
/

--Pass and retrieve values (the INTO clause is used before the USING clause).
openGauss=# CREATE OR REPLACE PROCEDURE dynamic_proc
AS
  staff_id     NUMBER(6) := 200;
  first_name   VARCHAR2(20);
  salary       NUMBER(8,2);
BEGIN
  EXECUTE IMMEDIATE 'select first_name, salary from hr.staffs where staff_id = :1'
     INTO first_name, salary
     USING IN staff_id;
  dbe_output.print_line(first_name || ' ' || salary);
END;
/

-- Call the stored procedure.
openGauss=# CALL dynamic_proc();

-- Delete the stored procedure.
openGauss=# DROP PROCEDURE dynamic_proc;
```

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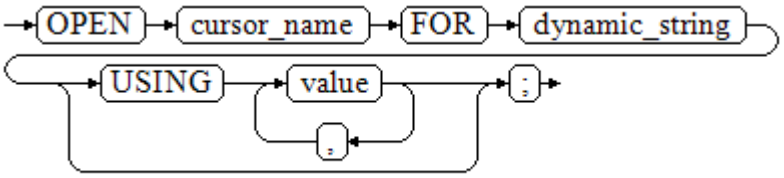
### OPEN FOR

Dynamic query statements can be executed by using **OPEN FOR** to open dynamic cursors.

**Figure 13-8** shows the syntax diagram.

**Figure 13-8** open_for::=




Parameter description:

- *cursor_name*: specifies the name of the cursor to be opened.
- *dynamic_string*: specifies the dynamic query statement.
- **USING** *value*: applies when a placeholder exists in *dynamic_string*.

For details about use of cursors, see **13.11 Cursors**.

Example:

```
openGauss=# DECLARE
    name          VARCHAR2(20);
    phone_number  VARCHAR2(20);
    salary        NUMBER(8,2);
    sqlstr        VARCHAR2(1024);

    TYPE app_ref_cur_type IS REF CURSOR; -- Define the cursor type.
    my_cur app_ref_cur_type; -- Define the cursor variable.

BEGIN
    sqlstr := 'select first_name,phone_number,salary from hr.staffs
        where section_id = :1';
    OPEN my_cur FOR sqlstr USING '30'; -- Open the cursor. USING is optional.
    FETCH my_cur INTO name, phone_number, salary; -- Retrieve the data.
    WHILE my_cur%FOUND LOOP
        dbe_output.print_line(name||'#'||phone_number||'#'||salary);
        FETCH my_cur INTO name, phone_number, salary;
    END LOOP;
    CLOSE my_cur; -- Close the cursor.
END;
/
```

## 13.7.2 Executing Dynamic Non-Query Statements

### Syntax

**Figure 13-9** shows the syntax diagram.

**Figure 13-9** noselect::=

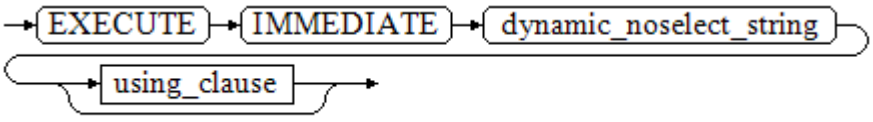



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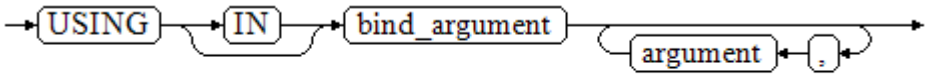
**Figure 13-10** shows the syntax diagram for **using_clause**.

**Figure 13-10** using_clause::=




The above syntax diagram is explained as follows:

**USING IN** *bind_argument* is used to specify the variable whose value is passed to the dynamic SQL statement. The variable is used when a placeholder exists in *dynamic_noselect_string*. That is, a placeholder is replaced by the corresponding *bind_argument* when a dynamic SQL statement is executed. Note that *bind_argument* can only be a value, variable, or expression, and cannot be a database object such as a table name, column name, and data type. If a stored procedure needs to transfer database objects through *bind_argument* to construct dynamic SQL statements (generally, DDL statements), you are advised to use double vertical bars (||) to concatenate *dynamic_select_clause* with a database object. In addition, a dynamic PL/SQL block allows duplicate placeholders. That is, a placeholder can correspond to only one *bind_argument*.

## Examples

```
-- Create a table.
openGauss=# CREATE TABLE sections_t1
(
   section       NUMBER(4) ,
   section_name  VARCHAR2(30),
   manager_id    NUMBER(6),
   place_id      NUMBER(4)
)
DISTRIBUTE BY hash(manager_id);

-- Declare a variable.
openGauss=# DECLARE
   section       NUMBER(4) := 280;
   section_name  VARCHAR2(30) := 'Info support';
   manager_id    NUMBER(6) := 103;
   place_id      NUMBER(4) := 1400;
   new_colname   VARCHAR2(10) := 'sec_name';
BEGIN
-- Execute the query.
    EXECUTE IMMEDIATE 'insert into sections_t1 values(:1, :2, :3, :4)'
       USING section, section_name, manager_id,place_id;
-- Execute the query (duplicate placeholders).
    EXECUTE IMMEDIATE 'insert into sections_t1 values(:1, :2, :3, :1)'
       USING section, section_name, manager_id;
-- Run the ALTER statement. You are advised to use double vertical bars (||) to concatenate the dynamic
DDL statement with a database object.
    EXECUTE IMMEDIATE 'alter table sections_t1 rename section_name to ' || new_colname;
END;
/

-- Query data.
openGauss=# SELECT * FROM sections_t1;

-- Delete the table.
openGauss=# DROP TABLE sections_t1;
```

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# 13.7.3 Dynamically Calling Stored Procedures

This section describes how to dynamically call store procedures. You must use anonymous statement blocks to package stored procedures or statement blocks and append **IN** and **OUT** behind the **EXECUTE IMMEDIATE...USING** statement to input and output parameters.

## Syntax

**Figure 13-11** shows the syntax diagram.

**Figure 13-11** call_procedure::=

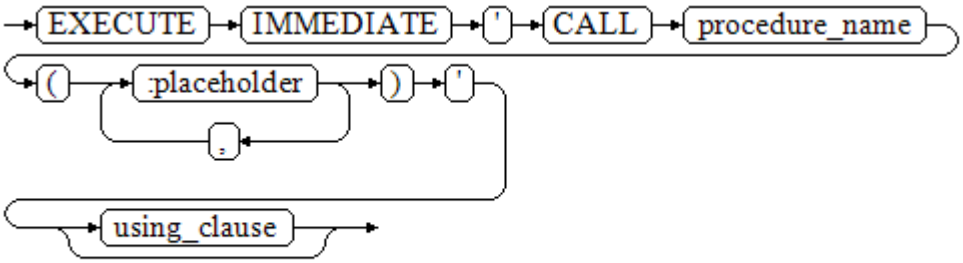
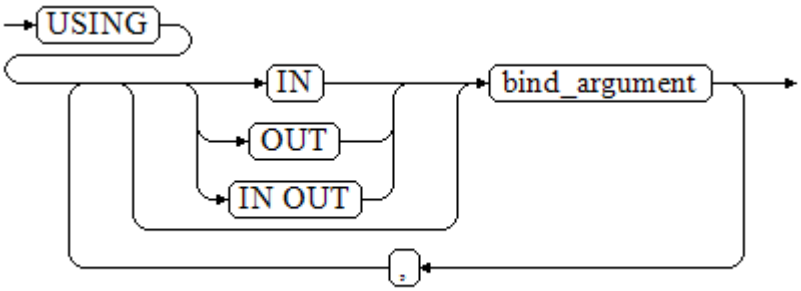



**Figure 13-12** shows the syntax diagram for **using_clause**.

**Figure 13-12** using_clause::=




The above syntax diagram is explained as follows:

- **CALL** *procedure_name*: calls the stored procedure.
- **[:placeholder1,:placeholder2,...]**: specifies the placeholder list of the stored procedure parameters. The numbers of the placeholders and parameters are the same.
- **USING [IN|OUT|IN OUT]** *bind_argument*: specifies the variable whose value is passed to the stored procedure parameter. The modifiers in front of *bind_argument* and of the corresponding parameter are the same.

## Examples

```
--Create the stored procedure proc_add.
openGauss=# CREATE OR REPLACE PROCEDURE proc_add
(
```

```
    param1    in   INTEGER,
    param2    out  INTEGER,
    param3    in   INTEGER
)
AS
BEGIN
   param2:= param1 + param3;
END;
/

openGauss=# DECLARE
    input1 INTEGER:=1;
    input2 INTEGER:=2;
    statement  VARCHAR2(200);
    param2     INTEGER;
BEGIN
   --Declare the call statement.
    statement := 'call proc_add(:col_1, :col_2, :col_3)';
   --Execute the statement.
    EXECUTE IMMEDIATE statement
        USING IN input1, OUT param2, IN input2;
    dbe_output.print_line('result is: '||to_char(param2));
END;
/

-- Delete the stored procedure.
openGauss=# DROP PROCEDURE proc_add;
```

## 13.7.4 Dynamically Calling Anonymous Blocks

This section describes how to execute anonymous blocks in dynamic statements. Append **IN** and **OUT** behind the **EXECUTE IMMEDIATE...USING** statement to input and output parameters.

### Syntax

**Figure 13-13** shows the syntax diagram.

**Figure 13-13** call_anonymous_block::=

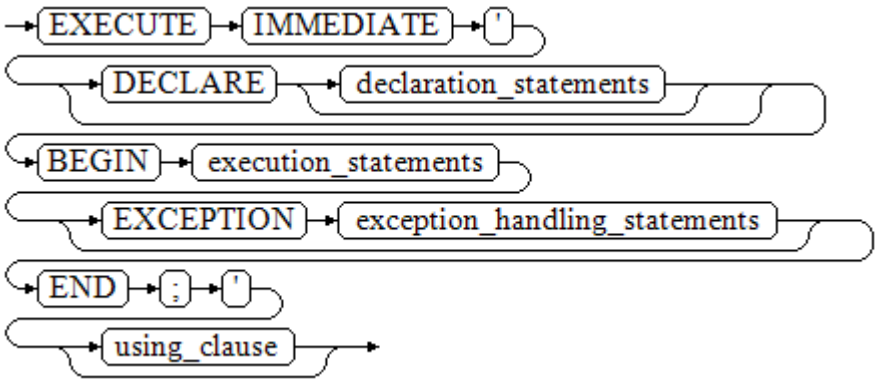



**Figure 13-14** shows the syntax diagram for **using_clause**.

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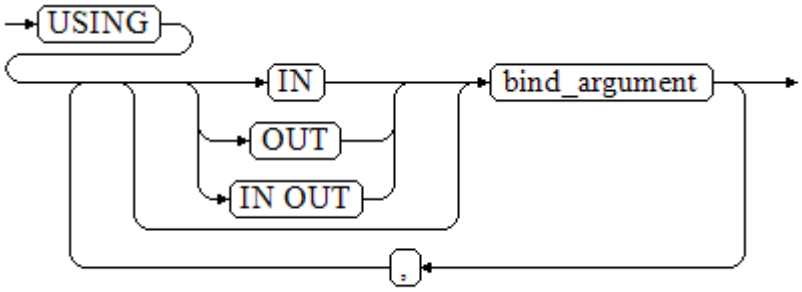
**Figure 13-14** using_clause::=




The above syntax diagram is explained as follows:

- The execution section of an anonymous block starts with a **BEGIN** statement, has a break with an **END** statement, and ends with a semicolon (;).
- **USING [IN|OUT|IN OUT]** *bind_argument*: specifies the variable whose value is passed to the stored procedure parameter. The modifiers in front of *bind_argument* and of the corresponding parameter are the same.
- The input and output parameters in the middle of an anonymous block are designated by placeholders. The numbers of the placeholders and the parameters are the same. The sequences of the parameters corresponding to the placeholders and the **USING** parameters are the same.
- Currently in GaussDB, when dynamic statements call anonymous blocks, placeholders cannot be used to pass input and output parameters in an **EXCEPTION** statement.

## Examples

```
--Create the stored procedure dynamic_proc.
openGauss=# CREATE OR REPLACE PROCEDURE dynamic_proc
AS
  staff_id     NUMBER(6) := 200;
  first_name   VARCHAR2(20);
  salary       NUMBER(8,2);
BEGIN
   --Execute the anonymous block.
   EXECUTE IMMEDIATE 'begin select first_name, salary into :first_name, :salary from hr.staffs where
staff_id= :dno; end;'
      USING OUT first_name, OUT salary, IN staff_id;
  dbe_output.print_line(first_name|| ' ' || salary);
END;
/

-- Call the stored procedure.
openGauss=# CALL dynamic_proc();

-- Delete the stored procedure.
openGauss=# DROP PROCEDURE dynamic_proc;
```

# 13.8 Control Statements

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# 13.8.1 RETURN Statements

In GaussDB, data can be returned in either of the following ways: **RETURN**, **RETURN NEXT**, or **RETURN QUERY**. **RETURN NEXT** and **RETURN QUERY** are used only for functions and cannot be used for stored procedures.

## 13.8.1.1 RETURN

### Syntax

**Figure 13-15** shows the syntax diagram for a return statement.

**Figure 13-15** return_clause::=

The above syntax diagram is explained as follows:

This statement returns control from a stored procedure or function to a caller.

### Examples

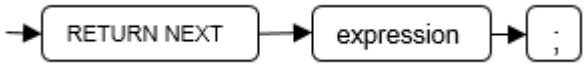
See **Examples** for call statement examples.

## 13.8.1.2 RETURN NEXT and RETURN QUERY

### Syntax

When creating a function, specify **SETOF** *datatype* for the return values.

return_next_clause::=




return_query_clause::=

The above syntax diagram is explained as follows:

If a function needs to return a result set, use **RETURN NEXT** or **RETURN QUERY** to add results to the result set, and then continue to execute the next statement of the function. As the **RETURN NEXT** or **RETURN QUERY** statement is executed repeatedly, more and more results will be added to the result set. After the function is executed, all results are returned.

**RETURN NEXT** can be used for scalar and compound data types.

**RETURN QUERY** has a variant **RETURN QUERY EXECUTE**. You can add dynamic queries and add parameters to the queries by **USING**.

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## Examples

```
openGauss=# CREATE TABLE t1(a int);
openGauss=# INSERT INTO t1 VALUES(1),(10);

--RETURN NEXT
openGauss=# CREATE OR REPLACE FUNCTION fun_for_return_next() RETURNS SETOF t1 AS $$
DECLARE
  r t1%ROWTYPE;
BEGIN
  FOR r IN select * from t1
  LOOP
    RETURN NEXT r;
  END LOOP;
  RETURN;
END;
$$ LANGUAGE PLPGSQL;
openGauss=# call fun_for_return_next();
 a
---
 1
 10
(2 rows)

-- RETURN QUERY
openGauss=# CREATE OR REPLACE FUNCTION fun_for_return_query() RETURNS SETOF t1 AS $$
DECLARE
  r t1%ROWTYPE;
BEGIN
  RETURN QUERY select * from t1;
END;
$$
language plpgsql;
openGauss=# call fun_for_return_next();
 a
---
 1
 10
(2 rows)
```

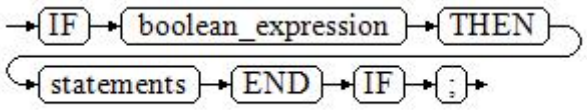
# 13.8.2 Conditional Statements

Conditional statements are used to decide whether given conditions are met. Operations are executed based on the decisions made.

GaussDB supports five usages of **IF**:

- IF_THEN

  **Figure 13-16** IF_THEN::=

  **IF_THEN** is the simplest form of **IF**. If the condition is true, statements are executed. If it is false, they are skipped.

  Example:

  ```
  openGauss=# IF v_user_id <> 0 THEN
      UPDATE users SET email = v_email WHERE user_id = v_user_id;
  END IF;
  ```

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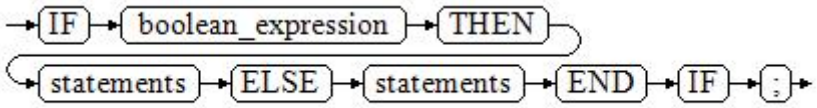
- IF_THEN_ELSE

  **Figure 13-17** IF_THEN_ELSE::=

  **IF-THEN-ELSE** statements add **ELSE** branches and can be executed if the condition is false.

  Example:

  ```
  openGauss=# IF parentid IS NULL OR parentid = ''
  THEN
      RETURN;
  ELSE
      hp_true_filename(parentid); -- Call the stored procedure.
  END IF;
  ```

- IF_THEN_ELSE IF

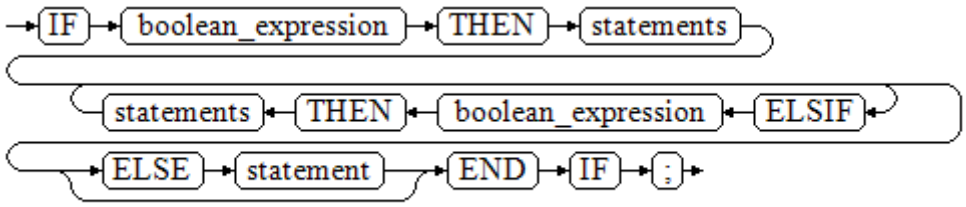
  **IF** statements can be nested in the following way:

  ```
  openGauss=# IF sex = 'm' THEN
      pretty_sex := 'man';
  ELSE
      IF sex = 'f' THEN
          pretty_sex := 'woman';
      END IF;
  END IF;
  ```

  Actually, this is a way of an **IF** statement nesting in the **ELSE** part of another **IF** statement. Therefore, an **END IF** statement is required for each nesting **IF** statement and another **END IF** statement is required to end the parent **IF-ELSE** statement. To set multiple options, use the following form:

- IF_THEN_ELSIF_ELSE

  **Figure 13-18** IF_THEN_ELSIF_ELSE::=

  Example:

  ```
  IF number_tmp = 0 THEN
      result := 'zero';
  ELSIF number_tmp > 0 THEN
      result := 'positive';
  ELSIF number_tmp < 0 THEN
      result := 'negative';
  ELSE
      result := 'NULL';
  END IF;
  ```

- IF_THEN_ELSEIF_ELSE

  **ELSEIF** is an alias of **ELSIF**.

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Example:

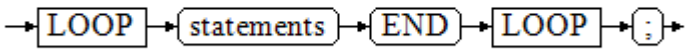
```
CREATE OR REPLACE PROCEDURE proc_control_structure(i in integer)
AS
   BEGIN
      IF i > 0 THEN
         raise info 'i:% is greater than 0. ',i;
      ELSIF i < 0 THEN
         raise info 'i:% is smaller than 0. ',i;
      ELSE
         raise info 'i:% is equal to 0. ',i;
      END IF;
      RETURN;
   END;
/

CALL proc_control_structure(3);

-- Delete the stored procedure.
DROP PROCEDURE proc_control_structure;
```

# 13.8.3 Loop Statements

## Simple LOOP Statements

### Syntax diagram

**Figure 13-19** loop::=




### Example

```
CREATE OR REPLACE PROCEDURE proc_loop(i in integer, count out integer)
AS
   BEGIN
      count:=0;
      LOOP
      IF count > i THEN
         raise info 'count is %. ', count;
         EXIT;
      ELSE
         count:=count+1;
      END IF;
      END LOOP;
   END;
/

CALL proc_loop(10,5);
```

**NOTICE**

The loop must be exploited together with **EXIT**; otherwise, a dead loop occurs.

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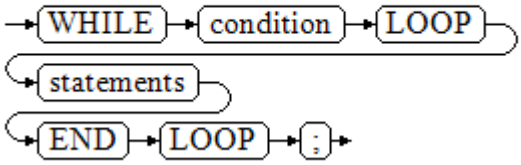
## WHILE_LOOP Statements

### Syntax diagram

**Figure 13-20** while_loop::=




If the conditional expression is true, a series of statements in the WHILE statement are repeatedly executed and the condition is decided each time the loop body is executed.

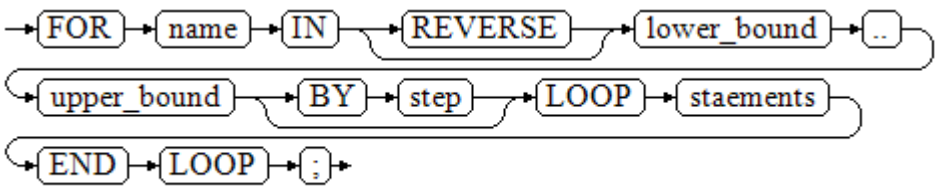
### Example

```
CREATE TABLE integertable(c1 integer) DISTRIBUTE BY hash(c1);
CREATE OR REPLACE PROCEDURE proc_while_loop(maxval in integer)
AS
    DECLARE
    i int :=1;
    BEGIN
        WHILE i < maxval LOOP
            INSERT INTO integertable VALUES(i);
            i:=i+1;
        END LOOP;
    END;
/

-- Invoke a function.
CALL proc_while_loop(10);

-- Delete the stored procedure and table.
DROP PROCEDURE proc_while_loop;
DROP TABLE integertable;
```

## FOR_LOOP (*Integer variable*) *Statement*

### Syntax diagram

**Figure 13-21** for_loop::=

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NOTE

- The variable **name** is automatically defined as the **integer** type and exists only in this loop. The variable name falls between lower_bound and upper_bound.
- When the keyword **REVERSE** is used, the lower bound must be greater than or equal to the upper bound; otherwise, the loop body is not executed.

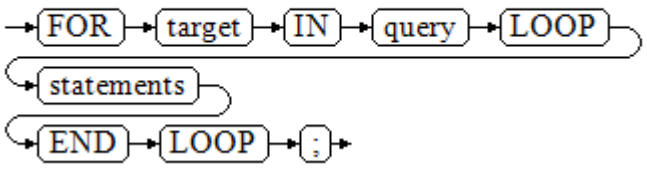
### Example

```
-- Loop from 0 to 5.
CREATE OR REPLACE PROCEDURE proc_for_loop()
AS
   BEGIN
   FOR I IN 0..5 LOOP
      DBE_OUTPUT.PRINT_LINE('It is '||to_char(I) || ' time;') ;
   END LOOP;
END;
/

-- Invoke a function.
CALL proc_for_loop();

-- Delete the stored procedure.
DROP PROCEDURE proc_for_loop;
```

## FOR_LOOP Query Statements

### Syntax diagram

**Figure 13-22** for_loop_query::=




NOTE

The variable **target** is automatically defined, its type is the same as that in the **query** result, and it is valid only in this loop. The target value is the query result.

### Example

```
-- Display the query result from the loop.
CREATE OR REPLACE PROCEDURE proc_for_loop_query()
AS
   record VARCHAR2(50);
BEGIN
   FOR record IN SELECT spcname FROM pg_tablespace LOOP
   dbe_output.print_line(record);
   END LOOP;
END;
/

-- Invoke a function.
CALL proc_for_loop_query();

-- Delete the stored procedure.
DROP PROCEDURE proc_for_loop_query;
```

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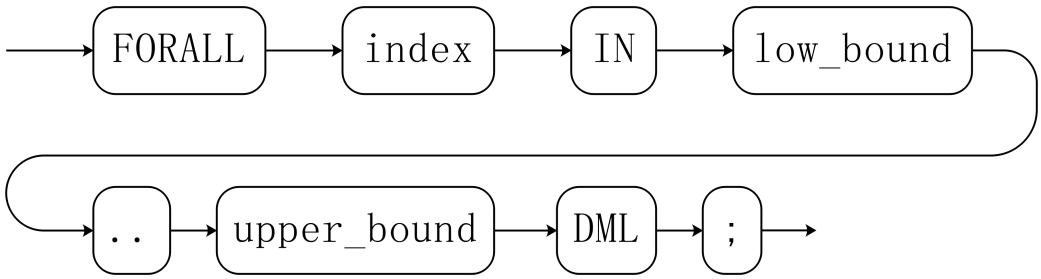
## FORALL Batch Query Statements

### Syntax diagram

**Figure 13-23** forall::=




NOTE

The variable **index** is automatically defined as the **integer** type and exists only in this loop. The index value falls between low_bound and upper_bound.

### Example

```
CREATE TABLE TEST_t1 (
  title NUMBER(6),
  did VARCHAR2(20),
  data_period VARCHAR2(25),
  kind VARCHAR2(25),
  interval VARCHAR2(20),
  time DATE,
  isModified VARCHAR2(10)
)
DISTRIBUTE BY hash(did);

INSERT INTO TEST_t1 VALUES( 8, 'Donald', 'OConnell', 'DOCONNEL', '650.507.9833', to_date('21-06-1999',
'dd-mm-yyyy'), 'SH_CLERK' );

CREATE OR REPLACE PROCEDURE proc_forall()
AS
BEGIN
    FORALL i IN 100..120
        update TEST_t1 set title = title + 100*i;
END;
/

-- Invoke a function.
CALL proc_forall();

-Query the invocation result of the stored procedure.
SELECT * FROM TEST_t1 WHERE title BETWEEN 100 AND 120;

-- Delete the stored procedure and table.
DROP PROCEDURE proc_forall;
DROP TABLE TEST_t1;
```

# 13.8.4 Branch Statements

## Syntax

**Figure 13-24** shows the syntax diagram for a return statement.

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**Figure 13-24** case_when::=

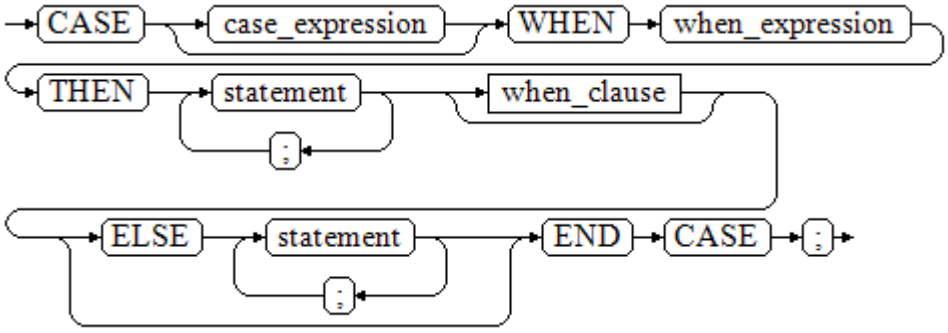
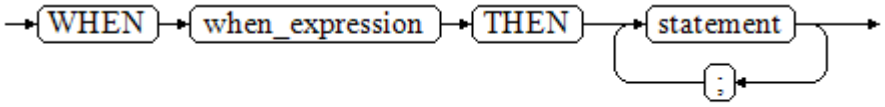



Figure 13-25 shows the syntax diagram for **when_clause**.

**Figure 13-25** when_clause::=




Parameter description:

- *case_expression*: specifies the variable or expression.
- *when_expression*: specifies the constant or conditional expression.
- *statement*: specifies the statement to be executed.

## Examples

```
CREATE OR REPLACE PROCEDURE proc_case_branch(pi_result in integer, pi_return out integer)
AS
   BEGIN
      CASE pi_result
         WHEN 1 THEN
            pi_return := 111;
         WHEN 2 THEN
            pi_return := 222;
         WHEN 3 THEN
            pi_return := 333;
         WHEN 6 THEN
            pi_return := 444;
         WHEN 7 THEN
            pi_return := 555;
         WHEN 8 THEN
            pi_return := 666;
         WHEN 9 THEN
            pi_return := 777;
         WHEN 10 THEN
            pi_return := 888;
         ELSE
            pi_return := 999;
      END CASE;
      raise info 'pi_return : %',pi_return ;
END;
/

CALL proc_case_branch(3,0);
```

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```
-- Delete the stored procedure.
DROP PROCEDURE proc_case_branch;
```

## 13.8.5 NULL Statements

In PL/SQL programs, **NULL** statements are used to indicate "nothing should be done", equal to placeholders. They grant meanings to some statements and improve program readability.

### Syntax

The following shows example use of **NULL** statements.

```
DECLARE
   ...
BEGIN
   ...
   IF v_num IS NULL THEN
      NULL; --No data needs to be processed.
   END IF;
END;
/
```

## 13.8.6 Error Trapping Statements

By default, any error occurring in a PL/SQL function aborts execution of the function, and indeed of the surrounding transaction as well. You can trap errors and restore from them by using a **BEGIN** block with an **EXCEPTION** clause. The syntax is an extension of the normal syntax for a **BEGIN** block:

```
[<<label>>]
[DECLARE
   declarations]
BEGIN
   statements
EXCEPTION
   WHEN condition [OR condition ...] THEN
      handler_statements
   [WHEN condition [OR condition ...] THEN
      handler_statements
   ...]
END;
```

If no error occurs, this form of block simply executes all the statements, and then control passes to the next statement after **END**. But if an error occurs within the statements, further processing of the statements is abandoned, and control passes to the **EXCEPTION** list. The list is searched for the first condition matching the error that occurred. If a match is found, the corresponding **handler_statements** are executed, and then control passes to the next statement after **END**. If no match is found, the error propagates out as though the **EXCEPTION** clause were not there at all: Error codes can be used to catch other error codes of the same type.

The error can be caught by an enclosing block with **EXCEPTION**, or if there is none it aborts processing of the function.

The condition names can be any of those shown in *Error Code Reference*. The special condition name **OTHERS** matches every error type except **QUERY_CANCELED**.

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If a new error occurs within the selected **handler_statements**, it cannot be caught by this **EXCEPTION** clause, but is propagated out. A surrounding **EXCEPTION** clause could catch it.

When an error is caught by an **EXCEPTION** clause, the local variables of the PL/SQL function remain as they were when the error occurred, but all changes to persistent database state within the block are rolled back.

Example:

```
CREATE TABLE mytab(id INT,firstname VARCHAR(20),lastname VARCHAR(20)) DISTRIBUTE BY hash(id);

INSERT INTO mytab(firstname, lastname) VALUES('Tom', 'Jones');

CREATE FUNCTION fun_exp() RETURNS INT
AS $$
DECLARE
   x INT :=0;
   y INT;
BEGIN
   UPDATE mytab SET firstname = 'Joe' WHERE lastname = 'Jones';
   x := x + 1;
   y := x / 0;
EXCEPTION
   WHEN division_by_zero THEN
      RAISE NOTICE 'caught division_by_zero';
      RETURN x;
END;$$
LANGUAGE plpgsql;

call fun_exp();
NOTICE:  caught division_by_zero
 fun_exp
---------
       1
(1 row)

select * from mytab;
 id | firstname | lastname
----+-----------+----------
    | Tom       | Jones
(1 row)

DROP FUNCTION fun_exp();
DROP TABLE mytab;
```

When control reaches the assignment to **y**, it will fail with a **division_by_zero** error. This will be caught by the **EXCEPTION** clause. The value returned in the **RETURN** statement will be the incremented value of **x**.

**NOTE**

A block containing an **EXCEPTION** clause is more expensive to enter and exit than a block without one. Therefore, do not use **EXCEPTION** without need.

In the following scenario, an exception cannot be caught, and the entire transaction rolls back. The threads of the nodes participating the stored procedure exit abnormally due to node failure and network fault, or the source data is inconsistent with that of the table structure of the target table during the COPY FROM operation.

Example: Exceptions with **UPDATE**/**INSERT**

This example uses exception handling to perform either **UPDATE** or **INSERT**, as appropriate:

```
CREATE TABLE db (a INT, b TEXT);
```

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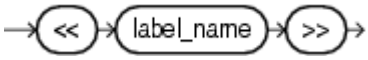
```
CREATE FUNCTION merge_db(key INT, data TEXT) RETURNS VOID AS
$$
BEGIN
    LOOP

-- First try to update the key
        UPDATE db SET b = data WHERE a = key;
        IF found THEN
            RETURN;
        END IF;
-- Not there, so try to insert the key. If someone else inserts the same key concurrently, we could get a
unique-key failure.
        BEGIN
            INSERT INTO db(a,b) VALUES (key, data);
            RETURN;
        EXCEPTION WHEN unique_violation THEN
        -- Do nothing, and loop to try the UPDATE again.
        END;
     END LOOP;
END;
$$
LANGUAGE plpgsql;

SELECT merge_db(1, 'david');
SELECT merge_db(1, 'dennis');

--Delete FUNCTION and TABLE:
DROP FUNCTION merge_db;
DROP TABLE db ;
```

# 13.8.7 GOTO Statements

A **GOTO** statement unconditionally transfers the control from the current statement to a labeled statement. The **GOTO** statement changes the execution logic. Therefore, use this statement only when necessary. Alternatively, you can use the **EXCEPTION** statement to handle issues in special scenarios. To run a **GOTO** statement, the labeled statement must be unique.

## Syntax

label declaration ::=




goto statement ::=

## Examples

```
openGauss=# CREATE OR REPLACE PROCEDURE GOTO_test()
AS
DECLARE
    v1  int;
BEGIN
    v1  := 0;
        LOOP
        EXIT WHEN v1 > 100;
                v1 := v1 + 2;
                if v1 > 25 THEN
                        GOTO pos1;
                END IF;
        END LOOP;
```

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```
<<pos1>>
v1 := v1 + 10;
raise info 'v1 is %. ', v1;
END;
/

call GOTO_test();
```

## Constraints

Using **GOTO** statements has the following constraints:

- A **GOTO** statement does not allow multiple labeled statements even if the statements are in different blocks.

```
BEGIN
 GOTO pos1;
 <<pos1>>
 SELECT * FROM ...
 <<pos1>>
 UPDATE t1 SET ...
END;
```

- A **GOTO** statement cannot transfer control to the **IF**, **CASE**, or **LOOP** statement.

```
BEGIN
  GOTO pos1;
  IF valid THEN
    <<pos1>>
    SELECT * FROM ...
  END IF;
END;
```

- A **GOTO** statement cannot transfer control from one **IF** clause to another, or from one **WHEN** clause in the **CASE** statement to another.

```
BEGIN
  IF valid THEN
    GOTO pos1;
    SELECT * FROM ...
  ELSE
    <<pos1>>
    UPDATE t1 SET ...
  END IF;
END;
```

- A **GOTO** statement cannot transfer control from an outer block to an inner **BEGIN-END** block.

```
BEGIN
  GOTO pos1;
  BEGIN
    <<pos1>>
    UPDATE t1 SET ...
  END;
END;
```

- A **GOTO** statement cannot transfer control from an exception handler to the current **BEGIN-END** block. However, a **GOTO** statement can transfer control to the upper-layer **BEGIN-END** block.

```
BEGIN
  <<pos1>>
  UPDATE t1 SET ...
  EXCEPTION
    WHEN condition THEN
      GOTO pos1;
END;
```

- To branch to a position that does not have an executable statement, add the **NULL** statement.

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```
DECLARE
  done  BOOLEAN;
BEGIN
  FOR i IN 1..50 LOOP
    IF done THEN
      GOTO end_loop;
    END IF;
    <<end_loop>>  -- not allowed unless an executable statement follows
    NULL; -- add NULL statement to avoid error
  END LOOP;  -- raises an error without the previous NULL
END;
/
```

# 13.9 Transaction Statements

A stored procedure itself is automatically in a transaction. A transaction is automatically started when the most peripheral stored procedure is called. In addition, the transaction is automatically committed when the calling ends, or is rolled back when an exception occurs during calling. In addition to automatic transaction control, you can also use COMMIT/ROLLBACK to control transactions in stored procedures. Running the COMMIT/ROLLBACK commands in a stored procedure will commit or roll back the current transaction and automatically starts a new transaction. All subsequent operations will be performed in the new transaction.

A savepoint is a special mark inside a transaction. It allows all commands that are executed after it was established to be rolled back, restoring the transaction state to what it was at the time of the savepoint. In a stored procedure, you can use savepoints to manage transactions. Currently, you can create, roll back, and release savepoints. If a savepoint for rollback is used in a stored procedure, only the modification of the current transaction is rolled back. The execution process of the stored procedure is not changed, and the values of local variables in the stored procedure are not rolled back.

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**NOTICE**

COMMIT/ROLLBACK can be used in the following contexts:

1. COMMIT/ROLLBACK/SAVEPOINT can be used in stored procedures/functions in PL/SQL.
2. COMMIT, ROLLBACK, and SAVEPOINT can be used in stored procedures/functions that contain EXCEPTION.
3. COMMIT, ROLLBACK, and SAVEPOINT can be used in EXCEPTION statements of stored procedures.
4. A stored procedure that contains COMMIT, ROLLBACK, or SAVEPOINT (which means the stored procedure is controlled by BEGIN, START, or END) can be called in a transaction block.
5. A stored procedure that contains savepoints can be invoked in a subtransaction and an externally defined savepoint is used to roll back the transaction to the savepoint defined outside the stored procedure.
6. A savepoint defined in the stored procedure can be viewed outside the stored procedure. That is, the modification of the transaction can be rolled back to the savepoint defined in the stored procedure.
7. COMMIT, ROLLBACK, and SAVEPOINT, as well as IF, FOR, CURSOR LOOP, and WHILE, can be called in most contexts and statements in PL/SQL.

The following content can be committed or rolled back:

1. DDL statements after COMMIT/ROLLBACK can be committed or rolled back.
2. DML statements after COMMIT/ROLLBACK can be committed.
3. GUC parameters in stored procedures can be committed or rolled back.

## Syntax

```
Define a savepoint.
   SAVEPOINT savepoint_name;
Roll back a savepoint.
   ROLLBACK TO [SAVEPOINT] savepoint_name;
Release a savepoint.
   RELEASE [SAVEPOINT] savepoint_name;
```

## Examples

**NOTE**

COMMIT/ROLLBACK can be used in PL/SQL stored procedures.

```
CREATE TABLE EXAMPLE1(COL1 INT);

CREATE OR REPLACE PROCEDURE TRANSACTION_EXAMPLE()
AS
BEGIN
   FOR i IN 0..20 LOOP
      INSERT INTO EXAMPLE1(COL1) VALUES (i);
      IF i % 2 = 0 THEN
         COMMIT;
      ELSE
         ROLLBACK;
      END IF;
   END LOOP;
END;
/
```

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**NOTE**

- COMMIT/ROLLBACK can be used in stored procedures that contain EXCEPTION.
- COMMIT/ROLLBACK can be used in EXCEPTION statements of stored procedures.
- DDL statements after COMMIT/ROLLBACK can be committed or rolled back.

```
CREATE OR REPLACE PROCEDURE TEST_COMMIT_INSERT_EXCEPTION_ROLLBACK()
AS
BEGIN
 DROP TABLE IF EXISTS TEST_COMMIT;
 CREATE TABLE TEST_COMMIT(A INT, B INT);
 INSERT INTO TEST_COMMIT SELECT 1, 1;
 COMMIT;
       CREATE TABLE TEST_ROLLBACK(A INT, B INT);
 RAISE EXCEPTION 'RAISE EXCEPTION AFTER COMMIT';
EXCEPTION
   WHEN OTHERS THEN
 INSERT INTO TEST_COMMIT SELECT 2, 2;
 ROLLBACK;
END;
/
```

**NOTE**

A stored procedure that contains COMMIT/ROLLBACK (which means the stored procedure is controlled by /BEGIN/START/END) can be called in a transaction block.

```
BEGIN;
   CALL TEST_COMMIT_INSERT_EXCEPTION_ROLLBACK();
END;
```

**NOTE**

COMMIT/ROLLBACK, including IF, FOR, CURSOR LOOP, and WHILE, can be called in most PL/SQL contexts and statements.

```
CREATE OR REPLACE PROCEDURE TEST_COMMIT2()
IS
BEGIN
   DROP TABLE IF EXISTS TEST_COMMIT;
   CREATE TABLE TEST_COMMIT(A INT);
   FOR I IN REVERSE 3..0 LOOP
 INSERT INTO TEST_COMMIT SELECT I;
 COMMIT;
   END LOOP;
   FOR I IN REVERSE 2..4 LOOP
 UPDATE TEST_COMMIT SET A=I;
 COMMIT;
   END LOOP;
EXCEPTION
WHEN OTHERS THEN
 INSERT INTO TEST_COMMIT SELECT 4;
   COMMIT;
END;
/
```

**NOTE**

GUC parameters in stored procedures can be committed or rolled back.

```
SHOW explain_perf_mode;
SHOW enable_force_vector_engine;

CREATE OR REPLACE PROCEDURE GUC_ROLLBACK()
AS
BEGIN
   SET enable_force_vector_engine = on;
   COMMIT;
   SET explain_perf_mode TO pretty;
```

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```
    ROLLBACK;
END;
/

call GUC_ROLLBACK();
SHOW explain_perf_mode;
SHOW enable_force_vector_engine;
SET enable_force_vector_engine = off;
```

**NOTE**

Savepoints can be used in PL/SQL stored procedures to roll back partial transaction modifications.

```
CREATE OR REPLACE PROCEDURE STP_SAVEPOINT_EXAMPLE1()
AS
BEGIN
    INSERT INTO EXAMPLE1 VALUES(1);
    SAVEPOINT s1;
    INSERT INTO EXAMPLE1 VALUES(2);
    ROLLBACK TO s1;  -- Roll back the insertion of record 2.
    INSERT INTO EXAMPLE1 VALUES(3);
END;
/
```

**NOTE**

You can use a savepoint in a PL/SQL stored procedure to roll back to a savepoint defined outside the stored procedure.

```
CREATE OR REPLACE PROCEDURE STP_SAVEPOINT_EXAMPLE2()
AS
BEGIN
    INSERT INTO EXAMPLE1 VALUES(2);
    ROLLBACK TO s1;  -- Roll back the insertion of record 2.
    INSERT INTO EXAMPLE1 VALUES(3);
END;
/

BEGIN;
INSERT INTO EXAMPLE1 VALUES(1);
SAVEPOINT s1;
CALL STP_SAVEPOINT_EXAMPLE2();
SELECT * FROM EXAMPLE1;
COMMIT;
```

**NOTE**

You can use a savepoint defined outside the stored procedure to roll back to a savepoint in a PL/SQL stored procedure.

```
CREATE OR REPLACE PROCEDURE STP_SAVEPOINT_EXAMPLE3()
AS
BEGIN
    INSERT INTO EXAMPLE1 VALUES(1);
    SAVEPOINT s1;
    INSERT INTO EXAMPLE1 VALUES(2);
END;
/

BEGIN;
INSERT INTO EXAMPLE1 VALUES(3);
CALL STP_SAVEPOINT_EXAMPLE3();
ROLLBACK TO SAVEPOINT s1; -- Roll back the insertion of record 2 to the stored procedure.
SELECT * FROM EXAMPLE1;
COMMIT;
```

**NOTE**

The COMMIT and ROLLBACK statements can be invoked in a function.

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```
CREATE OR REPLACE FUNCTION FUNCTION_EXAMPLE1() RETURN INT
AS
EXP INT;
BEGIN
    FOR i IN 0..20 LOOP
        INSERT INTO EXAMPLE1(col1) VALUES (i);
        IF i % 2 = 0 THEN
            COMMIT;
        ELSE
            ROLLBACK;
        END IF;
    END LOOP;
    SELECT COUNT(*) FROM EXAMPLE1 INTO EXP;
    RETURN EXP;
END;
/
```

## Constraints

**CAUTION**

- COMMIT/ROLLBACK cannot be used in the following contexts:
  1. COMMIT, ROLLBACK, and SAVEPOINT cannot be called in stored procedures other than PL/SQL, such as PLJava and PLPython.
  2. After SAVEPOINT is called in a transaction block, stored procedures that contain COMMIT/ROLLBACK cannot be called.
  3. Stored procedures that contain COMMIT, ROLLBACK, or SAVEPOINT cannot be called in TRIGGER.
  4. COMMIT, ROLLBACK, and SAVEPOINT cannot be invoked in EXECUTE statements.
  5. Stored procedures that contain COMMIT, ROLLBACK, or SAVEPOINT cannot be called in CURSOR statements.
  6. Stored procedures that contain IMMUTABLE or SHIPPABLE cannot call COMMIT, ROLLBACK, SAVEPOINT or another stored procedure that contain COMMIT, ROLLBACK, or SAVEPOINT.
  7. Stored procedures that contain COMMIT, ROLLBACK, or SAVEPOINT cannot be called in SQL statements other than SELECT PROC and CALL PROC.
  8. COMMIT, ROLLBACK, or SAVEPOINT cannot be called in a stored procedure whose header contains GUC parameters.
  9. COMMIT, ROLLBACK, or SAVEPOINT cannot be called in expressions or CURSOR and EXECUTE statements.
  10. Stored procedures that contain COMMIT, ROLLBACK, or SAVEPOINT cannot be called in the return values and expression calculation of stored procedures.
  11. Savepoints defined outside a stored procedure cannot be released in the stored procedure.
  12. A stored procedure transaction and its autonomous transaction are two independent transactions and cannot use savepoints defined in each other's transaction.
- The following content cannot be committed or rolled back:
  1. Variables declared or imported in stored procedures cannot be committed or rolled back.
  2. In stored procedures, GUC parameters that take effect only after a restart cannot be committed or rolled back.

There are the following constraints on the use of COMMIT/ROLLBACK in a stored procedure:

**NOTE**

A TRIGGER stored procedure cannot contain COMMIT/ROLLBACK or called another stored procedure that contains COMMIT/ROLLBACK.

```
CREATE OR REPLACE FUNCTION FUNCTION_TRI_EXAMPLE2() RETURN TRIGGER
AS
EXP INT;
```

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```
BEGIN
    FOR i IN 0..20 LOOP
        INSERT INTO EXAMPLE1(col1) VALUES (i);
        IF i % 2 = 0 THEN
            COMMIT;
        ELSE
            ROLLBACK;
        END IF;
    END LOOP;
    SELECT COUNT(*) FROM EXAMPLE1 INTO EXP;
END;
/

CREATE TRIGGER TRIGGER_EXAMPLE AFTER DELETE ON EXAMPLE1
FOR EACH ROW EXECUTE PROCEDURE FUNCTION_TRI_EXAMPLE2();

DELETE FROM EXAMPLE1;
```

**NOTE**

Stored procedures that contain IMMUTABLE or SHIPPABLE cannot call COMMIT/ROLLBACK or another stored procedure that contains COMMIT/ROLLBACK.

```
CREATE OR REPLACE PROCEDURE TRANSACTION_EXAMPLE1()
IMMUTABLE
AS
BEGIN
    FOR i IN 0..20 LOOP
        INSERT INTO EXAMPLE1 (col1) VALUES (i);
        IF i % 2 = 0 THEN
            COMMIT;
        ELSE
            ROLLBACK;
        END IF;
    END LOOP;
END;
/
```

**NOTE**

Variables declared or imported in stored procedures cannot be committed or rolled back.

```
CREATE OR REPLACE PROCEDURE TRANSACTION_EXAMPLE2(EXP_OUT OUT INT)
AS
EXP INT;
BEGIN
    EXP_OUT := 0;
    COMMIT;
    DBE_OUTPUT.PRINT_LINE('EXP IS:'||EXP);
    EXP_OUT := 1;
    ROLLBACK;
    DBE_OUTPUT.PRINT_LINE('EXP IS:'||EXP);
END;
/
```

**NOTE**

Calling in SQL statements (other than Select Procedure) is not supported.

```
CREATE OR REPLACE PROCEDURE TRANSACTION_EXAMPLE3()
AS
BEGIN
    FOR i IN 0..20 LOOP
        INSERT INTO EXAMPLE1 (col1) VALUES (i);
        IF i % 2 = 0 THEN
            EXECUTE IMMEDIATE 'COMMIT';
        ELSE
            EXECUTE IMMEDIATE 'ROLLBACK';
        END IF;
    END LOOP;
```

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```
END;
/
```

**NOTE**

COMMIT/ROLLBACK cannot be called in a stored procedure whose header contains GUC parameters.

```
CREATE OR REPLACE PROCEDURE TRANSACTION_EXAMPLE4()
SET ARRAY_NULLS TO "ON"
AS
BEGIN
   FOR i IN 0..20 LOOP
      INSERT INTO EXAMPLE1 (col1) VALUES (i);
      IF i % 2 = 0 THEN
         COMMIT;
      ELSE
         ROLLBACK;
      END IF;
   END LOOP;
END;
/
```

**NOTE**

A stored procedure object whose cursor is open cannot contain COMMIT/ROLLBACK.

```
CREATE OR REPLACE PROCEDURE TRANSACTION_EXAMPLE5(INTIN IN INT, INTOUT OUT INT)
AS
BEGIN
INTOUT := INTIN + 1;
COMMIT;
END;
/

CREATE OR REPLACE PROCEDURE TRANSACTION_EXAMPLE6()
AS
CURSOR CURSOR1(EXPIN INT)
IS SELECT TRANSACTION_EXAMPLE5(EXPIN);
INTEXP INT;
BEGIN
   FOR i IN 0..20 LOOP
      OPEN CURSOR1(i);
      FETCH CURSOR1 INTO INTEXP;
      INSERT INTO EXAMPLE1(COL1) VALUES (INTEXP);
      IF i % 2 = 0 THEN
         COMMIT;
      ELSE
         ROLLBACK;
      END IF;
      CLOSE CURSOR1;
   END LOOP;
END;
/
```

**NOTE**

COMMIT/ROLLBACK cannot be called in expressions or CURSOR/EXECUTE statements.

```
CREATE OR REPLACE PROCEDURE exec_func1()
AS
BEGIN
   CREATE TABLE TEST_exec(A INT);
COMMIT;
END;
/
CREATE OR REPLACE PROCEDURE exec_func2()
AS
BEGIN
EXECUTE exec_func1();
COMMIT;
```

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```
END;
/
```

NOTE

Return values and expression calculation of stored procedures are not supported.

```
CREATE OR REPLACE PROCEDURE exec_func3(RET_NUM OUT INT)
AS
BEGIN
   RET_NUM := 1+1;
COMMIT;
END;
/
CREATE OR REPLACE PROCEDURE exec_func4(ADD_NUM IN INT)
AS
SUM_NUM INT;
BEGIN
SUM_NUM := ADD_NUM + exec_func3();
COMMIT;
END;
/
```

NOTE

Savepoints defined outside a stored procedure cannot be released in the stored procedure.

```
CREATE OR REPLACE PROCEDURE STP_SAVEPOINT_EXAMPLE3()
AS
BEGIN
   INSERT INTO EXAMPLE1 VALUES(2);
   RELEASE SAVEPOINT s1; -- Release the savepoint defined outside the stored procedure.
   INSERT INTO EXAMPLE1 VALUES(3);
END;
/

BEGIN;
INSERT INTO EXAMPLE1 VALUES(1);
SAVEPOINT s1;
CALL STP_SAVEPOINT_EXAMPLE3();
COMMIT;
```

# 13.10 Other Statements

## 13.10.1 Lock Operations

GaussDB provides multiple lock modes to control concurrent accesses to table data. These modes are used when MVCC cannot give expected behaviors. Alike, most GaussDB commands automatically apply appropriate locks to ensure that called tables are not deleted or modified in an incompatible manner during command execution. For example, when concurrent operations exist, **ALTER TABLE** cannot be executed on the same table.

## 13.10.2 Cursor Operations

GaussDB provides cursors as a data buffer for users to store execution results of SQL statements. Each cursor region has a name. Users can use SQL statements to obtain records one by one from cursors and grant the records to master variables, then being processed further by host languages.

Cursor operations include cursor definition, open, fetch, and close operations.

For the complete example of cursor operations, see **13.11.2 Explicit Cursor**.

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# 13.11 Cursors

## 13.11.1 Overview

To process SQL statements, the stored procedure process assigns a memory segment to store context association. Cursors are handles or pointers pointing to context regions. With cursors, stored procedures can control alterations in context regions.

NOTICE

If JDBC is used to call a stored procedure whose returned value is a cursor, the returned cursor cannot be used.

Cursors are classified into explicit cursors and implicit cursors. **Table 13-2** shows the usage conditions of explicit and implicit cursors for different SQL statements.

**Table 13-2** Cursor usage conditions

| SQL Statement | Cursor |
| --- | --- |
| Non-query statements | Implicit |
| Query statements with single-line results | Implicit or explicit |
| Query statements with multi-line results | Explicit |

## 13.11.2 Explicit Cursor

An explicit cursor is used to process query statements, particularly when query results are multiple records.

### Procedure

An explicit cursor performs the following six PL/SQL steps to process query statements:

**Step 1** Define a static cursor: Define a cursor name and its corresponding **SELECT** statement.

**Figure 13-26** shows the syntax diagram for defining a static cursor.

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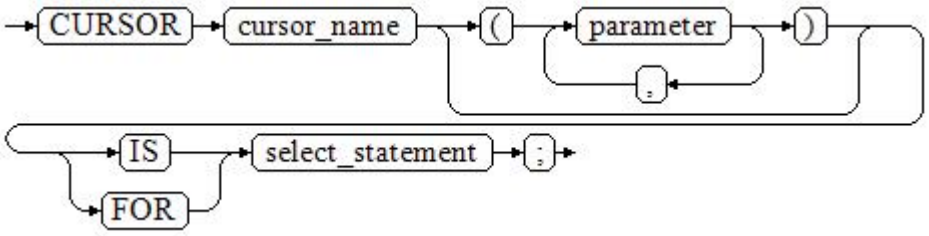
**Figure 13-26** static_cursor_define::=




Parameter description:

- *cursor_name*: defines a cursor name.
- *parameter*: specifies cursor parameters. Only input parameters are allowed. Its format is as follows:
  ```
  parameter_name datatype
  ```
- *select_statement*: specifies a query statement.

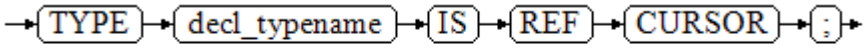
NOTE

The system automatically determines whether the cursor can be used for backward fetching based on the execution plan.

Define a dynamic cursor: Define a **ref** cursor, which means that the cursor can be opened dynamically by a set of static SQL statements. Define the type of the **ref** cursor first, and then the cursor variable of this cursor type. Dynamically bind a **SELECT** statement through **OPEN FOR** when the cursor is opened.

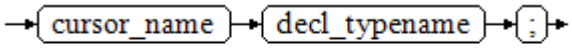
**Figure 13-27** and **Figure 13-28** show the syntax diagrams for defining a dynamic cursor.

**Figure 13-27** cursor_typename::=




GaussDB supports the dynamic cursor type **sys_refcursor**. A function or stored procedure can use the **sys_refcursor** parameter to pass on or pass out the cursor result set. A function can return **sys_refcursor** to return the cursor result set.

**Figure 13-28** dynamic_cursor_define::=




**Step 2** Open the static cursor: Execute the **SELECT** statement corresponding to the cursor. The query result is placed in the workspace and the pointer directs to the head of the workspace to identify the cursor result set. If the cursor query statement carries the **FOR UPDATE** option, the **OPEN** statement locks the data rows corresponding to the cursor result set in the database table.

**Figure 13-29** shows the syntax diagram for opening a static cursor.

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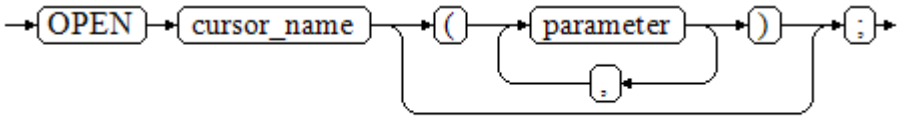
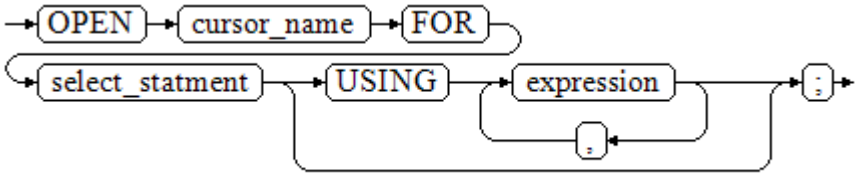
**Figure 13-29** open_static_cursor::=




Open the dynamic cursor: Use the **OPEN FOR** statement to open the dynamic cursor and the SQL statement is dynamically bound.

**Figure 13-30** shows the syntax diagrams for opening a dynamic cursor.

**Figure 13-30** open_dynamic_cursor::=

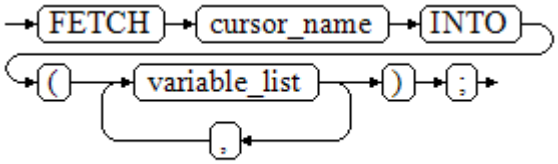



A PL/SQL program cannot use the **OPEN** statement to repeatedly open a cursor.

**Step 3** Fetch cursor data: Retrieve data rows in the result set and place them in specified output variables.

**Figure 13-31** shows the syntax diagrams for fetching cursor data.

**Figure 13-31** fetch_cursor::=



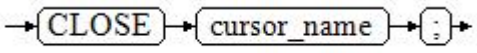

**Step 4** Process the record.

**Step 5** Continue to process until the active set has no record.

**Step 6** Close the cursor: After you fetch and process the data in the cursor result set, close the cursor in time to release system resources used by the cursor and invalidate the workspace of the cursor so that the **FETCH** statement cannot be used to fetch data any more. A closed cursor can be reopened by an **OPEN** statement.

**Figure 13-32** shows the syntax diagram for closing a cursor.

**Figure 13-32** close_cursor::=




**----End**

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## Attributes

Cursor attributes are used to control program procedures or know program status. When a DML statement is executed, the PL/SQL opens a built-in cursor and processes its result. A cursor is a memory segment for maintaining query results. It is opened when a DML statement is executed and closed when the execution is finished. An explicit cursor has the following attributes:

- **%FOUND**: Boolean attribute, which returns **TRUE** if the last fetch returns a row.
- **%NOTFOUND**: Boolean attribute, which works opposite to the **%FOUND** attribute.
- **%ISOPEN**: Boolean attribute, which returns **TRUE** if the cursor has been opened.
- **%ROWCOUNT**: numeric attribute, which returns the number of records fetched from the cursor.

## Examples

```
-- Specify the method for passing cursor parameters.
CREATE OR REPLACE PROCEDURE cursor_proc1()
AS
DECLARE
   DEPT_NAME VARCHAR(100);
   DEPT_LOC NUMBER(4);
   -- Define a cursor.
   CURSOR C1 IS
      SELECT section_name, place_id FROM hr.sections WHERE section_id <= 50;
   CURSOR C2(sect_id INTEGER) IS
      SELECT section_name, place_id FROM hr.sections WHERE section_id <= sect_id;
   TYPE CURSOR_TYPE IS REF CURSOR;
   C3 CURSOR_TYPE;
   SQL_STR VARCHAR(100);
BEGIN
   OPEN C1;-- Open the cursor.
   LOOP
      -- Fetch data from the cursor.
      FETCH C1 INTO DEPT_NAME, DEPT_LOC;
      EXIT WHEN C1%NOTFOUND;
      DBE_OUTPUT.PRINT_LINE(DEPT_NAME||'---'||DEPT_LOC);
   END LOOP;
   CLOSE C1;-- Close the cursor.

   OPEN C2(10);
   LOOP
      FETCH C2 INTO DEPT_NAME, DEPT_LOC;
      EXIT WHEN C2%NOTFOUND;
      DBE_OUTPUT.PRINT_LINE(DEPT_NAME||'---'||DEPT_LOC);
   END LOOP;
   CLOSE C2;

   SQL_STR := 'SELECT section_name, place_id FROM hr.sections WHERE section_id <= :DEPT_NO;';
   OPEN C3 FOR SQL_STR USING 50;
   LOOP
      FETCH C3 INTO DEPT_NAME, DEPT_LOC;
      EXIT WHEN C3%NOTFOUND;
      DBE_OUTPUT.PRINT_LINE(DEPT_NAME||'---'||DEPT_LOC);
   END LOOP;
   CLOSE C3;
END;
/

CALL cursor_proc1();
```

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```
DROP PROCEDURE cursor_proc1;
-- Give a salary raise to employees whose salary is lower than 3000 by adding 500.
CREATE TABLE hr.staffs_t1 AS TABLE hr.staffs;

CREATE OR REPLACE PROCEDURE cursor_proc2()
AS
DECLARE
  V_EMPNO  NUMBER(6);
  V_SAL    NUMBER(8,2);
  CURSOR C IS SELECT staff_id, salary FROM hr.staffs_t1;
BEGIN
  OPEN C;
  LOOP
    FETCH C INTO V_EMPNO, V_SAL;
    EXIT WHEN C%NOTFOUND;
    IF V_SAL<=3000 THEN
        UPDATE hr.staffs_t1 SET salary =salary + 500 WHERE staff_id = V_EMPNO;
    END IF;
  END LOOP;
  CLOSE C;
END;
/

CALL cursor_proc2();

-- Delete the stored procedure.
DROP PROCEDURE cursor_proc2;
DROP TABLE hr.staffs_t1;
-- Use function parameters of the SYS_REFCURSOR type.
CREATE OR REPLACE PROCEDURE proc_sys_ref(O OUT SYS_REFCURSOR)
IS
C1 SYS_REFCURSOR;
BEGIN
OPEN C1 FOR SELECT section_ID FROM HR.sections ORDER BY section_ID;
O := C1;
END;
/

DECLARE
C1 SYS_REFCURSOR;
TEMP NUMBER(4);
BEGIN
proc_sys_ref(C1);
LOOP
  FETCH C1 INTO TEMP;
  DBE_OUTPUT.PRINT_LINE(C1%ROWCOUNT);
  EXIT WHEN C1%NOTFOUND;
END LOOP;
END;
/

-- Delete the stored procedure.
DROP PROCEDURE proc_sys_ref;
```

## 13.11.3 Implicit Cursor

Implicit cursors are automatically set by the system for non-query statements such as modify or delete operations, along with their workspace. Implicit cursors are named **SQL**, which is defined by the system.

### Overview

Implicit cursor operations, such as definition, open, value-grant, and close operations, are automatically performed by the system and do not need users to process. Users can use only attributes related to implicit cursors to complete

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operations. In workspace of implicit cursors, the data of the latest SQL statement is stored and is not related to explicit cursors defined by users.

Format call: **SQL%**

NOTE

**INSERT**, **UPDATE**, **DELETE**, and **SELECT** statements do not need defined cursors.

## Attributes

An implicit cursor has the following attributes:

- **SQL%FOUND**: Boolean attribute, which returns **TRUE** if the last fetch returns a row.
- **SQL%NOTFOUND**: Boolean attribute, which works opposite to the **SQL %FOUND** attribute.
- **SQL%ROWCOUNT**: numeric attribute, which returns the number of records fetched from the cursor.
- **SQL%ISOPEN**: Boolean attribute, whose value is always **FALSE**. Close implicit cursors immediately after an SQL statement is run.

## Examples

```
-- Delete all employees in a department from the EMP table. If the department has no employees, delete the department from the DEPT table.
CREATE TABLE hr.staffs_t1 AS TABLE hr.staffs;
CREATE TABLE hr.sections_t1 AS TABLE hr.sections;

CREATE OR REPLACE PROCEDURE proc_cursor3()
AS
   DECLARE
   V_DEPTNO NUMBER(4) := 100;
   BEGIN
      DELETE FROM hr.staffs WHERE section_ID = V_DEPTNO;
      -- Proceed based on cursor status.
      IF SQL%NOTFOUND THEN
      DELETE FROM hr.sections_t1 WHERE section_ID = V_DEPTNO;
      END IF;
   END;
/

CALL proc_cursor3();

-- Delete the stored procedure and the temporary table.
DROP PROCEDURE proc_cursor3;
DROP TABLE hr.staffs_t1;
DROP TABLE hr.sections_t1;
```

# 13.11.4 Cursor Loop

Use of cursors in **WHILE** and **LOOP** statements is called a cursor loop. Generally, **OPEN**, **FETCH**, and **CLOSE** statements are called in this kind of loop. The following describes a loop that simplifies a cursor loop without the need for these operations. This mode is applicable to a static cursor loop, without executing four steps about a static cursor.

## Syntax

**Figure 13-33** shows the syntax diagram of the **FOR AS** loop.

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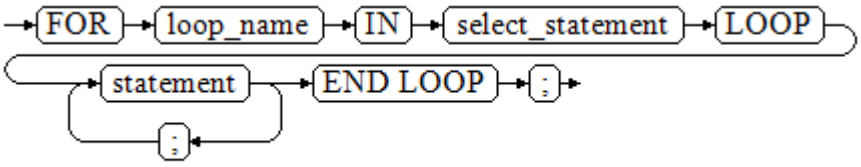
**Figure 13-33** FOR_AS_loop::=




## Precautions

- The **UPDATE** operation for the queried table is not allowed in the loop statement.
- The variable *loop_name* is automatically defined and is valid only in this loop. Its type is the same as that in the query result of *select_statement*. The value of *loop_name* is the query result of *select_statement*.
- The **%FOUND**, **%NOTFOUND**, and **%ROWCOUNT** attributes access the same internal variable in GaussDB. Transactions and the anonymous block do not support multiple cursor accesses at the same time.

## Examples

```
BEGIN
FOR ROW_TRANS IN
        SELECT first_name FROM hr.staffs
    LOOP
        DBE_OUTPUT.PRINT_LINE (ROW_TRANS.first_name );
    END LOOP;
END;
/

-- Create a table.
CREATE TABLE integerTable1( A INTEGER) DISTRIBUTE BY hash(A);
CREATE TABLE integerTable2( B INTEGER) DISTRIBUTE BY hash(B);
INSERT INTO integerTable2 VALUES(2);

-- Multiple cursors share the parameters of cursor attributes.
DECLARE
   CURSOR C1 IS SELECT A FROM integerTable1;-- Declare the cursor.
   CURSOR C2 IS SELECT B FROM integerTable2;
   PI_A INTEGER;
   PI_B INTEGER;
BEGIN
    OPEN C1;-- Open the cursor.
   OPEN C2;
   FETCH C1 INTO PI_A; ---- The values of C1%FOUND and C2%FOUND are FALSE.
   FETCH C2 INTO PI_B; ---- The values of C1%FOUND and C2%FOUND are TRUE.
   -- Determine the cursor status.
   IF C1%FOUND THEN
      IF C2%FOUND THEN
        DBE_OUTPUT.PRINT_LINE('Dual cursor share paremeter.');
      END IF;
   END IF;
    CLOSE C1;-- Close the cursor.
   CLOSE C2;
END;
/

-- Delete the temporary table.
DROP TABLE integerTable1;
DROP TABLE integerTable2;
```

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# 13.12 Advanced Packages

Advanced packages have two sets of interfaces. The first set is basic interfaces, and the second set is secondary encapsulation interfaces that are used improve usability. The second set is recommended.

## 13.12.1 Basic Interfaces

### 13.12.1.1 PKG_SERVICE

Table 13-3 lists all interfaces supported by the **PKG_SERVICE** package.

**Table 13-3** PKG_SERVICE

| Interface | Description |
| --- | --- |
| PKG_SERVICE.SQL_IS_CONTEXT_ACTIVE | Checks whether a context is registered. |
| PKG_SERVICE.SQL_CLEAN_ALL_CONTEXTS | Deregisters all registered contexts. |
| PKG_SERVICE.SQL_REGISTER_CONTEXT | Registers a context. |
| PKG_SERVICE.SQL_UNREGISTER_CONTEXT | Deregisters a context. |
| PKG_SERVICE.SQL_SET_SQL | Sets a SQL statement for a context. Currently, only the **SELECT** statement is supported. |
| PKG_SERVICE.SQL_RUN | Executes the configured SQL statement on a context. |
| PKG_SERVICE.SQL_NEXT_ROW | Reads the next row of data in a context. |
| PKG_SERVICE.SQL_GET_VALUE | Reads a dynamically defined column value in a context. |
| PKG_SERVICE.SQL_SET_RESULT_TYPE | Dynamically defines a column of a context based on the type OID. |
| PKG_SERVICE.JOB_CANCEL | Removes a scheduled task by task ID. |
| PKG_SERVICE.JOB_FINISH | Disables or enables scheduled task execution. |
| PKG_SERVICE.JOB_SUBMIT | Submits a scheduled task. Job ID can be automatically generated by the system or specified manually. |

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| Interface | Description |
| --- | --- |
| PKG_SERVICE.JOB_UPDATE | Modifies user-definable attributes of a scheduled task, including the task content, next-execution time, and execution interval. |
| PKG_SERVICE.SUBMIT_ON_NODES | Submits a task to all nodes. The task ID is automatically generated by the system. |
| PKG_SERVICE.ISUBMIT_ON_NODES | Submits a job to all nodes. The job ID is specified by the user. |
| PKG_SERVICE.SQL_GET_ARRAY_RESULT | Obtains the array value returned in the context. |
| PKG_SERVICE.SQL_GET_VARIABLE_RESULT | Obtains the column value returned in the context. |

- PKG_SERVICE.SQL_IS_CONTEXT_ACTIVE

  This function checks whether a context is registered. This function transfers the ID of the context to be queried. If the context exists, **TRUE** is returned. Otherwise, **FALSE** is returned.

  The prototype of the **PKG_SERVICE.SQL_IS_CONTEXT_ACTIVE** function is as follows:

  ```
  PKG_SERVICE.SQL_IS_CONTEXT_ACTIVE(
   context_id      IN INTEGER
  )
  RETURN BOOLEAN;
  ```

  **Table 13-4** PKG_SERVICE.SQL_IS_CONTEXT_ACTIVE interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the context to be queried |

- PKG_SERVICE.SQL_CLEAN_ALL_CONTEXTS

  This function cancels all contexts.

  The prototype of the **PKG_SERVICE.SQL_CLEAN_ALL_CONTEXTS** function is as follows:

  ```
  PKG_SERVICE.SQL_CLEAN_ALL_CONTEXTS(
  )
  RETURN VOID;
  ```

- PKG_SERVICE.SQL_REGISTER_CONTEXT

  This function opens a context, which is the prerequisite for the subsequent operations in the context. This function does not transfer any parameter. It automatically generates context IDs in an ascending order and returns values to integer variables.

  The prototype of the **PKG_SERVICE.SQL_REGISTER_CONTEXT** function is as follows:

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```
DBE_SQL.REGISTER_CONTEXT(
)
RETURN INTEGER;
```

- PKG_SERVICE.SQL_UNREGISTER_CONTEXT

  This function closes a context, which is the end of each operation in the context. If this function is not called when the stored procedure ends, the memory is still occupied by the context. Therefore, remember to close a context when you do not need to use it. If an exception occurs, the stored procedure exits but the context is not closed. Therefore, you are advised to include this interface in the exception handling of the stored procedure.

  The prototype of the **PKG_SERVICE.SQL_UNREGISTER_CONTEXT** function is as follows:

```
PKG_SERVICE.SQL_UNREGISTER_CONTEXT(
 context_id     IN INTEGER
)
RETURN INTEGER;
```

**Table 13-5** PKG_SERVICE.SQL_UNREGISTER_CONTEXT interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the context to be closed |

- PKG_SERVICE.SQL_SET_SQL

  This function parses the query statement of a given context. The input query statement is executed immediately. Currently, only the **SELECT** query statement can be parsed. The statement parameters can be transferred only through the **TEXT** type. The length cannot exceed 1 GB.

  The prototype of the **PKG_SERVICE.SQL_SET_SQL** function is as follows:

```
PKG_SERVICE.SQL_SET_SQL(
context_id     IN INTEGER,
query_string   IN TEXT,
language_flag  IN INTEGER
)
RETURN BOOLEAN;
```

**Table 13-6** PKG_SERVICE.SQL_SET_SQL interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the context whose query statement is to be parsed |
| query_string | Query statement to be parsed |
| language_flag | Version language number. Currently, only **1** is supported. |

- PKG_SERVICE.SQL_RUN

  This function executes a given context. It receives a context ID first, and the data obtained after execution is used for subsequent operations. Currently, only the **SELECT** query statement can be executed.

  The prototype of the **PKG_SERVICE.SQL_RUN** function is as follows:

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```
PKG_SERVICE.SQL_RUN(
context_id     IN INTEGER,
)
RETURN INTEGER;
```

**Table 13-7** PKG_SERVICE.SQL_RUN interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the context whose query statement is to be parsed |

- PKG_SERVICE.SQL_NEXT_ROW

  This function returns the number of data rows returned after the SQL statement is executed. Each time the interface is executed, the system obtains a set of new rows until all data is read.

  The prototype of the **PKG_SERVICE.SQL_NEXT_ROW** function is as follows:

```
PKG_SERVICE.SQL_NEXT_ROW(
context_id     IN INTEGER,
)
RETURN INTEGER;
```

**Table 13-8** PKG_SERVICE.SQL_NEXT_ROW interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the context to be executed |

- PKG_SERVICE.SQL_GET_VALUE

  This function returns the context element value in a specified position of a context and accesses the data obtained by **PKG_SERVICE.SQL_NEXT_ROW**.

  The prototype of the **PKG_SERVICE.SQL_GET_VALUE** function is as follows:

```
PKG_SERVICE.SQL_GET_VALUE(
context_id          IN    INTEGER,
pos                 IN    INTEGER,
col_type            IN    ANYELEMENT
)
RETURN ANYELEMENT;
```

**Table 13-9** PKG_SERVICE.SQL_GET_VALUE interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the context to be executed |
| pos | Position of a dynamically defined column in the query |
| col_type | Variable of any type, which defines the return value type of columns |

- PKG_SERVICE.SQL_SET_RESULT_TYPE

  This function defines columns returned from a given context and can be used only for contexts defined by **SELECT**. The defined columns are identified by

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the relative positions in the query list. The prototype of **PKG_SERVICE.SQL_SET_RESULT_TYPE** is as follows:

```
PKG_SERVICE.SQL_SET_RESULT_TYPE(
context_id      IN INTEGER,
pos             IN INTEGER,
coltype_oid     IN ANYELEMENT,
maxsize         IN INTEGER
)
RETURN INTEGER;
```

**Table 13-10** PKG_SERVICE.SQL_SET_RESULT_TYPE interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the context to be executed |
| pos | Position of a dynamically defined column in the query |
| coltype_oid | Variable of any type. The OID of the corresponding type can be obtained based on the variable type. |
| maxsize | Length of a defined column |

- PKG_SERVICE.JOB_CANCEL

  The stored procedure **CANCEL** deletes a specified task.

  The prototype of the **PKG_SERVICE.JOB_CANCEL** function is as follows:

  ```
  PKG_SERVICE.JOB_CANCEL(
  job  IN  INTEGER);
  ```

  **Table 13-11** PKG_SERVICE.JOB_CANCEL interface parameters

  | Parameter | Type | Input/ Output Parameter | Empty or Not | Description |
  | --- | --- | --- | --- | --- |
  | id | integer | IN | No | Specifies the job ID. |

  Example:

  ```
  CALL PKG_SERVICE.JOB_CANCEL(101);
  ```

- PKG_SERVICE.JOB_FINISH

  The stored procedure **FINISH** disables or enables a scheduled task.

  The prototype of the **PKG_SERVICE.JOB_FINISH** function is as follows:

  ```
  PKG_SERVICE.JOB_FINISH(
  id          IN   INTEGER,
  broken      IN   BOOLEAN,
  next_time   IN   TIMESTAMP  DEFAULT  sysdate);
  ```

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**Table 13-12** PKG_SERVICE.JOB_FINISH interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| id | integer | IN | No | Specifies the job ID. |
| broken | Boolean | IN | No | Specifies the status flag, **true** for broken and **false** for not broken. The current job is updated based on the parameter value **true** or **false**. If the parameter is left empty, the job status remains unchanged. |
| next_time | timestamp | IN | Yes | Specifies the next execution time. The default value is the current system time. If **broken** is set to **true**, **next_time** is updated to **'4000-1-1'**. If **broken** is set to **false** and **next_time** is not empty, **next_time** is updated for the job. If **next_time** is empty, it will not be updated. This parameter can be omitted, and its default value will be used in this case. |

- PKG_SERVICE.JOB_SUBMIT

  The stored procedure **JOB_SUBMIT** submits a scheduled task provided by the system.

  The prototype of the **PKG_SERVICE.JOB_SUBMIT** function is as follows:

```
PKG_SERVICE.JOB_SUBMIT(
id            IN   BIGINT,
content       IN   TEXT,
next_date     IN   TIMESTAMP DEFAULT sysdate,
interval_time IN   TEXT  DEFAULT 'null',
job           OUT  INTEGER);
```

  **NOTE**

  When a scheduled task (using **JOB**) is created, the system binds the current database and the username to the task by default. This function can be called by using **call** or **select**. If you call this function by using **select**, there is no need to specify output parameters. To call this function within a stored procedure, use **perform**. If the committed SQL statement task uses a non-public schema, specify the schema to a table schema or a function schema, or add **set current_schema = xxx** before the SQL statement.

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**Table 13-13** PKG_SERVICE.JOB_SUBMIT interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| id | bigint | IN | No | Specifies the job ID. If the input ID is **NULL**, a job ID is generated internally. |
| context | text | IN | No | Specifies the SQL statement to be executed. One or multiple DMLs, anonymous blocks, and statements for calling stored procedures, or all three combined are supported. |
| next_time | timestamp | IN | No | Specifies the next time the job will be executed. The default value is the current system time (**sysdate**). If the specified time has past, the job is executed at the time it is submitted. |
| interval_time | text | IN | Yes | Calculates the next time to execute the job. It can be an interval expression, or **sysdate** followed by a numeric value, for example, **sysdate+1.0/24**. If this parameter is left empty or set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward. |
| job | integer | OUT | No | Specifies the job ID. The value ranges from 1 to 32767. When **pkg_service.job_submit** is called using **select**, this parameter can be omitted. |

Example:

```
SELECT PKG_SERVICE.JOB_SUBMIT(NULL, 'call pro_xxx();', to_date('20180101','yyyymmdd'),'sysdate
+1');

SELECT PKG_SERVICE.JOB_SUBMIT(NULL, 'call pro_xxx();', to_date('20180101','yyyymmdd'),'sysdate
+1.0/24');

CALL PKG_SERVICE.JOB_SUBMIT(NULL, 'INSERT INTO T_JOB  VALUES(1);  call pro_1(); call pro_2();',
add_months(to_date('201701','yyyymm'),1), 'date_trunc(''day'',SYSDATE) + 1 +(8*60+30.0)/
(24*60)' ,:jobid);

SELECT PKG_SERVICE.JOB_SUBMIT (101, 'insert_msg_statistic1;', sysdate, 'sysdate+3.0/24');
```

- PKG_SERVICE.JOB_UPDATE

  The stored procedure **UPDATE** modifies user-definable attributes of a task, including the task content, next-execution time, and execution interval.

  The prototype of the **PKG_SERVICE.JOB_UPDATE** function is as follows:

```
PKG_SERVICE.JOB_UPDATE(
id              IN   BIGINT,
```

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```
next_time      IN   TIMESTAMP,
interval_time  IN   TEXT,
content        IN   TEXT);
```

**Table 13-14** PKG_SERVICE.JOB_UPDATE interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| id | integer | IN | No | Specifies the job ID. |
| next_time | timestamp | IN | Yes | Specifies the next execution time. If this parameter is left empty, the system does not update the **next_time** parameter for the specified job. Otherwise, the system updates the **next_time** parameter for the specified job. |
| interval_time | text | IN | Yes | Specifies the time expression for calculating the next time the job will be executed. If this parameter is left empty, the system does not update the **interval_time** parameter for the specified job. Otherwise, the system updates the **interval_time** parameter for the specified job after necessary validity check. If this parameter is set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward. |
| content | text | IN | Yes | Specifies the name of the stored procedure or SQL statement block that is executed. If this parameter is left empty, the system does not update the **content** parameter for the specified job. Otherwise, the system updates the **content** parameter for the specified job. |

Example:

```
CALL PKG_SERVICE.JOB_UPDATE(101, 'call userproc();', sysdate, 'sysdate + 1.0/1440');
CALL PKG_SERVICE.JOB_UPDATE(101, 'insert into tbl_a values(sysdate);', sysdate, 'sysdate + 1.0/1440');
```

- PKG_SERVICE.SUBMIT_ON_NODES

  The stored procedure **SUBMIT_ON_NODES** creates a scheduled task on all CNs and DNs. Only users **sysadmin** and **monitor admin** have this permission.

  The prototype of the **PKG_SERVICE.SUBMIT_ON_NODES** function is as follows:

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```
PKG_SERVICE.SUBMIT_ON_NODES(
node_name    IN   NAME,
database     IN   NAME,
what         IN   TEXT,
next_date    IN   TIMESTAMP WITHOUT TIME ZONE,
job_interval IN   TEXT,
job          OUT  INTEGER);
```

**Table 13-15** PKG_SERVICE.SUBMIT_ON_NODES interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| node_name | text | IN | No | Specifies the job execution node. Currently, the value can only be **ALL_NODE** (indicating that the job is executed on all nodes) or **CCN** (indicating that the job is executed on the central coordinator node). |
| database | text | IN | No | Database used by a cluster job. When the node type is **ALL_NODE**, the value can only be **postgres**. |
| what | text | IN | No | Specifies the SQL statement to be executed. One or multiple DMLs, anonymous blocks, and statements for calling stored procedures, or all three combined are supported. |
| nextdate | timestamp | IN | No | Specifies the next time the job will be executed. The default value is the current system time (**sysdate**). If the specified time has past, the job is executed at the time it is submitted. |
| job_interval | text | IN | No | Calculates the next time to execute the job. It can be an interval expression, or **sysdate** followed by a numeric value, for example, **sysdate+1.0/24**. If this parameter is left empty or set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward. |
| job | integer | OUT | No | Specifies the job ID. The value ranges from 1 to 32767. When **dbms.submit_on_nodes** is called using **select**, this parameter can be omitted. |

Example:

```
select pkg_service.submit_on_nodes('ALL_NODE', 'postgres', 'select
capture_view_to_json(''dbe_perf.statement'', 0);', sysdate, 'interval ''60 second''');
```

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```
select pkg_service.submit_on_nodes('CCN', 'postgres', 'select
capture_view_to_json(''dbe_perf.statement'', 0);', sysdate, 'interval ''60 second''');
```

- PKG_SERVICE.ISUBMIT_ON_NODES

  **ISUBMIT_ON_NODES** has the same syntax function as **SUBMIT_ON_NODES**, but the first parameter of **ISUBMIT_ON_NODES** is an input parameter, that is, a specified task ID. In contrast, that last parameter of **ISUBMIT_ON_NODES** is an output parameter, indicating the task ID automatically generated by the system. Only users **sysadmin** and **monitor admin** have this permission.

- PKG_SERVICE.SQL_GET_ARRAY_RESULT

  This function is used to return the value of the bound OUT parameter of the array type and obtain the OUT parameter in a stored procedure.

  The prototype of the **PKG_SERVICE.SQL_GET_ARRAY_RESULT** function is as follows:

```
PKG_SERVICE.SQL_GET_ARRAY_RESULT(
    context_id in int,
    pos in VARCHAR2,
    column_value inout anyarray,
    result_type in anyelement
);
```

**Table 13-16** PKG_SERVICE.SQL_GET_ARRAY_RESULT parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the context to be queried |
| pos | Name of the bound parameter |
| column_value | Return value |
| result_type | Return type |

- PKG_SERVICE.SQL_GET_VARIABLE_RESULT

  This function is used to return the value of the bound OUT parameter of the non-array type and obtain the OUT parameter in a stored procedure.

  The prototype of the **PKG_SERVICE.SQL_GET_VARIABLE_RESULT** function is as follows:

```
PKG_SERVICE.SQL_GET_VARIABLE_RESULT(
    context_id in int,
    pos in VARCHAR2,
    result_type in anyelement
)
RETURNS anyelement;
```

**Table 13-17** PKG_SERVICE.SQL_GET_VARIABLE_RESULT parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the context to be queried |
| pos | Name of the bound parameter |
| result_type | Return type |

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### 13.12.1.2 PKG_UTIL

Table 13-18 lists all interfaces supported by the **PKG_UTIL** package.

**Table 13-18** PKG_UTIL

| Interface | Description |
| --- | --- |
| PKG_UTIL.LOB_GET_LENGTH | Obtains the length of a LOB. |
| PKG_UTIL.LOB_READ | Reads a part of a LOB. |
| PKG_UTIL.LOB_WRITE | Writes the source object to the target object in the specified format. |
| PKG_UTIL.LOB_APPEND | Appends a specified number of characters of the source LOB to the target LOB. |
| PKG_UTIL.LOB_COMPARE | Compares two LOBs based on the specified length. |
| PKG_UTIL.LOB_MATCH | Returns the position of the *N*th occurrence of a character string in a LOB. |
| PKG_UTIL.LOB_RESET | Resets the character in specified position of a LOB to a specified character. |
| PKG_UTIL.IO_PRINT | Displays character strings. |
| PKG_UTIL.RAW_GET_LENGTH | Obtains the length of RAW data. |
| PKG_UTIL.RAW_CAST_FROM_VARCHAR2 | Converts VARCHAR2 data to RAW data. |
| PKG_UTIL.RAW_CAST_FROM_BINARY_INTEGER | Converts binary integers to RAW data. |
| PKG_UTIL.RAW_CAST_TO_BINARY_INTEGER | Converts RAW data to binary integers. |
| PKG_UTIL.SET_RANDOM_SEED | Sets a random seed. |
| PKG_UTIL.RANDOM_GET_VALUE | Returns a random value. |
| PKG_UTIL.FILE_SET_DIRNAME | Sets the directory to be operated. |
| PKG_UTIL.FILE_OPEN | Opens a file based on the specified file name and directory. |
| PKG_UTIL.FILE_SET_MAX_LINE_SIZE | Sets the maximum length of a line to be written to a file. |
| PKG_UTIL.FILE_IS_CLOSE | Checks whether a file handle is closed. |

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| Interface | Description |
| --- | --- |
| PKG_UTIL.FILE_READ | Reads data of a specified length from an open file handle. |
| PKG_UTIL.FILE_READLINE | Reads a line of data from an open file handle. |
| PKG_UTIL.FILE_WRITE | Writes the data specified in the buffer to a file. |
| PKG_UTIL.FILE_WRITELINE | Writes the buffer to a file and adds newline characters. |
| PKG_UTIL.FILE_NEWLINE | Adds a line. |
| PKG_UTIL.FILE_READ_RAW | Reads binary data of a specified length from an open file handle. |
| PKG_UTIL.FILE_WRITE_RAW | Writes binary data to a file. |
| PKG_UTIL.FILE_FLUSH | Writes data from a file handle to a physical file. |
| PKG_UTIL.FILE_CLOSE | Closes an open file handle. |
| PKG_UTIL.FILE_REMOVE | Deletes a physical file. To do so, you must have the corresponding permission. |
| PKG_UTIL.FILE_RENAME | Renames a file on the disk, similar to **mv** in Unix. |
| PKG_UTIL.FILE_SIZE | Returns the size of a file. |
| PKG_UTIL.FILE_BLOCK_SIZE | Returns the number of blocks contained in a file. |
| PKG_UTIL.FILE_EXISTS | Checks whether a file exists. |
| PKG_UTIL.FILE_GETPOS | Specifies the offset of a returned file, in bytes. |
| PKG_UTIL.FILE_SEEK | Sets the offset for file position. |
| PKG_UTIL.FILE_CLOSE_ALL | Closes all file handles opened in a session. |
| PKG_UTIL.EXCEPTION_REPORT_ERROR | Throws an exception. |

- PKG_UTIL.LOB_GET_LENGTH

  This function obtains the length of the input data.

  The prototype of the **PKG_UTIL.LOB_GET_LENGTH** function is as follows:

  ```
  PKG_UTIL.LOB_GET_LENGTH(
  lob      IN   anyelement
  ```

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```
)
RETURN INTEGER;
```

**Table 13-19** PKG_UTIL.LOB_GET_LENGTH interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| lob | clob / blob | IN | No | Indicates the object whose length is to be obtained. |

- PKG_UTIL.LOB_READ

  This function reads an object and returns the specified part.

  The prototype of the **PKG_UTIL.LOB_READ** function is as follows:

```
PKG_UTIL.LOB_READ(
lob       IN   anyelement,
len       IN   int,
start     IN   int,
mode      IN   int
)
RETURN ANYELEMENT
```

**Table 13-20** PKG_UTIL.LOB_READ interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| lob | clob/ blob | IN | No | Specifies CLOB or BLOB data. |
| len | int | IN | No | Specifies the length of the returned result. |
| start | int | IN | No | Specifies the offset to the first character. |
| mode | int | IN | No | Specifies the type of the read operation. **0** indicates **READ**, **1** indicates **TRIM**, and **2** indicates **SUBSTR**. |

- PKG_UTIL.LOB_WRITE

  This function writes the source object to the target object based on the specified parameters and returns the target object.

  The prototype of the **PKG_UTIL.LOB_WRITE** function is as follows:

```
PKG_UTIL.LOB_WRITE(
dest_lob    INOUT   blob,
src_lob     IN      raw
len         IN      int,
```

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```
start_pos   IN      int
)
RETURN BLOB;
PKG_UTIL.LOB_WRITE(
dest_lob    INOUT   clob,
src_lob     IN      varchar2
len         IN      int,
start_pos   IN      int
)
RETURN CLOB;
```

**Table 13-21** PKG_UTIL.LOB_WRITE interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| dest_lob | clob/blob | INOUT | No | Specifies the target object that data will be written to. |
| src_lob | clob/blob | IN | No | Specifies the source object to be written. |
| len | int | IN | No | Specifies the write length of the source object. |
| start_pos | int | IN | No | Specifies the write start position of the target object. |

- PKG_UTIL.LOB_APPEND

  This function appends the source object to the target BLOB/CLOB and returns the target BLOB/CLOB.

  The prototype of the **PKG_UTIL.LOB_APPEND** function is as follows:

```
PKG_UTIL.LOB_APPEND(
dest_lob    INOUT   blob,
src_lob     IN      blob,
len         IN      int default NULL
)
RETURN BLOB;

PKG_UTIL.LOB_APPEND(
dest_lob    INOUT   clob,
src_lob     IN      clob,
len         IN      int default NULL
)
RETURN CLOB;
```

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**Table 13-22** PKG_UTIL.LOB_APPEND interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| dest_lob | blob/clob | INOUT | No | Specifies the target BLOB/CLOB that data will be written to. |
| src_lob | blob/clob | IN | No | Specifies the source BLOB/CLOB to be written. |
| len | int | IN | Yes | Specifies the length of the source object to be written. If the value is **NULL**, the entire source object is written by default. |

- PKG_UTIL.LOB_COMPARE

  This function checks whether objects are the same based on the specified start position and size. If **lob1** is larger, **1** is returned. If **lob2** is larger, **–1** is returned. If **lob1** is equal to **lob2**, **0** is returned.

  The prototype of the **PKG_UTIL.LOB_COMPARE** function is as follows:

```
PKG_UTIL.LOB_COMPARE(
lob1        IN   anyelement,
lob2        IN   anyelement,
len         IN   int default 1073741771,
start_pos1      IN   int default 1,
start_pos2      IN   int default 1
)
RETURN INTEGER;
```

**Table 13-23** PKG_UTIL.LOB_COMPARE interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| lob1 | clob/blob | IN | No | Indicates the character string for comparison. |
| lob2 | clob/blob | IN | No | Indicates the character string for comparison. |
| len | int | IN | No | Indicates the length to be compared. |
| start_pos1 | int | IN | No | Specifies the start offset of **lob1**. |

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| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| start_pos2 | int | IN | No | Specifies the start offset of **lob2**. |

- PKG_UTIL.LOB_MATCH

  This function returns the position where a pattern is displayed in a LOB for the *match_n*th time.

  The prototype of the **PKG_UTIL.LOB_MATCH** function is as follows:

```
PKG_UTIL.LOB_MATCH(
lob          IN   anyelement,
pattern      IN   anyelement,
start        IN   int,
match_nth    IN   int default 1
)
RETURN INTEGER;
```

  **Table 13-24** PKG_UTIL.LOB_MATCH interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| lob | clob/blob | IN | No | Indicates the character string for comparison. |
| pattern | clob/blob | IN | No | Specifies the pattern to be matched. |
| start | int | IN | No | Specifies the start position for LOB comparison. |
| match_nth | int | IN | No | Specifies the matching times. |

- PKG_UTIL.LOB_RESET

  This function clears a character string and resets the string to the value of **value**.

  The prototype of the **PKG_UTIL.LOB_RESET** function is as follows:

```
PKG_UTIL.LOB_RESET(
lob          IN   blob,
len          IN   int,
start        IN   int,
value         IN   int default 0
```

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```
)
RETURN record;
```

**Table 13-25** PKG_UTIL.LOB_RESET interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| lob | blob | IN | No | Indicates the character string for reset. |
| len | int | IN | No | Specifies the length of the string to be reset. |
| start | int | IN | No | Specifies the start position for reset. |
| value | int | IN | Yes | Sets characters. Default value: **'0'** |

- PKG_UTIL.IO_PRINT

  This function outputs a string.

  The prototype of the **PKG_UTIL.IO_PRINT** function is as follows:

```
PKG_UTIL.IO_PRINT(
format      IN   text,
is_one_line IN   boolean
)
RETURN void;
```

**Table 13-26** PKG_UTIL.IO_PRINT interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| format | text | IN | No | Indicates the character string to be output. |
| is_one_line | boolean | IN | No | Indicates whether to output the string as a line. |

- PKG_UTIL.RAW_GET_LENGTH

  This function obtains the length of RAW data.

  The prototype of the **PKG_UTIL.RAW_GET_LENGTH** function is as follows:

```
PKG_UTIL.RAW_GET_LENGTH(
value      IN   raw
)
RETURN integer;
```

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**Table 13-27** PKG_UTIL.RAW_GET_LENGTH interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| raw | raw | IN | No | Indicates the object whose length is to be obtained. |

- PKG_UTIL.RAW_CAST_FROM_VARCHAR2

  This function converts VARCHAR2 data to RAW data.

  The prototype of the **PKG_UTIL.RAW_CAST_FROM_VARCHAR2** function is as follows:

```
PKG_UTIL.RAW_CAST_FROM_VARCHAR2(
str      IN   varchar2
)
RETURN raw;
```

**Table 13-28** PKG_UTIL.RAW_CAST_FROM_VARCHAR2 interface parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| str | varchar2 | IN | No | Indicates the source data to be converted |

- PKG_UTIL.RANDOM_SET_SEED

  This function sets a random seed.

  The prototype of the **PKG_UTIL.RANDOM_SET_SEED** function is as follows:

```
PKG_UTIL.RANDOM_SET_SEED(
seed        IN   int
)
RETURN integer;
```

**Table 13-29** PKG_UTIL.RANDOM_SET_SEED parameters

| Parameter | Type | Input/Output Parameter | Empty or Not | Description |
| --- | --- | --- | --- | --- |
| seed | int | IN | No | Sets a random seed. |

- PKG_UTIL.RANDOM_GET_VALUE

  The **RANDOM_GET_VALUE** function returns a 15-digit random number ranging from 0 to 1.

  The prototype of the **PKG_UTIL.RANDOM_GET_VALUE** function is as follows:

```
PKG_UTIL.RANDOM_GET_VALUE(
)
RETURN numeric;
```

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- PKG_UTIL.FILE_SET_DIRNAME

  This function sets the directory to be operated. It must be called to set directory for each operation involving a single directory.

  The prototype of the **PKG_UTIL.FILE_SET_DIRNAME** function is as follows:

```
PKG_UTIL.FILE_SET_DIRNAME(
dir  IN  text
)
RETURN bool
```

  **Table 13-30** PKG_UTIL.FILE_SET_DIRNAME interface parameters

| Parameter | Description |
| --- | --- |
| dirname | Directory of a file. It is a string, indicating an object name.<br>**NOTE**<br>File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule. |

- PKG_UTIL.FILE_OPEN

  This function opens a file. A maximum of 50 files can be opened at a time. This function returns a handle of the **INTEGER** type.

  The prototype of the **PKG_UTIL.FILE_OPEN** function is as follows:

```
PKG_UTIL.FILE_OPEN(
file_name    IN  text,
open_mode    IN  integer)
```

  **Table 13-31** PKG_UTIL.FILE_OPEN interface parameters

| Parameter | Description |
| --- | --- |
| file_name | File name with an extension (file type), excluding the path name. A path contained in a file name is ignored in the **OPEN** function. In Unix, the file name cannot end with the combination of a slash and a dot (/.). |
| open_mode | File opening mode, including **r** (read), **w** (write), and **a** (append).<br>**NOTE**<br>For the write operation, the system checks the file type. If the ELF file is written, an error is reported and the system exits. |

- PKG_UTIL.FILE_SET_MAX_LINE_SIZE

  This function sets the maximum length of a line to be written to a file.

  The prototype of the **PKG_UTIL.FILE_SET_MAX_LINE_SIZE** function is as follows:

```
PKG_UTIL.FILE_SET_MAX_LINE_SIZE(
max_line_size in integer)
RETURN BOOL
```

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**Table 13-32** PKG_UTIL.FILE_SET_MAX_LINE_SIZE interface parameters

| Parameter | Description |
| --- | --- |
| max_line_size | Maximum number of characters in each line, including newline characters. The minimum value is **1** and the maximum is **32767**. If this parameter is not specified, the default value **1024** is used. |

- PKG_UTIL.FILE_IS_CLOSE

  This function checks whether a file handle is closed.

  The prototype of the **PKG_UTIL.FILE_IS_CLOSE** function is as follows:

```
PKG_UTIL.FILE_IS_CLOSE(
file in integer
)
RETURN BOOL
```

**Table 13-33** PKG_UTIL.FILE_IS_CLOSE interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |

- PKG_UTIL.FILE_READ

  This function reads a line of data from an open file handle based on the specified length.

  The prototype of the **PKG_UTIL.FILE_READ** function is as follows:

```
PKG_UTIL.FILE_READ(
file     IN   integer,
buffer   OUT  text,
len      IN   bigint default 1024)
```

**Table 13-34** PKG_UTIL.FILE_READ interface parameters

| Parameter | Description |
| --- | --- |
| file | File handle opened by calling the **OPEN** function. The file must be opened in read mode. Otherwise, the **INVALID_OPERATION** exception is thrown. |
| buffer | Buffer used to receive data |
| len | Number of bytes read from a file |

- PKG_UTIL.FILE_READLINE

  This function reads a line of data from an open file handle based on the specified length.

  The prototype of the **PKG_UTIL.FILE_READLINE** function is as follows:

```
PKG_UTIL.FILE_READLINE(
file    IN  integer,
buffer  OUT text,
len     IN  integer default NULL)
```

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**Table 13-35** PKG_UTIL.FILE_READLINE interface parameters

| Parameter | Description |
| --- | --- |
| file | File handle opened by calling the **OPEN** function. The file must be opened in read mode. Otherwise, the **INVALID_OPERATION** exception is thrown. |
| buffer | Buffer used to receive data |
| len | Number of bytes read from a file. The default value is **NULL**. If the default value **NULL** is used, **max_line_size** is used to specify the line size. |

- PKG_UTIL.FILE_WRITE

  This function writes the data specified in the buffer to a file.

  The prototype of the **PKG_UTIL.FILE_WRITE** function is as follows:

  ```
  PKG_UTIL.FILE_WRITE(
  file in integer,
  buffer in text
  )
  RETURN BOOL
  ```

  **Table 13-36** PKG_UTIL.FILE_WRITE interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |
  | buffer | Text data to be written to a file. The maximum buffer size is 32767 bytes. If no value is specified, the default value is 1024 bytes. Before the writing is performed, the buffer occupied by **PUT** operations cannot exceed 32767 bytes.<br>**NOTE**<br>For the write operation, the system checks the file type. If the ELF file is written, an error is reported and the system exits. |

- PKG_UTIL.FILE_NEWLINE

  This function writes a line terminator to an open file. The line terminator is related to the platform.

  The prototype of the **PKG_UTIL.FILE_NEWLINE** function is as follows:

  ```
  PKG_UTIL.FILE_NEWLINE(
  file in integer
  )
  RETURN BOOL
  ```

  **Table 13-37** PKG_UTIL.FILE_NEWLINE interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |

- PKG_UTIL.FILE_WRITELINE

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Writes a line to a file.

The prototype of the **PKG_UTIL.FILE_WRITELINE** function is as follows:

```
PKG_UTIL.FILE_WRITELINE(
file in integer,
buffer in text
)
RETURN BOOL
```

**Table 13-38** PKG_UTIL.FILE_WRITELINE parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |
| buffer | Content to be written |

- PKG_UTIL.FILE_READ_RAW

  This function reads binary data of a specified length from an open file handle and returns the read binary data. The return type is **raw**.

  The prototype of the **PKG_UTIL.FILE_READ_RAW** function is as follows:

  ```
  PKG_UTIL.FILE_READ_RAW(
  file      in integer,
  length    in integer default NULL
  )
  RETURN raw
  ```

  **Table 13-39** PKG_UTIL.FILE_READ_RAW interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |
  | length | Length of the data to be read. The default value is **NULL**. By default, all data in the file is read. The maximum size is 1 GB. |

- PKG_UTIL.FILE_WRITE_RAW

  This function writes the input binary object **RAW** to an opened file. If the insertion is successful, **true** is returned.

  The prototype of the **PKG_UTIL.FILE_WRITE_RAW** function is as follows:

  ```
  PKG_UTIL.FILE_WRITE_RAW(
  file in integer,
  r    in raw
  )
  RETURN BOOL
  ```

  **Table 13-40** PKG_UTIL.FILE_WRITE_RAW parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |

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| Parameter | Description |
| --- | --- |
| r | Data to be written to the file<br>**NOTE**<br>For the write operation, the system checks the file type. If the ELF file is written, an error is reported and the system exits. |

- PKG_UTIL.FILE_FLUSH

  Data in a file handle must be written into a physical file. Data in the buffer must have a line terminator. Refresh is important if a file must be read when it is opened. For example, debugging information can be refreshed to a file so that it can be read immediately.

  The prototype of the **PKG_UTIL.FILE_FLUSH** function is as follows:

  ```
  PKG_UTIL.FILE_FLUSH (
  file in integer
  )
  RETURN VOID
  ```

  **Table 13-41** PKG_UTIL.FILE_FLUSH interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |

- PKG_UTIL.FILE_CLOSE

  This function closes an open file handle.

  The prototype of the **PKG_UTIL.FILE_CLOSE** function is as follows:

  ```
  PKG_UTIL.FILE_CLOSE (
  file in integer
  )
  RETURN BOOL
  ```

  **Table 13-42** PKG_UTIL.FILE_CLOSE interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |

- PKG_UTIL.FILE_REMOVE

  This function deletes a disk file. To perform this operation, you must have required permissions.

  The prototype of the **PKG_UTIL.FILE_REMOVE** function is as follows:

  ```
  PKG_UTIL.FILE_REMOVE(
  file_name in text
  )
  RETURN VOID
  ```

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**Table 13-43** PKG_UTIL.FILE_REMOVE interface parameters

| Parameter | Description |
| --- | --- |
| filen_ame | Name of the file to be deleted |

- PKG_UTIL.FILE_RENAME

  The function renames a file on the disk, similar to **mv** in Unix.

  The prototype of the **PKG_UTIL.FILE_RENAME** function is as follows:

```
PKG_UTIL.FILE_RENAME(
src_dir in text,
src_file_name in text,
dest_dir in text,
dest_file_name in text,
overwrite boolean default false)
```

**Table 13-44** PKG_UTIL.FILE_RENAME interface parameters

| Parameter | Description |
| --- | --- |
| src_dir | Source file directory (case-sensitive)<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
| src_file_name | Source file name |
| dest_dir | Target file directory (case-sensitive)<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
| dest_file_name | Target file name |
| overwrite | The default value is **false**. If a file with the same name exists in the destination directory, the file will not be rewritten. |

- PKG_UTIL.FILE_SIZE

  This function returns the size of a specified file.

  The prototype of the **PKG_UTIL.FILE_SIZE** function is as follows:

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```
bigint PKG_UTIL.FILE_SIZE(
file_name in text
)return bigint
```

**Table 13-45** PKG_UTIL.FILE_SIZE interface parameters

| Parameter | Description |
| --- | --- |
| file_name | File name |

- PKG_UTIL.FILE_BLOCK_SIZE

  This function returns the number of blocks contained in a specified file.

  The prototype of the **PKG_UTIL.FILE_BLOCK_SIZE** function is as follows:

  ```
  bigint PKG_UTIL.FILE_BLOCK_SIZE(
  file_name in text
  )return bigint
  ```

  **Table 13-46** PKG_UTIL.FILE_BLOCK_SIZE interface parameters

  | Parameter | Description |
  | --- | --- |
  | file_name | File name |

- PKG_UTIL.FILE_EXISTS

  This function checks whether a file exists.

  The prototype of the **PKG_UTIL.FILE_EXISTS** function is as follows:

  ```
  PKG_UTIL.FILE_EXISTS(
  file_name in text
  )
  RETURN BOOL
  ```

  **Table 13-47** PKG_UTIL.FILE_EXISTS interface parameters

  | Parameter | Description |
  | --- | --- |
  | file_name | File name |

- PKG_UTIL.FILE_GETPOS

  This function specifies the offset of a returned file, in bytes.

  The prototype of the **PKG_UTIL.FILE_GETPOS** function is as follows:

  ```
  PKG_UTIL.FILE_GETPOS(
  file in integer
  )
  RETURN BIGINT
  ```

  **Table 13-48** PKG_UTIL.FILE_GETPOS interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |

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- PKG_UTIL.FILE_SEEK

  This function adjusts the position of a file pointer forward or backward based on the specified number of bytes.

  The prototype of the **PKG_UTIL.FILE_SEEK** function is as follows:

```
void PKG_UTIL.FILE_SEEK(
file in integer,
start in bigint
)
RETURN VOID
```

  **Table 13-49** PKG_UTIL.FILE_SEEK interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |
| start | File offset, in bytes. |

- PKG_UTIL.FILE_CLOSE_ALL

  This function closes all file handles opened in a session.

  The prototype of the **PKG_UTIL.FILE_CLOSE_ALL** function is as follows:

```
PKG_UTIL.FILE_CLOSE_ALL(
)
RETURN VOID↵
```

  **Table 13-50** PKG_UTIL.FILE_CLOSE_ALL interface parameters

| Parameter | Description |
| --- | --- |
| None | None |

- PKG_UTIL.EXCEPTION_REPORT_ERROR

  This function throws an exception.

  The prototype of the **PKG_UTIL.EXCEPTION_REPORT_ERROR** function is as follows:

```
PKG_UTIL.EXCEPTION_REPORT_ERROR(
code integer,
log text,
flag boolean DEFAULT false
)
RETURN INTEGER
```

  **Table 13-51** PKG_UTIL.EXCEPTION_REPORT_ERROR interface parameters

| Parameter | Description |
| --- | --- |
| code | Error code displayed when an exception occurs. |
| log | Log information displayed when an exception occurs. |
| flag | Reserved. The default value is **false**. |

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- PKG_UTIL.app_read_client_info
  Reads the client information.
  The prototype of the **PKG_UTIL.app_read_client_info** function is as follows:

```
PKG_UTIL.app_read_client_info(
OUT buffer text
)return text
```

**Table 13-52** PKG_UTIL.app_read_client_info parameters

| Parameter | Description |
| --- | --- |
| buffer | Client information returned |

- PKG_UTIL.app_set_client_info
  Sets the client information.
  The prototype of the **PKG_UTIL.app_set_client_info** function is as follows:

```
PKG_UTIL.app_set_client_info(
str text
)
```

**Table 13-53** PKG_UTIL.app_set_client_info interface parameters

| Parameter | Description |
| --- | --- |
| str | Client information to be set |

- PKG_UTIL.lob_converttoblob
  Converts a CLOB to a BLOB. **amount** indicates the conversion length.
  The prototype of the **PKG_UTIL.lob_converttoblob** function is as follows:

```
PKG_UTIL.lob_converttoblob(
dest_lob blob,
src_clob clob,
amount integer,
dest_offset integer,
src_offset integer
)return raw
```

**Table 13-54** PKG_UTIL.lob_converttoblob interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | Target LOB |
| src_clob | CLOB to be converted |
| amount | Conversion length |
| dest_offset | Start position of the target LOB |
| src_offset | Start position of the source CLOB |

- PKG_UTIL.lob_converttoclob
  Converts a BLOB to a CLOB. **amount** indicates the conversion length.

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The prototype of the **PKG_UTIL.lob_converttoclob** function is as follows:

```
PKG_UTIL.lob_converttoclob(
dest_lob clob,
src_blob blob,
amount integer,
dest_offset integer,
src_offset integer
)return text
```

**Table 13-55** PKG_UTIL.lob_converttoclob interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | Target LOB |
| src_blob | BLOB to be converted |
| amount | Conversion length |
| dest_offset | Start position of the target LOB |
| src_offset | Start position of the source CLOB |

- PKG_UTIL.lob_texttoraw

  Converts the text type to the raw type.

  The prototype of the **PKG_UTIL.lob_texttoraw** function is as follows:

  ```
  PKG_UTIL.lob_texttoraw(
  src_lob clob
  )
  RETURN raw
  ```

  **Table 13-56** PKG_UTIL.lob_texttoraw parameters

  | Parameter | Description |
  | --- | --- |
  | src_lob | LOB to be converted |

- PKG_UTIL.match_edit_distance_similarity

  Calculates the difference between two character strings.

  The prototype of the **PKG_UTIL.match_edit_distance_similarity** function is as follows:

  ```
  PKG_UTIL.match_edit_distance_similarity(
  str1 text,
  str2 text
  )
  RETURN INTEGER
  ```

  **Table 13-57** PKG_UTIL.match_edit_distance_similarity parameters

  | Parameter | Description |
  | --- | --- |
  | str1 | First character string |
  | str2 | Second character string |

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- PKG_UTIL.raw_cast_to_varchar2

  Converts the raw type to the varchar2 type.

  The prototype of the **PKG_UTIL.raw_cast_to_varchar2** function is as follows:

```
PKG_UTIL.raw_cast_to_varchar2(
str raw
)
RETURN varchar2
```

  **Table 13-58** PKG_UTIL.raw_cast_to_varchar2 interface parameters

| Parameter | Description |
| --- | --- |
| str | Hexadecimal string |

- PKG_UTIL.session_clear_context

  Clears the session context.

  The prototype of the **PKG_UTIL.session_clear_context** function is as follows:

```
PKG_UTIL.session_clear_context(
namespace text,
client_identifier text,
attribute text
)
RETURN INTEGER
```

  **Table 13-59** PKG_UTIL.session_clear_context parameters

| Parameter | Description |
| --- | --- |
| namespace | Namespace of an attribute |
| client_identifier | Usually same as the value of **namespace**. If this parameter is set to **null**, all namespaces are modified by default. |
| attribute | Attribute value to be cleared |

- PKG_UTIL.session_search_context

  Searches for an attribute value.

  The prototype of the **PKG_UTIL.session_clear_context** function is as follows:

```
PKG_UTIL.session_clear_context(
namespace text,
attribute text
)
RETURN INTEGER
```

  **Table 13-60** PKG_UTIL.session_clear_context parameters

| Parameter | Description |
| --- | --- |
| namespace | Namespace of an attribute |
| attribute | Attribute value to be cleared |

- PKG_UTIL.session_set_context

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Sets an attribute value.

The prototype of the **PKG_UTIL.session_set_context** function is as follows:

```
PKG_UTIL.session_set_context(
namespace text,
attribute text,
value text
)
RETURN INTEGER
```

**Table 13-61** PKG_UTIL.session_set_context parameters

| Parameter | Description |
| --- | --- |
| namespace | Namespace of an attribute |
| attribute | Attribute to be set |
| value | Attribute value |

- PKG_UTIL.utility_get_time

  Prints the Unix timestamp.

  The prototype of the **PKG_UTIL.utility_get_time** function is as follows:

  ```
  PKG_UTIL.utility_get_time()
  RETURN bigint
  ```

- PKG_UTIL.utility_format_error_backtrace

  Displays the error stack of a stored procedure.

  The prototype of the **PKG_UTIL.utility_format_error_backtrace** function is as follows:

  ```
  PKG_UTIL.utility_format_error_backtrace()
  RETURN text
  ```

- PKG_UTIL.utility_format_error_stack

  Displays the error information about a stored procedure.

  The prototype of the **PKG_UTIL.utility_format_error_stack** function is as follows:

  ```
  PKG_UTIL.utility_format_error_stack()
  RETURN text
  ```

- PKG_UTIL.utility_format_call_stack

  Displays the call stack of a stored procedure.

  The prototype of the **PKG_UTIL.utility_format_call_stack** function is as follows:

  ```
  PKG_UTIL.utility_format_call_stack()
  RETURN text
  ```

# 13.12.2 Secondary Encapsulation Interfaces (Recommended)

## 13.12.2.1 DBE_LOB

## Interface Description

Table 13-62 provides all interfaces supported by the **DBE_LOB** package.

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**Table 13-62** DBE_LOB

| Interface | Description |
| --- | --- |
| DBE_LOB.GET_LENGTH | Obtains and returns the specified length of a LOB. |
| DBE_LOB.OPEN | Opens a LOB and returns a LOB descriptor. |
| DBE_LOB.READ | Loads a part of LOB content to the buffer based on the specified length and initial position offset. |
| DBE_LOB.WRITE | Copies content in the buffer to a LOB based on the specified length and initial position offset. |
| DBE_LOB.WRITE_APPEND | Copies content in the buffer to the end part of a LOB based on the specified length. |
| DBE_LOB.COPY | Copies content in a BLOB to another BLOB based on the specified length and initial position offset. |
| DBE_LOB.ERASE | Deletes content in a BLOB based on the specified length and initial position offset. |
| DBE_LOB.CLOSE | Closes a LOB descriptor. |
| DBE_LOB.MATCH | Returns the position of the *M*th occurrence of a character string in a LOB. |
| DBE_LOB.COMPARE | Compares two LOBs or a certain part of two LOBs. |
| DBE_LOB.SUBSTR | Reads the substring of a LOB and returns the number of read bytes or the number of characters. |
| DBE_LOB.STRIP | Truncates the LOB of a specified length. After the execution is complete, the length of the LOB is set to the length specified by the **newlen** parameter. |
| DBE_LOB.CREATE_TEMPORARY | Creates a temporary BLOB or CLOB. |
| DBE_LOB.FREETEMPORARY | Deletes a temporary BLOB or CLOB. |
| DBE_LOB.APPEND | Adds the content of a LOB to another LOB. |
| DBE_LOB.FILEOPEN | Opens a database-external file and returns a file descriptor. |
| DBE_LOB.FILECLOSE | Closes an external file opened by **FILEOPEN**. |
| DBE_LOB.LOADFROMFILE | Reads a database-external file to a BLOB file. |
| DBE_LOB.LOADBLOBFROMFILE | Reads a database-external file to a BLOB file. |
| DBE_LOB.LOADCLOBFROMFILE | Reads a database-external file to a CLOB file. |

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| Interface | Description |
| --- | --- |
| DBE_LOB.CONVERTTOBLOB | Converts a CLOB file to a BLOB file. |
| DBE_LOB.CONVERTTOCLOB | Converts a BLOB file to a CLOB file. |

- DBE_LOB.GET_LENGTH

  The stored procedure **GET_LENGTH** obtains and returns the specified length of a LOB.

  The function prototype of **DBE_LOB.GET_LENGTH** is as follows:

```
DBE_LOB.GET_LENGTH (
lob    IN   BLOB)
RETURN INTEGER;

DBE_LOB.GET_LENGTH (
lob    IN   CLOB)
RETURN INTEGER;
```

  **Table 13-63** DBE_LOB.GET_LENGTH interface parameters

| Parameter | Description |
| --- | --- |
| lob | BLOB/CLOB whose length is to be obtained |

- DBE_LOB.OPEN

  This stored procedure opens a LOB and returns a LOB descriptor. This process is used only for compatibility.

  The function prototype of **DBE_LOB.OPEN** is as follows:

```
DBE_LOB.OPEN (
lob    INOUT   BLOB
);

DBE_LOB.OPEN (
lob  INOUT    CLOB
);

DBE_LOB.OPEN (
bfile dbe_lob.bfile,
open_mode text DEFAULT 'null'::text
);
```

  **Table 13-64** DBE_LOB.OPEN interface parameters

| Parameter | Description |
| --- | --- |
| lob | BLOB or CLOB that is opened |

- DBE_LOB.READ

  The stored procedure **READ** loads a part of LOB content to the buffer based on the specified length and initial position offset.

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The function prototype of **DBE_LOB.READ** is as follows:

```
DBE_LOB.READ (
lob     IN     BLOB,
len     IN     INTEGER,
start   IN     INTEGER,
buffer  OUT    RAW);

DBE_LOB.READ (
lob     IN     CLOB,
len     INOUT  INTEGER,
start   IN     INTEGER,
buffer  OUT    VARCHAR2);
```

**Table 13-65** DBE_LOB.READ interface parameters

| Parameter | Description |
| --- | --- |
| lob | BLOB/CLOB to be read |
| len | Length of read content<br>**NOTE**<br>If the length is negative, the error message "ERROR: argument 2 is null, invalid, or out of range." is displayed. |
| start | Indicates where to start reading the LOB content, that is, the offset bytes to initial position of LOB content. |
| buffer | Target buffer to store the read LOB content |

- DBE_LOB.WRITE

  The stored procedure **WRITE** copies content in the buffer to LOB variables based on the specified length and initial position.

  The prototype of the **DBE_LOB.WRITE** function is as follows:

```
DBE_LOB.WRITE (
dest_lob   INOUT    BLOB,
len        IN       INTEGER,
start      IN       INTEGER,
src_lob    IN       RAW);

DBE_LOB.WRITE (
dest_lob   INOUT   CLOB,
len        IN      INTEGER,
start      IN      INTEGER,
src_lob    IN      VARCHAR2);
```

**Table 13-66** DBE_LOB.WRITE interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | BLOB/CLOB to be written |
| len | Length of written content<br>**NOTE**<br>If the length of written content is shorter than 1 or longer than the length of content to be written, an error is reported. |

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| Parameter | Description |
| --- | --- |
| start | Indicates where to start writing the LOB content, that is, the offset bytes to initial position of LOB content.<br>**NOTE**<br>If the offset value is less than 1, an error is reported. If the offset value is greater than the maximum length of LOB type contents, no error is reported. |
| src_lob | Content to be written |

- DBE_LOB.WRITE_APPEND

  The stored procedure **WRITE_APPEND** copies content in the buffer to the end part of a LOB based on the specified length.

  The function prototype of **DBE_LOB.WRITE_APPEND** is as follows:

```
DBE_LOB.WRITE_APPEND (
dest_lob    INOUT    BLOB,
len         IN       INTEGER,
src_lob     IN       RAW);

DBE_LOB.WRITE_APPEND (
dest_lob    INOUT     CLOB,
len         IN       INTEGER,
src_lob     IN       VARCHAR2);
```

**Table 13-67** DBE_LOB.WRITE_APPEND interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | BLOB/CLOB to be written |
| len | Length of written content<br>**NOTE**<br>If the length of written content is shorter than 1 or longer than the length of content to be written, an error is reported. |
| src_lob | Content to be written |

- DBE_LOB.COPY

  The stored procedure **COPY** copies content in a BLOB to another BLOB based on the specified length and initial position offset.

  The function prototype of **DBE_LOB.COPY** is as follows:

```
DBE_LOB.COPY (
dest_lob     INOUT    BLOB,
src_lob      IN       BLOB,
len          IN       INTEGER,
dest_start   IN       INTEGER  DEFAULT 1,
src_start    IN       INTEGER  DEFAULT 1);
```

**Table 13-68** DBE_LOB.COPY interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | BLOB to be pasted |

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| Parameter | Description |
| --- | --- |
| src_lob | BLOB to be copied |
| len | Length of copied content<br>**NOTE**<br>If the length of copied content is shorter than 1 or longer than the maximum length of BLOB, an error is reported. |
| dest_start | Indicates where to start pasting the BLOB content, that is, the offset bytes to initial position of BLOB content.<br>**NOTE**<br>If the offset is shorter than 1 or longer than the maximum length of BLOB, an error is reported. |
| src_start | Indicates where to start copying the BLOB content, that is, the offset bytes to initial position of BLOB content.<br>**NOTE**<br>If the offset is shorter than 1 or longer than the length of source BLOB, an error is reported. |

- DBE_LOB.ERASE

  The stored procedure **ERASE** deletes content in BLOB based on the specified length and initial position offset.

  The prototype of the **DBE_LOB.ERASE** function is as follows:

```
DBE_LOB.ERASE (
lob       INOUT   BLOB,
len       INOUT   INTEGER,
start     IN      INTEGER DEFAULT 1);
```

  **Table 13-69** DBE_LOB.ERASE interface parameters

| Parameter | Description |
| --- | --- |
| lob | BLOB whose content is to be deleted |
| len | Length of content to be deleted<br>**NOTE**<br>If the length of deleted content is shorter than 1 or longer than the maximum length of BLOB, an error is reported. |
| start | Indicates where to start deleting the BLOB content, that is, the offset bytes to initial position of BLOB content.<br>**NOTE**<br>If the offset is shorter than 1 or longer than the maximum length of BLOB, an error is reported. |

- DBE_LOB.CLOSE

  The stored procedure CLOSE closes the LOB descriptor that has been opened.

  The prototype of the **DBE_LOB.CLOSE** function is as follows:

```
DBE_LOB.CLOSE(
lob     IN      BLOB);

DBE_LOB.CLOSE (
```

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```
lob     IN     CLOB);

DBE_LOB.CLOSE (
file     IN     INTEGER);
```

**Table 13-70** DBE_LOB.CLOSE interface parameters

| Parameter | Description |
| --- | --- |
| lob | BLOB/CLOB to be disabled |

- DBE_LOB.MATCH

  This function returns the *M*th occurrence position of **pattern** in a LOB. **NULL** is returned for any of the following conditions: offset < 1 or offset > **LOBMAXSIZE**; *n*th < 1 or *n*th > **LOBMAXSIZE**

  The function prototype of **DBE_LOB.MATCH** is as follows:

```
DBE_LOB.MATCH (
lob             IN     BLOB,
pattern         IN     RAW,
start_index     IN     INTEGER  DEFAULT 1,
match_index     IN     INTEGER  DEFAULT 1)
RETURN INTEGER;

DBE_LOB.MATCH (
lob             IN     CLOB,
pattern         IN     VARCHAR2 ,
start_index     IN     INTEGER  DEFAULT 1,
match_index     IN     INTEGER  DEFAULT 1)
RETURN INTEGER;
```

**Table 13-71** DBE_LOB.MATCH interface parameters

| Parameter | Description |
| --- | --- |
| lob | BLOB/CLOB descriptor to be searched for |
| pattern | Matched pattern. It is **RAW** for BLOB and **TEXT** for CLOB. |
| start_index | For BLOB, the absolute offset is in the unit of byte. For CLOB, the offset is in the unit of character. The matching start position is 1. |
| match_index | Number of pattern matching times. The minimum value is 1. |

- DBE_LOB.COMPARE

  This function compares two LOBs or a certain part of two LOBs.

  – If the two parts are equal, **0** is returned. Otherwise, a non-zero value is returned.
  – If the first LOB is smaller than the second, **-1** is returned. If the first LOB is larger than the second, **1** is returned.
  – If any of the **len**, **start1**, and **start2** parameters is invalid, **NULL** is returned. The valid offset range is 1 to **LOBMAXSIZE**.

  The function prototype of **DBE_LOB.COMPARE** is as follows:

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```
DBE_LOB.COMPARE (
lob1     IN     BLOB,
lob2     IN     BLOB,
len      IN     INTEGER DEFAULT DBE_LOB.LOBMAXSIZE,
start1   IN     INTEGER DEFAULT 1,
start2   IN     INTEGER DEFAULT 1)
RETURN INTEGER;

DBE_LOB.COMPARE (
lob1     IN     CLOB,
lob2     IN     CLOB,
len      IN     INTEGER DEFAULT DBE_LOB.LOBMAXSIZE,
start1   IN     INTEGER DEFAULT 1,
start2   IN     INTEGER DEFAULT 1)
RETURN INTEGER;
```

**Table 13-72** DBE_LOB.COMPARE interface parameters

| Parameter | Description |
| --- | --- |
| lob1 | First BLOB/CLOB to be compared |
| lob2 | Second BLOB/CLOB to be compared |
| len | Number of characters or bytes to be compared. The maximum value is **DBE_LOB.LOBMAXSIZE**. |
| start1 | Offset of the first LOB descriptor. The initial position is 1. |
| start2 | Offset of the second LOB descriptor. The initial position is 1. |

- DBE_LOB.SUBSTR

  This function reads the substring of a LOB and returns the number of read bytes or the number of characters. **NULL** is returned for any of the following conditions: amount > 1 or amount < 32767; offset < 1 or offset > **LOBMAXSIZE**

  The prototype of the **DBE_LOB.SUBSTR** function is as follows:

```
DBE_LOB.SUBSTR (
lob      IN     BLOB,
len      IN     INTEGER DEFAULT  32767,
start    IN     INTEGER DEFAULT  1)
RETURN RAW;

DBE_LOB.SUBSTR (
lob      IN     CLOB,
len      IN     INTEGER DEFAULT  32767,
start    IN     INTEGER DEFAULT  1)
RETURN VARCHAR2;
```

**Table 13-73** DBE_LOB.SUBSTR interface parameters

| Parameter | Description |
| --- | --- |
| lob | LOB descriptor of the substring to be read. For BLOB, the return value is the number of read bytes. For CLOB, the return value is the number of characters. |
| len | Number of bytes or characters to be read. |

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| Parameter | Description |
| --- | --- |
| start | Number of characters or bytes offset from the start position. |

- DBE_LOB.STRIP

  This stored procedure truncates the LOB of a specified length. After this stored procedure is executed, the length of the LOB is set to the length specified by the **newlen** parameter. If an empty LOB is truncated, no execution result is displayed. If the specified length is longer than the length of the LOB, an exception occurs.

  The prototype of the **DBE_LOB.STRIP** function is as follows:

```
DBE_LOB.STRIP (
lob       IN OUT     BLOB,
newlen    IN       INTEGER);

DBE_LOB.STRIP (
lob       IN OUT     CLOB,
newlen    IN       INTEGER);
```

  **Table 13-74** DBE_LOB.STRIP interface parameters

| Parameter | Description |
| --- | --- |
| lob | BLOB to be read |
| newlen | After truncation, the new LOB length for BLOB is in the unit of byte and that for CLOB is in the unit of character. |

- DBE_LOB.CREATE_TEMPORARY

  This stored procedure creates a temporary BLOB or CLOB and is used only for syntax compatibility.

  The function prototype of **DBE_LOB.CREATE_TEMPORARY** is as follows:

```
DBE_LOB.CREATE_TEMPORARY (
locator          INOUT      BLOB,
cache            IN         BOOLEAN,
keep_alive_time   IN         INTEGER);

DBE_LOB.CREATE_TEMPORARY (
locator          INOUT      CLOB,
cache            IN         BOOLEAN,
keep_alive_time   IN         INTEGER);
```

  **Table 13-75** DBE_LOB.CREATE_TEMPORARY interface parameters

| Parameter | Description |
| --- | --- |
| locator | LOB descriptor |
| cache | Used only for syntax compatibility. |
| keep_alive_time | Used only for syntax compatibility. |

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- DBE_LOB.APPEND

  The stored procedure **APPEND** loads a part of BLOB content to the buffer based on the specified length and initial position offset.

  The function prototype of **DBE_LOB.APPEND** is as follows:

```
DBE_LOB.APPEND (
dest_lob    INOUT       BLOB,
src_lob     IN          BLOB);

DBE_LOB.APPEND (
dest_lob    INOUT       CLOB,
src_lob     IN          CLOB);
```

  **Table 13-76** DBE_LOB.APPEND interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | BLOB/CLOB to be written |
| src_lob | BLOB/CLOB to be read |

- DBE_LOB.FREETEMPORARY

  The stored procedure is used to release LOB files created by **CREATE_TEMPORARY**.

  The **DBE_LOB.FREETEMPORARY** function prototype is as follows:

```
DBE_LOB.FREETEMPORARY (
lob_loc    INOUT       BLOB);

DBE_LOB.FREETEMPORARY (
lob_loc    INOUT       CLOB);
```

  **Table 13-77** DBE_LOB.FREETEMPORARY interface parameters

| Parameter | Description |
| --- | --- |
| lob_loc | BLOB or CLOB to be released. |

- DBE_LOB.FILEOPEN

  This function is used to open a database-external file of the BFILE type and return the file descriptor corresponding to the file.

  The BFILE type is defined as follows:

```
DBE_LOB.BFILE (
directory    text,
filename     text);
```

  The **DBE_LOB.FILEOPEN** function prototype is as follows:

```
DBE_LOB.FILEOPEN (
file         IN    DBE_LOB.BFILE,
open_mode    IN    text)
RETURN integer;
```

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**Table 13-78** DBE_LOB.FILEOPEN parameters

| Parameter | Description |
| --- | --- |
| file | Specifies the database-external file to be opened. The BFILE type contains the file path and file name. |
| open_mode | Specifies the file open mode (**w**, **r**, or **a**). |

- DBE_LOB.FILECLOSE

  This function is used to close an external BFILE file.

  The **DBE_LOB.FILECLOSE** function prototype is as follows:

```
DBE_LOB.FILECLOSE (
file     IN     integer);
```

**Table 13-79** DBE_LOB.FILECLOSE interface parameters

| Parameter | Description |
| --- | --- |
| file | Specifies the database-external file to be closed (the file descriptor is returned by **FILEOPEN**). |

- DBE_LOB.LOADFROMFILE

  This is used to read an external BFILE file to a BLOB file.

  The prototype of the **DBE_LOB.LOADFROMFILE** function is as follows:

```
DBE_LOB.LOADFROMFILE (
dest_lob      IN     BLOB,
src_file      IN     INTEGER,
amount        IN     INTEGER,
dest_offset   IN     INTEGER,
src_offset    IN     INTEGER)
RETURN raw;
```

**Table 13-80** DBE_LOB.LOADFROMFILE interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | Target BLOB file. The BFILE file will be read to this file. |
| src_bfile | Source BFILE file to be read. |
| amount | Size of a BLOB file. If the size of a file exceeds this threshold, the file will not be saved to the BLOB file. |
| dest_offset | Offset length of the BLOB file. If **dest_offset** is set to **1**, data is loaded from the start position of the file. The rest may be deduced by analogy. |
| src_offset | Offset length of the BFILE file. If **src_offset** is set to **1**, data is read from the start position of the file. The rest may be deduced by analogy. |

- DBE_LOB.LOADBLOBFROMFILE

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This is used to read an external BFILE file to a BLOB file.

The prototype of the **DBE_LOB.LOADBLOBFROMFILE** function is as follows:

```
DBE_LOB.LOADBLOBFROMFILE (
dest_lob      IN    BLOB,
src_file     IN    INTEGER,
amount        IN    INTEGER,
dest_offset   IN    INTEGER,
src_offset    IN    INTEGER)
RETURN raw;
```

**Table 13-81** DBE_LOB.LOADBLOBFROMFILE interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | Target BLOB file. The BFILE file will be read to this file. |
| src_bfile | Source BFILE file to be read. |
| amount | Size of a BLOB file. If the size of a file exceeds this threshold, the file will not be saved to the BLOB file. |
| dest_offset | Offset length of the BLOB file. If **dest_offset** is set to **1**, data is loaded from the start position of the file. The rest may be deduced by analogy. |
| src_offset | Offset length of the BFILE file. If **src_offset** is set to **1**, data is read from the start position of the file. The rest may be deduced by analogy. |

- DBE_LOB.LOADCLOBFROMFILE

  This is used to read an external BFILE file to a CLOB file.

  The prototype of the **DBE_LOB.LOADCLOBFROMFILE** function is as follows:

  ```
  DBE_LOB.LOADCLOBFROMFILE (
  dest_lob      IN    CLOB,
  src_file     IN    INTEGER,
  amount        IN    INTEGER,
  dest_offset   IN    INTEGER,
  src_offset    IN    INTEGER)
  RETURN raw;
  ```

  **Table 13-82** DBE_LOB.LOADCLOBFROMFILE interface parameters

  | Parameter | Description |
  | --- | --- |
  | dest_lob | Target CLOB file. The BFILE file will be read to this file. |
  | src_bfile | Source BFILE file to be read. |
  | amount | Size of a CLOB file. If the size of a file exceeds this threshold, the file will not be saved to the CLOB file. |
  | dest_offset | Offset length of the CLOB file. If **dest_offset** is set to **1**, data is loaded from the start position of the file. The rest may be deduced by analogy. |

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| Parameter | Description |
| --- | --- |
| src_offset | Offset length of the BFILE file. If **src_offset** is set to **1**, data is read from the start position of the file. The rest may be deduced by analogy. |

- DBE_LOB.CONVERTTOBLOB

  This function is used to convert a CLOB file to a BLOB file.

  The prototype of the **DBE_LOB.CONVERTTOBLOB** function is as follows:

```
DBE_LOB.CONVERTTOBLOB(
dest_blob     IN   BLOB,
src_clob      IN   CLOB,
amount        IN   INTEGER default 32767,
dest_offset   IN   INTEGER default 1,
src_offset    IN   INTEGER default 1)
RETURN raw;
```

  **Table 13-83** DBE_LOB.CONVERTTOBLOB interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | Target BLOB file, which is converted from a CLOB file. |
| src_bfile | Source CLOB file to be read. |
| amount | Size of a BLOB file. If the size of a file exceeds this threshold, the file will not be saved to the BLOB file. |
| dest_offset | Offset length of the BLOB file. If **dest_offset** is set to **1**, data is loaded from the start position of the file. The rest may be deduced by analogy. |
| src_offset | Offset length of the CLOB file. If **src_offset** is set to **1**, data is read from the start position of the file. The rest may be deduced by analogy. |

- DBE_LOB.CONVERTTOCLOB

  This function is used to convert a BLOB file to a CLOB file.

  The prototype of the **DBE_LOB.CONVERTTOCLOB** function is as follows:

```
DBE_LOB.CONVERTTOCLOB(
dest_clob     IN   CLOB,
src_blob      IN   BLOB,
amount        IN   INTEGER default 32767,
dest_offset   IN   INTEGER default 1,
src_offset    IN   INTEGER default 1)
RETURN text;
```

  **Table 13-84** DBE_LOB.CONVERTTOCLOB interface parameters

| Parameter | Description |
| --- | --- |
| dest_lob | Target CLOB file, which is converted from a BLOB file. |
| src_bfile | Source BLOB file to be read. |

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| Parameter | Description |
| --- | --- |
| amount | Size of a CLOB file. If the size of a file exceeds this threshold, the file will not be saved to the CLOB file. |
| dest_offset | Offset length of the CLOB file. If **dest_offset** is set to **1**, data is loaded from the start position of the file. The rest may be deduced by analogy. |
| src_offset | Offset length of the BLOB file. If **src_offset** is set to **1**, data is read from the start position of the file. The rest may be deduced by analogy. |

## Examples

```
-- Obtain the length of a string.
SELECT DBE_LOB.GET_LENGTH('12345678');

DECLARE
myraw  RAW(100);
amount INTEGER :=2;
buffer INTEGER :=1;
begin
DBE_LOB.READ('123456789012345',amount,buffer,myraw);
dbe_output.print_line(myraw);
end;
/

CREATE TABLE blob_Table (t1 blob) DISTRIBUTE BY REPLICATION;
CREATE TABLE blob_Table_bak (t2 blob) DISTRIBUTE BY REPLICATION;
INSERT INTO blob_Table VALUES('abcdef');
INSERT INTO blob_Table_bak VALUES('22222');

DECLARE
str varchar2(100) := 'abcdef';
source raw(100);
dest blob;
copyto blob;
amount int;
PSV_SQL varchar2(100);
PSV_SQL1 varchar2(100);
a int :=1;
len int;
BEGIN
source := dbe_raw.cast_from_varchar2_to_raw(str);
amount := dbe_raw.get_length(source);

PSV_SQL :='select * from blob_Table for update';
PSV_SQL1 := 'select * from blob_Table_bak for update';

EXECUTE IMMEDIATE PSV_SQL into dest;
EXECUTE IMMEDIATE PSV_SQL1 into copyto;

DBE_LOB.WRITE(dest, amount, 1, source);
DBE_LOB.WRITE_APPEND(dest, amount, source);

DBE_LOB.ERASE(dest, a, 1);
DBE_OUTPUT.PRINT_LINE(a);
DBE_LOB.COPY(copyto, dest, amount, 10, 1);
perform DBE_LOB.CLOSE(dest);
RETURN;
END;
/
```

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```
-- Delete the table.
DROP TABLE blob_Table;
DROP TABLE blob_Table_bak;
```

## 13.12.2.2 DBE_RANDOM

## Interface Description

Table 13-85 lists all interfaces supported by the **DBE_RANDOM** package.

**Table 13-85** DBE_RANDOM interface parameters

| Interface | Description |
| --- | --- |
| DBE_RANDOM.SET_SEED | Sets a seed for a random number. |
| DBE_RANDOM.GET_VALUE | Generates a random number between a specified **low** and a specified **high**. |

- DBE_RANDOM.SET_SEED

  The stored procedure **SEED** is used to set a seed for a random number. The function prototype of **DBE_RANDOM.SET_SEED** is as follows:

  ```
  DBE_RANDOM.SET_SEED (seed  IN  INTEGER);
  ```

  **Table 13-86** DBE_RANDOM.SET_SEED interface parameters

  | Parameter | Description |
  | --- | --- |
  | seed | Generates a seed for a random number. |

- DBE_RANDOM.GET_VALUE

  The stored procedure **VALUE** generates a random number between a specified **low** and a specified **high**. The function prototype of **DBE_RANDOM.GET_VALUE** is as follows:

  ```
  DBE_RANDOM.GET_VALUE(
  min  IN  NUMBER default 0,
  max  IN  NUMBER default 1)
  RETURN NUMBER;
  ```

  **Table 13-87** DBE_RANDOM.GET_VALUE interface parameters

  | Parameter | Description |
  | --- | --- |
  | min | Sets the low bound for a random number. The generated random number is greater than or equal to **min**. |
  | max | Sets the high bound for a random number. The generated random number is less than **max**. |

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NOTE

- The only requirement is that the parameter type is **NUMERIC** regardless of the right and left bound values.
- **DBE_RANDOM** implements pseudo-random numbers. Therefore, if the initial value (seed) remains unchanged, the sequence of the pseudo-random numbers also remains unchanged.
- The generated random number contains 15 valid digits.

## Examples

```
-- Generate a random number between 0 and 1.
SELECT DBE_RANDOM.GET_VALUE(0,1);

-- For integers within a specified range, add the arguments min and max, and truncate the decimals from the result (the maximum value is not included as a possible value). Therefore, for integers from 0 to 99, you can use the following code:
SELECT TRUNC(DBE_RANDOM.GET_VALUE(0,100));
```

# 13.12.2.3 DBE_OUTPUT

## Interface Description

13.12.2.3 DBE_OUTPUT provides all interfaces supported by the **DBE_OUTPUT** package.

**Table 13-88** DBE_OUTPUT

| Interface | Description |
| --- | --- |
| DBE_OUTPUT.PRINT_LINE | Outputs the specified text with newline characters. |
| DBE_OUTPUT.PRINT | Outputs the specified text without newline characters. |
| DBE_OUTPUT.SET_BUFFER_SIZE | Sets the size of the output buffer. If the size is not specified, the buffer can contain a maximum of 20000 bytes. If the size is set to a value less than or equal to 2000 bytes, the buffer can contain a maximum of 2000 bytes. |

- DBE_OUTPUT.PRINT_LINE

The stored procedure **PRINT_LINE** writes a row of text carrying a line end symbol in the buffer. The function prototype of **DBE_OUTPUT.PRINT_LINE** is as follows:

```
DBE_OUTPUT.PRINT_LINE (
format IN VARCHAR2);
```

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**Table 13-89** DBE_OUTPUT.PRINT_LINE interface parameters

| Parameter | Description |
| --- | --- |
| format | Specifies the text that was written to the buffer. |

- DBE_OUTPUT.PRINT

The stored procedure **PRINT** outputs the specified text to the front of the specified text without adding a newline character. The function prototype of **DBE_OUTPUT.PRINT** is as follows:

```
DBE_OUTPUT.PRINT (
format IN VARCHAR2);
```

**Table 13-90** DBE_OUTPUT.PRINT interface parameters

| Parameter | Description |
| --- | --- |
| format | Specifies the text that was written to the specified text. |

- DBE_OUTPUT.SET_BUFFER_SIZE

The stored procedure **SET_BUFFER_SIZE** sets the output buffer size. If the size is not specified, it contains a maximum of 20000 bytes. The function prototype of **DBE_OUTPUT.SET_BUFFER_SIZE** is as follows:

```
DBE_OUTPUT.SET_BUFFER_SIZE (
size IN INTEGER default 20000);
```

**Table 13-91** DBE_OUTPUT.SET_BUFFER_SIZE interface parameters

| Parameter | Description |
| --- | --- |
| size | Sets the output buffer size. |

## Examples

```
BEGIN
    DBE_OUTPUT.SET_BUFFER_SIZE(50);
    DBE_OUTPUT.PRINT('hello, ');
    DBE_OUTPUT.PRINT_LINE('database!');-- Output "hello, database!".
END;
/
```

### 13.12.2.4 DBE_RAW

## Interface Description

Table 13-92 provides all interfaces supported by the **DBE_RAW** package.

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**Table 13-92** DBE_RAW

| Interface | Description |
| --- | --- |
| DBE_RAW.CAST_FROM_BINARY_INTEGER_TO_RAW | Converts a value of the **INTEGER** type to a binary representation (**RAW** type). |
| DBE_RAW.CAST_FROM_RAW_TO_BINARY_INTEGER | Converts a binary representation (**RAW** type) to a value of the **INTEGER** type. |
| DBE_RAW.GET_LENGTH | Obtains the length of a **RAW** object. |
| DBE_RAW.CAST_FROM_VARCHA... | Converts a value of the **VARCHAR2** type to a binary representation (**RAW** type). |
| DBE_RAW.CAST_TO_VARCHAR2 | Converts a value of the **RAW** type to a value of the **VARCHAR2** type. |
| DBE_RAW.SUBSTR | Returns the substring of the **RAW** type. |
| DBE_RAW.BIT_OR | Performs the bitwise OR operation on raw data. |

**NOTICE**

**RAW** data is represented as hexadecimal characters externally, and stored as binary characters internally. For example, one byte of **RAW** data with bits **11001011** is displayed and entered as **'CB'**.

- DBE_RAW.CAST_FROM_BINARY_INTEGER_TO_RAW

  The stored procedure **CAST_FROM_BINARY_INTEGER_TO_RAW** converts a value of the **INTEGER** type to a binary representation (**RAW** type).

  The function prototype of **DBE_RAW.CAST_FROM_BINARY_INTEGER_TO_RAW** is as follows:

  ```
  DBE_RAW.CAST_FROM_BINARY_INTEGER_TO_RAW (
  value         IN  INTEGER,
  endianess     IN  INTEGER DEFAULT 1)
  RETURN RAW;
  ```

  **Table 13-93** DBE_RAW.CAST_FROM_BINARY_INTEGER_TO_RAW interface parameters

  | Parameter | Description |
  | --- | --- |
  | value | Specifies the **INTEGER** value to be converted to the **RAW** value. |
  | endianess | Specifies the **INTEGER** value **1** or **2** for the byte sequence. (**1** indicates **BIG_ENDIAN** and **2** indicates **LITTLE-ENDIAN**.) |

- DBE_RAW.CAST_FROM_RAW_TO_BINARY_INTEGER

  The stored procedure **CAST_FROM_RAW_TO_BINARY_INTEGER** converts a binary representation (**RAW** type) to a value of the **INTEGER** type.

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The function prototype of **DBE_RAW.CAST_FROM_RAW_TO_BINARY_INTEGER** is as follows:

```
DBE_RAW.CAST_FROM_RAW_TO_BINARY_INTEGER (
value          IN  RAW,
endianess      IN  INTEGER DEFAULT 1)
RETURN BINARY_INTEGER;
```

**Table 13-94** DBE_RAW.CAST_FROM_RAW_TO_BINARY_INTEGER interface parameters

| Parameter | Description |
| --- | --- |
| value | Specifies an **INTEGER** value in a binary representation (**RAW** type). |
| endianess | Specifies the **INTEGER** value **1** or **2** for the byte sequence. (**1** indicates **BIG_ENDIAN** and **2** indicates **LITTLE-ENDIAN**.) |

- DBE_RAW.GET_LENGTH

  The stored procedure **GET_LENGTH** returns the length of a **RAW** object.

  The function prototype of **DBE_RAW.GET_LENGTH** is as follows:

  ```
  DBE_RAW.GET_LENGTH(
  value     IN    RAW)
  RETURN INTEGER;
  ```

  **Table 13-95** DBE_RAW.GET_LENGTH interface parameters

  | Parameter | Description |
  | --- | --- |
  | value | Specifies a **RAW** object. |

- DBE_RAW.CAST_FROM_VARCHAR2_TO_RAW

  The stored procedure **CAST_FROM_VARCHAR2_TO_RAW** converts a **VARCHAR2** object to a **RAW** object.

  The function prototype of **DBE_RAW.CAST_FROM_VARCHAR2_TO_RAW** is as follows:

  ```
  DBE_RAW.CAST_TO_RAW(
  str     IN    VARCHAR2)
  RETURN RAW;
  ```

  **Table 13-96** DBE_RAW.CAST_FROM_VARCHAR2_TO_RAW interface parameters

  | Parameter | Description |
  | --- | --- |
  | c | Specifies a **VARCHAR2** object to be converted. |

- DBE_RAW.CAST_TO_VARCHAR2

  The stored procedure **CAST_TO_VARCHAR2** converts a **RAW** object to a **VARCHAR2** object.

  The **DBE_RAW.CAST_TO_VARCHAR2** function prototype is as follows:

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```
DBE_RAW.CAST_TO_VARCHAR2(
str     IN     RAW)
RETURN VARCHAR2;
```

**Table 13-97** DBE_RAW.CAST_TO_VARCHAR2 interface parameters

| Parameter | Description |
| --- | --- |
| str | Specifies a **RAW** object to be converted. |

- DBE_RAW.BIT_OR

  The stored procedure **BIT_OR** calculates the bitwise OR result of two raw data records.

  The **DBE_RAW.BIT_OR** function prototype is as follows:

  ```
  DBE_RAW.BIT_OR(
  str1     IN     RAW,
  str2     IN     RAW)
  RETURN RAW;
  ```

  **Table 13-98** DBE_RAW.BIT_OR interface parameters

  | Parameter | Description |
  | --- | --- |
  | str1 | First character string of the bitwise OR operation |
  | str2 | Second character string of the bitwise OR operation |

- DBE_RAW.SUBSTR

  The stored procedure **SUBSTR** truncates an object of the **RAW** type based on the start bit and length.

  The **DBE_RAW.SUBSTR** function prototype is as follows:

  ```
  DBE_RAW.SUBSTR(
     IN lob_loc raw,
     IN off_set integer default 1,
     IN amount integer default 32767)
  RETURN RAW;
  ```

  **Table 13-99** DBE_RAW.SUBSTR interface parameters

  | Parameter | Description |
  | --- | --- |
  | lob_loc | Source raw character string |
  | off_set | Start position of a substring. The default value is **1**. |
  | amount | Length of a substring. The default value is **32767**. |

## Examples

```
--Perform operations on RAW data in a stored procedure.
CREATE OR REPLACE PROCEDURE proc_raw
AS
str varchar2(100) := 'abcdef';
source raw(100);
```

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```
amount integer;
BEGIN
source := dbe_raw.cast_from_varchar2_to_raw(str);--Convert the type.
 amount := dbe_raw.get_length(source);--Obtain the length.
dbe_output.print_line(amount);
END;
/

-- Call the stored procedure.
CALL proc_raw();

-- Delete the stored procedure.
DROP PROCEDURE proc_raw;
```

### 13.12.2.5 DBE_TASK

## Interface Description

Table 13-100 lists all interfaces supported by the **DBE_TASK** package.

**Table 13-100** DBE_TASK

| Interface | Description |
| --- | --- |
| DBE_TASK.SUBMIT | Submits a scheduled task. The job ID is automatically generated by the system. |
| DBE_TASK.JOB_SUBMIT | Same as DBE_TASK.SUBMIT. However, It provides syntax compatibility parameters. |
| DBE_TASK.ID_SUBMIT | Submits a scheduled task. The job ID is specified by the user. |
| DBE_TASK.CANCEL | Removes a scheduled task by job ID. |
| DBE_TASK.RUN | Executes a scheduled task. |
| DBE_TASK.FINISH | Disables or enables scheduled task execution. |
| DBE_TASK.UPDATE | Modifies user-definable attributes of a scheduled task, including the task content, next-execution time, and execution interval. |
| DBE_TASK.CHANGE | Same as DBE_TASK.UPDATE. However, It provides syntax compatibility parameters. |
| DBE_TASK.CONTENT | Modifies the task content attribute of a scheduled task. |
| DBE_TASK.NEXT_TIME | Modifies the next-execution time attribute of a scheduled task. |
| DBE_TASK.INTERVAL | Modifies the execution interval attribute of a scheduled task. |

- DBE_TASK.SUBMIT

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The stored procedure **SUBMIT** submits a scheduled task provided by the system.

The function prototype of **DBE_TASK.SUBMIT** is as follows:

```
DBE_TASK.SUBMIT(
what          IN   TEXT,
next_time     IN   TIMESTAMP DEFAULT sysdate,
interval_time IN   TEXT  DEFAULT 'null',
id            OUT  INTEGER
)RETURN INTEGER;
```

NOTE

When a scheduled task is created (using **DBE_TASK**), the system binds the current database and the username to the task by default. This function can be called by using **call** or **select**. If you call this function by using **select**, there is no need to specify output parameters. To call this function within a stored procedure, use **perform**. If the committed SQL statement task uses a non-public schema, specify the schema to a table schema or a function schema, or add **set current_schema = xxx** before the SQL statement.

**Table 13-101** DBE_TASK.SUBMIT interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| what | text | IN | No | SQL statement to be executed. One or multiple DDLs (excluding database-related operations), DMLs, anonymous blocks, and statements for calling stored procedures, or all four combined are supported. |
| next_time | timestamp | IN | No | Specifies the next time the job will be executed. The default value is the current system time (**sysdate**). If the specified time has past, the job is executed at the time it is submitted. |
| interval_time | text | IN | Yes | Calculates the next time to execute the job. It can be an interval expression, or **sysdate** followed by a numeric value, for example, **sysdate+1.0/24**. If this parameter is left empty or set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward. |
| id | integer | OUT | No | Specifies the job ID. The value ranges from 1 to 32767. When SELECT is used for calling, this parameter cannot be added. When CALL is used for calling, this parameter must be added. |

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**NOTICE**

When you create a user using the **what** parameter, the plaintext password of the user is recorded in the log. Therefore, you are not advised to do so. Tasks created using this API may not be highly available. You are advised to use **PKG_SERVICE.SUBMIT_ON_NODES** to create a task and specify the CCN as the job execution node.

Example:

```
select DBE_TASK.SUBMIT('call pro_xxx();', to_date('20180101','yyyymmdd'),'sysdate+1');

select DBE_TASK.SUBMIT('call pro_xxx();', to_date('20180101','yyyymmdd'),'sysdate+1.0/24');

CALL DBE_TASK.SUBMIT('INSERT INTO T_JOB  VALUES(1);  call pro_1(); call pro_2();',
add_months(to_date('201701','yyyymm'),1), 'date_trunc(''day'',SYSDATE) + 1 +(8*60+30.0)/
(24*60)' ,:jobid);

DECLARE
    jobid int;
BEGIN
    PERFORM DBE_TASK.SUBMIT('call pro_xxx();', sysdate, 'interval ''5 minute''', jobid);
END;
/
```

- DBE_TASK.JOB_SUBMIT

  The stored procedure **SUBMIT** submits a scheduled task provided by the system. In addition, it provides additional compatibility parameters.

  The **DBE_TASK.JOB_SUBMIT** function prototype is as follows:

```
DBE_TASK.JOB_SUBMIT(
job           OUT  INTEGER,
what           IN   TEXT,
next_date      IN   TIMESTAMP  DEFAULT sysdate,
job_interval  IN   TEXT       DEFAULT 'null',
no_parse       IN   BOOLEAN    DEFAULT false,
instance       IN   INTEGER    DEFAULT 0,
force         IN   BOOLEAN    DEFAULT false
)RETURN INTEGER;
```

**Table 13-102** DBE_TASK.JOB_SUBMIT interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| job | integer | OUT | No | Specifies the job ID. The value ranges from 1 to 32767. When **dbe.job_submit** is called using SELECT, this parameter can be omitted. |
| what | text | IN | No | SQL statement to be executed. One or multiple DDLs (excluding database-related operations), DMLs, anonymous blocks, and statements for calling stored procedures, or all four combined are supported. |

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| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| next_date | timestamp | IN | Yes | Specifies the next time the job will be executed. The default value is the current system time (**sysdate**). If the specified time has past, the job is executed at the time it is submitted. |
| job_interval | text | IN | Yes | Calculates the next time to execute the job. It can be an interval expression, or **sysdate** followed by a numeric value, for example, **sysdate+1.0/24**. If this parameter is left empty or set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward. |
| no_parse | boolean | IN | Yes | The default value is **false**, which is used only for syntax compatibility. |
| instance | integer | IN | Yes | The default value is **0**, which is used only for syntax compatibility. |
| force | boolean | IN | Yes | The default value is **false**, which is used only for syntax compatibility. |

Example:

```
DECLARE
    id integer;
BEGIN
    id = DBE_TASK.JOB_SUBMIT(
        what => 'insert into t1 values (1, 2)',
        job_interval => 'sysdate + 1' --daily
    );
END;
/
```

- DBE_TASK.ID_SUBMIT

  **ID_SUBMIT** has the same syntax function as **SUBMIT**, but the first parameter of **ID_SUBMIT** is an input parameter, that is, a specified job ID. In contrast, that last parameter of **ID_SUBMIT** is an output parameter, indicating the job ID automatically generated by the system.

  ```
  DBE_TASK.ID_SUBMIT(
  id            IN   BIGINT,
  what          IN   TEXT,
  next_time     IN   TIMESTAMP DEFAULT sysdate,
  interval_time IN   TEXT  DEFAULT 'null');
  ```

  Example:

  ```
  CALL dbe_task.id_submit(101, 'insert_msg_statistic1;', sysdate, 'sysdate+3.0/24');
  ```

- DBE_TASK.CANCEL

  The stored procedure **CANCEL** deletes a specified task.

  The function prototype of **DBE_TASK.CANCEL** is as follows:

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```
CANCEL(id  IN  INTEGER);
```

**Table 13-103** DBE_TASK.CANCEL interface parameters

| Parameter | Type | Input/ Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| id | integer | IN | No | Specifies the job ID. |

Example:

```
CALL dbe_task.cancel(101);
```

- DBE_TASK.RUN

  The stored procedure runs a scheduled task.

  The prototype of the **DBE_TASK.RUN** function is as follows:

  ```
  DBE_TASK.RUN(
  job          IN   BIGINT,
  force        IN   BOOLEAN DEFAULT FALSE);
  ```

  **Table 13-104** DBE_TASK.RUN interface parameters

  | Parameter | Type | Input/ Output Parameter | Can Be Empty | Description |
  | --- | --- | --- | --- | --- |
  | job | bigint | IN | No | Specifies the job ID. |
  | force | Boolean | IN | Yes | Used only for syntax compatibility. |

  Example:

  ```
  BEGIN
     DBE_TASK.ID_SUBMIT(12345, 'insert_msg_statistic1;', sysdate, 'sysdate+3.0/24');
     DBE_TASK.RUN(12345);
  END;
  /
  ```

- DBE_TASK.FINISH

  The stored procedure **FINISH** disables or enables a scheduled task.

  The function prototype of **DBE_TASK.FINISH** is as follows:

  ```
  DBE_TASK.FINISH(
  id           IN   INTEGER,
  broken       IN   BOOLEAN,
  next_time    IN   TIMESTAMP  DEFAULT  sysdate);
  ```

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**Table 13-105** DBE_TASK.FINISH interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| id | integer | IN | No | Specifies the job ID. |
| broken | Boolean | IN | No | Specifies the status flag, **true** for broken and **false** for not broken. The current job is updated based on the parameter value **true** or **false**. If the parameter is left empty, the job status remains unchanged. |
| next_time | timestamp | IN | Yes | Specifies the next execution time. The default value is the current system time. If **broken** is set to **true**, **next_time** is updated to **'4000-1-1'**. If **broken** is set to **false** and **next_time** is not empty, **next_time** is updated for the job. If **next_time** is empty, it will not be updated. This parameter can be omitted, and its default value will be used in this case. |

Example:

```
CALL dbe_task.finish(101, true);
CALL dbe_task.finish(101, false, sysdate);
```

- DBE_TASK.UPDATE

  The stored procedure **UPDATE** modifies user-definable attributes of a task, including the task content, next-execution time, and execution interval.

  The **DBE_TASK.UPDATE** function prototype is as follows:

```
dbe_task.UPDATE(
id              IN     INTEGER,
content         IN     TEXT,
next_time       IN     TIMESTAMP,
interval_time   IN  TEXT);
```

**Table 13-106** DBE_TASK.UPDATE interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| id | integer | IN | No | Specifies the job ID. |

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| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| content | text | IN | Yes | Specifies the name of the stored procedure or SQL statement block that is executed. If this parameter is left empty, the system does not update the **content** parameter for the specified job. Otherwise, the system updates the **content** parameter for the specified job. |
| next_time | timestamp | IN | Yes | Specifies the next execution time. If this parameter is left empty, the system does not update the **next_time** parameter for the specified job. Otherwise, the system updates the **next_time** parameter for the specified job. |
| interval_time | text | IN | Yes | Specifies the time expression for calculating the next time the job will be executed. If this parameter is left empty, the system does not update the **interval_time** parameter for the specified job. Otherwise, the system updates the **interval_time** parameter for the specified job after necessary validity check. If this parameter is set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward. |

Example:

```
CALL dbe_task.update(101, 'call userproc();', sysdate, 'sysdate + 1.0/1440');
CALL dbe_task.update(101, 'insert into tbl_a values(sysdate);', sysdate, 'sysdate + 1.0/1440');
```

- DBE_TASK.CHANGE

  The stored procedure **UPDATE** modifies user-definable attributes of a task, including the task content, next-execution time, and execution interval.

  The prototype of the **DBE_TASK.CHANGE** function is as follows:

```
DBE_TASK.CHANGE(
job             IN    INTEGER,
what            IN    TEXT       DEFAULT NULL,
next_date       IN    TIMESTAMP  DEFAULT NULL,
job_interval    IN    TEXT       DEFAULT NULL,
instance        IN    INTEGER    DEFAULT NULL,
force           IN    BOOLEAN    DEFAULT false);
```

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**Table 13-107** DBE_TASK.CHANGE interface parameters

| Parameter | Type | Input/ Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| job | integer | IN | No | Specifies the job ID. |
| what | text | IN | Yes | Specifies the name of the stored procedure or SQL statement block that is executed. If this parameter is left empty, the system does not update the **what** parameter for the specified job. Otherwise, the system updates the **what** parameter for the specified job. |
| next_date | timestamp | IN | Yes | Specifies the next execution time. If this parameter is left empty, the system does not update the **next_time** parameter for the specified job. Otherwise, the system updates the **next_date** parameter for the specified job. |
| job_interval | text | IN | Yes | Specifies the time expression for calculating the next time the job will be executed. If this parameter is left empty, the system does not update the **job_interval** parameter for the specified job. Otherwise, the system updates the **job_interval** parameter for the specified job after necessary validity check. If this parameter is set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward. |
| instance | integer | IN | Yes | Used only for syntax compatibility. |
| force | boolean | IN | No | Used only for syntax compatibility. |

```
BEGIN
    DBE_TASK.CHANGE(
        job => 1234,
        what => 'insert into t2 values (2);'
    );
END;
/
```

- DBE_TASK.CONTENT

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The stored procedure **CONTENT** modifies the procedures to be executed by a specified task.

The function prototype of **DBE_TASK.CONTENT** is as follows:

```
DBE_TASK.CONTENT(
id          IN     INTEGER,
content     IN TEXT);
```

**Table 13-108** DBE_TASK.CONTENT interface parameters

| Parameter | Type | Input/ Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| id | integer | IN | No | Specifies the job ID. |
| content | text | IN | No | Specifies the name of the stored procedure or SQL statement block that is executed. |

NOTE

- If the value specified by the **content** parameter is one or multiple executable SQL statements, program blocks, or stored procedures, this procedure can be executed successfully; otherwise, it will fail to be executed.
- If the value specified by the **content** parameter is a simple statement such as **INSERT** and **UPDATE**, a schema name must be added in front of the table name.

Example:

```
CALL dbe_task.content(101, 'call userproc();');
CALL dbe_task.content(101, 'insert into tbl_a values(sysdate);');
```

- DBE_TASK.NEXT_TIME

  The stored procedure **NEXT_TIME** modifies the next-execution time attribute of a task.

  The function prototype of **DBE_TASK.NEXT_TIME** is as follows:

```
DBE_TASK.NEXT_TIME(
id          IN     BIGINT,
next_time   IN    TEXT);
```

**Table 13-109** DBE_TASK.NEXT_TIME interface parameters

| Parameter | Type | Input/ Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| id | bigint | IN | No | Specifies the job ID. |
| next_time | text | IN | No | Specifies the next execution time. |

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NOTE

If the specified **next_time** value is earlier than the current date, the job is executed once immediately.

Example:

```
CALL dbe_task.next_time(101, sysdate);
```

- DBE_TASK.INTERVAL

  The stored procedure **INTERVAL** modifies the execution interval attribute of a task.

  The function prototype of **DBE_TASK.INTERVAL** is as follows:

```
DBE_TASK.INTERVAL(
id             IN      INTEGER,
interval_time      IN    TEXT);
```

**Table 13-110** DBE_TASK.INTERVAL interface parameters

| Parameter | Type | Input / Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| id | integer | IN | No | Specifies the job ID. |
| interval_time | text | IN | Yes | Specifies the time expression for calculating the next time the job will be executed. If this parameter is left empty or set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward. **interval** must be a valid time or interval type. |

Example:

```
CALL dbe_task.interval(101, 'sysdate + 1.0/1440');
```

NOTE

For a job that is currently running (that is, **job_status** is **'r'**), it is not allowed to use **cancel**, **update**, **next_time**, **content**, or **interval** to delete or modify job parameters.

## Constraints

1. After a job is created by using **SUMMIT/ID_SUBMIT**, the job belongs to the current coordinator (that is, the job is scheduled and executed only on the current coordinator). Other coordinators do not schedule and execute the job. If the coordinator node is faulty, the job cannot be properly executed. You are advised to use the **PKG_SERVICE.SUBMIT_ON_NODES** API to specify the job execution node as CCN to ensure that the job is still available when a node is

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faulty. Not all coordinators can query, modify, and delete tasks created on other CNs.

2. You can create, update, and delete tasks only using the procedures provided by the **dbe_task** package. These procedures synchronize task information between different CNs and associate primary keys between the **pg_job** and **pg_job_proc** catalogs. If you use DML statements to add, delete, or modify records in the **pg_job** catalog, task information will become inconsistent between CNs and system catalogs may fail to be associated, compromising internal task management.
3. Each task created by a user is bound to a CN. If the CN fails while a task is being executed, the task status cannot be updated in real time and will stay at **'r'**. The task status will be updated to **'s'** only after the CN recovers. When a CN fails, all tasks on this CN cannot be scheduled or executed until the CN is restored manually, or deleted and then replaced.
4. For each task, the bound CN updates the real-time task information (including the task status, last execution start time, last execution end time, next execution start time, the number of execution failures [if any]) to the **pg_job** catalog, and synchronizes the information to other CNs, ensuring consistent task information between different CNs. In the case of faults on other CNs, task information synchronization is reattempted by the bound CN, which increases task execution time. Although task information fails to be synchronized between CNs, task information can still be properly updated in the **pg_job** catalog on the bound CN and the task can be executed successfully. After the faulty CN recovers, task information such as task execution time and status in its **pg_job** catalog may be incorrect and will be updated only after the task is executed again on the bound CN.
5. For each job, a thread is established to execute it. If multiple jobs are triggered concurrently as scheduled, the system will need some time to start the required threads, resulting in a latency of 0.1 ms in job execution.

### 13.12.2.6 DBE_UTILITY

## Interface Description

**Table 13-111** provides all interfaces supported by the **DBE_UTILITY** package.

**Table 13-111** DBE_UTILITY

| Interface | Description |
| --- | --- |
| **DBE_UTILITY.FORMAT_ERROR...** | Outputs a call stack of an abnormal stored procedure. |
| **DBE_UTILITY.FORMAT_ERROR...** | Outputs detailed information about the stored procedure exception. |
| **DBE_UTILITY.FORMAT_CALL_...** | Output a call stack of a stored procedure. |
| **DBE_UTILITY.GET_TIME** | Outputs the current time, which is used to obtain the execution duration. |

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- DBE_UTILITY.FORMAT_ERROR_BACKTRACE

The stored procedure **FORMAT_ERROR_BACKTRACE** returns the call stack where an error occurs during execution. The **DBE_UTILITY.FORMAT_ERROR_BACKTRACE** function prototype is as follows:

```
DBE_UTILITY.FORMAT_ERROR_BACKTRACE()
RETURN TEXT;
```

- DBE_UTILITY.FORMAT_ERROR_STACK

The stored procedure **FORMAT_ERROR_STACK** returns the detailed information about the error location when an error occurs during the execution. The **DBE_UTILITY.FORMAT_ERROR_STACK** function prototype is as follows:

```
DBE_UTILITY.FORMAT_ERROR_STACK()
RETURN TEXT;
```

- DBE_UTILITY.FORMAT_CALL_STACK

The stored procedure **FORMAT_CALL_STACK** sets the call stack of the output function. The **DBE_UTILITY.FORMAT_CALL_STACK** function prototype is as follows:

```
DBE_UTILITY.FORMAT_CALL_STACK()
RETURN TEXT;
```

- DBE_UTILITY.GET_TIME

The stored procedure **GET_TIME** sets the output time, which is usually used for difference. A separate return value is meaningless. The **DBE_UTILITY.GET_TIME** function prototype is as follows:

```
DBE_UTILITY.GET_TIME()
RETURN BIGINT;
```

## Example

```
CREATE OR REPLACE PROCEDURE test_get_time1()
AS
declare
    start_time  bigint;
    end_time  bigint;
BEGIN
    start_time:= dbe_utility.get_time ();
    pg_sleep(1);
    end_time:=dbe_utility.get_time ();
    dbe_output.print_line(end_time - start_time);
END;
/
```

## 13.12.2.7 DBE_SQL

## Interface Description

Table 13-112 lists interfaces supported by the **DBE_SQL** package.

**Table 13-112** DBE_SQL

| Interface | Description |
| --- | --- |
| DBE_SQL.REGISTER_CONTEXT | Opens a cursor. |

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| Interface | Description |
| --- | --- |
| DBE_SQL.SQL_UNREGISTER_CONTEXT | Closes an open cursor. |
| DBE_SQL.SQL_SET_SQL | Passes a set of SQL statements to a cursor. |
| DBE_SQL.SQL_RUN | Performs a set of dynamically defined operations on a cursor. |
| DBE_SQL.NEXT_ROW | Reads a row of cursor data. |
| DBE_SQL.SET_RESULT_TYPE | Dynamically defines a column. |
| DBE_SQL.SET_RESULT_TYPE_CHAR | Dynamically defines a column of the **CHAR** type. |
| DBE_SQL.SET_RESULT_TYPE_INT | Dynamically defines a column of the **INT** type. |
| DBE_SQL.SET_RESULT_TYPE_LONG | Dynamically defines a column of the **LONG** type. |
| DBE_SQL.SET_RESULT_TYPE_RAW | Dynamically defines a column of the **RAW** type. |
| DBE_SQL.SET_RESULT_TYPE_TEXT | Dynamically defines a column of the **TEXT** type. |
| DBE_SQL.SET_RESULT_TYPE_UNKNOWN | Dynamically defines a column of an unknown type. |
| DBE_SQL.GET_RESULT | Reads a dynamically defined column value. |
| DBE_SQL.GET_RESULT_CHAR | Reads a dynamically defined column value of the **CHAR** type. |
| DBE_SQL.GET_RESULT_INT | Reads a dynamically defined column value of the **INT** type. |
| DBE_SQL.GET_RESULT_LONG | Reads a dynamically defined column value of the **LONG** type. |
| DBE_SQL.GET_RESULT_RAW | Reads a dynamically defined column value of the **RAW** type. |
| DBE_SQL.GET_RESULT_TEXT | Reads a dynamically defined column value of the **TEXT** type. |
| DBE_SQL.GET_RESULT_UNKNOWN | Reads a dynamically defined column value of an unknown type. |
| DBE_SQL.DBE_SQL_GET_RES.... | Reads a dynamically defined column value of the **CHAR** type. |
| DBE_SQL.DBE_SQL_GET_RES.... | Reads a dynamically defined column value of the **LONG** type. |

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| Interface | Description |
| --- | --- |
| DBE_SQL.DBE_SQL_GET_RES.... | Reads a dynamically defined column value of the **RAW** type. |
| DBE_SQL.IS_ACTIVE | Checks whether a cursor is opened. |
| DBE_SQL.LAST_ROW_COUNT | Compatible interface. This function is not supported currently. |
| DBE_SQL.RUN_AND_NEXT | Reserved interface. This function is not supported currently. |
| DBE_SQL.SQL_BIND_VARIABL... | Binds a value to a variable in a statement. |
| DBE_SQL.SQL_BIND_ARRAY | Binds a group of values to a variable in a statement. |
| DBE_SQL.SET_RESULT_TYPE_... | Dynamically defines a column of the **INT** array type. |
| DBE_SQL.SET_RESULT_TYPE_... | Dynamically defines a column of the **TEXT** array type. |
| DBE_SQL.SET_RESULT_TYPE_... | Dynamically defines a column of the **RAW** array type. |
| DBE_SQL.SET_RESULT_TYPE_... | Dynamically defines a column of the **BYTEA** array type. |
| DBE_SQL.SET_RESULT_TYPE_... | Dynamically defines a column of the **CHAR** array type. |
| DBE_SQL.SET_RESULTS_TYPE | Dynamically defines a column of the array type. |
| DBE_SQL.GET_RESULTS_INT | Reads a dynamically defined column value of the **INT** array type. |
| DBE_SQL.GET_RESULTS_TEXT | Reads a dynamically defined column value of the **TEXT** array type. |
| DBE_SQL.GET_RESULTS_RAW | Reads a dynamically defined column value of the **RAW** array type. |
| DBE_SQL.GET_RESULTS_BYTE... | Reads a dynamically defined column value of the **BYTEA** array type. |

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| Interface | Description |
| --- | --- |
| DBE_SQL.GET_RESULTS_CHAR | Reads a dynamically defined column value of the **CHAR** array type. |
| DBE_SQL.GET_RESULTS | Reads a dynamically defined column value. |
| DBE_SQL.SQL_DESCRIBE_COL... | Describes the column information read by the cursor. |
| DBE_SQL.DESC_REC | Stores the type of the column information read by the cursor. |
| DBE_SQL.DESC_TAB | The TABLE type of DESC_REC. |
| DBE_SQL.DATE_TABLE | The TABLE type of DATE. |
| DBE_SQL.NUMBER_TABLE | The TABLE type of NUMBER. |
| DBE_SQL.VARCHAR2_TABLE | The TABLE type of VARCHAR2. |
| DBE_SQL.BIND_VARIABLE | Binds parameters. |
| DBE_SQL.SQL_SET_RESULTS_... | Dynamically defines a column of the array type. |
| DBE_SQL.SQL_GET_VALUES_C | Reads a dynamically defined column value. |
| DBE_SQL.GET_VARIABLE_RES... | Reads the return value of an SQL statement. |
| DBE_SQL.GET_VARIABLE_RES... | Reads the return value of an SQL statement. (The value is of the **CHAR** type.) |
| DBE_SQL.GET_VARIABLE_RES... | Reads the return value of an SQL statement. (The value is of the **RAW** type.) |
| DBE_SQL.GET_VARIABLE_RES... | Reads the return value of an SQL statement. (The value is of the **TEXT** type.) |
| DBE_SQL.GET_VARIABLE_RES... | Reads the return value of an SQL statement. (The value is of the **INT** type.) |
| DBE_SQL.GET_ARRAY_RESULT... | Reads the return value of an SQL statement. (The value is of the **TEXT** array type.) |
| DBE_SQL.GET_ARRAY_RESULT... | Reads the return value of an SQL statement. (The value is of the **RAW** array type.) |

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| Interface | Description |
| --- | --- |
| DBE_SQL.GET_ARRAY_RESULT... | Reads the return value of an SQL statement. (The value is of the **CHAR** array type.) |
| DBE_SQL.GET_ARRAY_RESULT... | Reads the return value of an SQL statement. (The value is of the **INT** array type.) |

NOTE

- You are advised to use **dbe_sql.set_result_type** and **dbe_sql.get_result** to define columns.
- If the size of the result set is greater than the value of **work_mem**, the result set will be spilled to a disk temporarily. The value of **work_mem** must be no greater than 512 MB.

- DBE_SQL.REGISTER_CONTEXT

  This function opens a cursor, which is the prerequisite for the subsequent **dbe_sql** operations. This function does not transfer any parameter. It automatically generates cursor IDs in an ascending order and returns values to integer variables.

  The prototype of the **DBE_SQL.REGISTER_CONTEXT** function is as follows:

  ```
  DBE_SQL.REGISTER_CONTEXT(
  )
  RETURN INTEGER;
  ```

- DBE_SQL.SQL_UNREGISTER_CONTEXT

  This function closes a cursor, which is the end of each **dbe_sql** operation. If this function is not called when the stored procedure ends, the memory is still occupied by the cursor. Therefore, remember to close a cursor when you do not need to use it. If an exception occurs, the stored procedure exits but the cursor is not closed. Therefore, you are advised to include this interface in the exception handling of the stored procedure.

  The prototype of the **DBE_SQL.SQL_UNREGISTER_CONTEXT** function is as follows:

  ```
  DBE_SQL.SQL_UNREGISTER_CONTEXT(
  context_id      IN INTEGER
  )
  RETURN INTEGER;
  ```

  **Table 13-113** DBE_SQL.SQL_UNREGISTER_CONTEXT interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be closed |

- DBE_SQL.SQL_SET_SQL

  This function is used to parse the query statement of a specified cursor. The statement parameters can be transferred only through the **TEXT** type. The length cannot exceed 1 GB.

  The prototype of the **DBE_SQL.SQL_SET_SQL** function is as follows:

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```
DBE_SQL.SQL_SET_SQL(
context_id     IN INTEGER,
query_string IN TEXT,
language_flag        IN INTEGER
)
RETURN BOOLEAN;
```

**Table 13-114** DBE_SQL.SQL_SET_SQL interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor whose query statement is to be parsed |
| query_string | Query statement to be parsed |
| language_flag | Version language number. Currently, only **1** is supported. |

- DBE_SQL.SQL_RUN

  This function executes a given cursor. It receives a cursor ID first, and the data obtained after execution is used for subsequent operations.

  The prototype of the **DBE_SQL.SQL_RUN** function is as follows:

```
DBE_SQL.SQL_RUN(
context_id     IN INTEGER,
)
RETURN INTEGER;
```

**Table 13-115** DBE_SQL.SQL_RUN interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor whose query statement is to be parsed |

- DBE_SQL.NEXT_ROW

  This function returns the number of data rows that meet query conditions. Each time the interface is executed, the system obtains a set of new rows until all data is read.

  The prototype of the **DBE_SQL.NEXT_ROW** function is as follows:

```
DBE_SQL.NEXT_ROW(
context_id     IN INTEGER,
)
RETURN INTEGER;
```

**Table 13-116** DBE_SQL.NEXT_ROW interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |

- DBE_SQL.SET_RESULT_TYPE

  This function defines columns returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by

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the relative positions in the query list. The data type of an input variable determines the corresponding column type.

The prototype of the **DBE_SQL.SET_RESULT_TYPE** function is as follows:

```
DBE_SQL.SET_RESULT_TYPE(
context_id     IN INTEGER,
pos     IN INTEGER,
column_ref   IN ANYELEMENT,
maxsize     IN INTEGER default 1024
)
RETURN INTEGER;
```

**Table 13-117** DBE_SQL.SET_RESULT_TYPE interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| column_ref | Variable of any type. You can select an appropriate interface to dynamically define columns based on variable types. |
| maxsize | Length of a defined column |

- DBE_SQL.SET_RESULT_TYPE_CHAR

  This function defines columns of the **CHAR** type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_CHAR** function is as follows:

```
DBE_SQL.SET_RESULT_TYPE_CHAR(
context_id     IN INTEGER,
pos     IN INTEGER,
column_ref       IN TEXT,
column_size     IN INTEGER
)
RETURN INTEGER;
```

**Table 13-118** DBE_SQL.SET_RESULT_TYPE_CHAR interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| column_ref | Parameter to be defined |
| column_size | Length of a dynamically defined column |

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- DBE_SQL.SET_RESULT_TYPE_INT

  This function defines columns of the **INT** type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_INT** function is as follows:

```
DBE_SQL.SET_RESULT_TYPE_INT(
context_id     IN INTEGER,
pos     IN INTEGER
)
RETURN INTEGER;
```

  **Table 13-119** DBE_SQL.SET_RESULT_TYPE_INT interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |

- DBE_SQL.SET_RESULT_TYPE_LONG

  This function defines columns of a long type (not **LONG**) returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type. The maximum size of a long column is 1 GB.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_LONG** function is as follows:

```
DBE_SQL.SET_RESULT_TYPE_LONG(
context_id     IN INTEGER,
pos     IN INTEGER
)
RETURN INTEGER;
```

  **Table 13-120** DBE_SQL.SET_RESULT_TYPE_LONG interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |

- DBE_SQL.SET_RESULT_TYPE_RAW

  This function defines columns of the **RAW** type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_RAW** function is as follows:

```
DBE_SQL.SET_RESULT_TYPE_RAW(
context_id     IN INTEGER,
pos     IN INTEGER,
```

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```
column_ref      IN RAW,
column_size     IN INTEGER
)
RETURN INTEGER;
```

**Table 13-121** DBE_SQL.SET_RESULT_TYPE_RAW interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| column_ref | Parameter of the **RAW** type |
| column_size | Column length |

- DBE_SQL.SET_RESULT_TYPE_TEXT

  This function defines columns of the **TEXT** type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_TEXT** function is as follows:

  ```
  DBE_SQL.DEFINE_COLUMN_CHAR(
  context_id     IN INTEGER,
  pos     IN INTEGER,
  maxsize     IN INTEGER
  )
  RETURN INTEGER;
  ```

  **Table 13-122** DBE_SQL.SET_RESULT_TYPE_TEXT interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be executed |
  | pos | Position of a dynamically defined column in the query |
  | maxsize | Maximum length of the defined **TEXT** type |

- DBE_SQL.SET_RESULT_TYPE_UNKNOWN

  This function processes columns of unknown data types returned from a given cursor. It is used only for the system to report an error and exist when the type cannot be identified.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_UNKNOWN** function is as follows:

  ```
  DBE_SQL.SET_RESULT_TYPE_UNKNOWN(
  context_id     IN INTEGER,
  pos     IN INTEGER,
  col_type       IN TEXT
  )
  RETURN INTEGER;
  ```

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**Table 13-123** DBE_SQL.SET_RESULT_TYPE_UNKNOWN interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| posn | Position of a dynamically defined column in the query |
| col_type | Dynamically defined parameter |

- DBE_SQL.GET_RESULT

  This function returns the cursor element value in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULT** function is as follows:

```
DBE_SQL.GET_RESULT(
context_id               IN    INTEGER,
pos              IN    INTEGER,
column_value             INOUT ANYELEMENT
)
RETURN ANYELEMENT;
```

**Table 13-124** DBE_SQL.GET_RESULT interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| column_value | Return value of a defined column |

- DBE_SQL.GET_RESULT_CHAR

  This stored procedure returns the value of the **CHAR** type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULT_CHAR** function is as follows:

```
DBE_SQL.GET_RESULT_CHAR(
context_id          IN    INTEGER,
pos                 IN    INTEGER,
tr                  INOUT CHARACTER,
err                 INOUT NUMERIC,
actual_length       INOUT INTEGER
);
```

**Table 13-125** DBE_SQL.GET_RESULT_CHAR interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| tr | Return value |

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| Parameter | Description |
| --- | --- |
| err | Error No. It is an output parameter. The input parameter must be a variable. Currently, the output value is **–1** regardless of the input parameter. |
| actual_length | Length of a return value |

The overloaded function of the **DBE_SQL.GET_RESULT_CHAR** function is as follows:

```
DBE_SQL.GET_RESULT_CHAR(
context_id          IN    INTEGER,
pos                 IN    INTEGER,
tr                  INOUT CHARACTER
);
```

**Table 13-126** DBE_SQL.GET_RESULT_CHAR interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| tr | Return value |

- DBE_SQL.GET_RESULT_INT

  This function returns the value of the **INT** type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**. The prototype of the **DBE_SQL.GET_RESULT_INT** function is as follows:

  ```
  DBE_SQL.GET_RESULT_INT(
  context_id              IN    INTEGER,
  pos                 IN    INTEGER
  )
  RETURN INTEGER;
  ```

  **Table 13-127** DBE_SQL.GET_RESULT_INT interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be executed |
  | pos | Position of a dynamically defined column in the query |

- DBE_SQL.GET_RESULT_LONG

  This function returns the value of a long type (not **LONG** or **BIGINT**) in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULT_LONG** function is as follows:

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```
DBE_SQL.GET_RESULT_LONG(
context_id          IN INTEGER,
pos                 IN      INTEGER,
lgth                IN    INTEGER,
off_set             IN   INTEGER,
vl                INOUT     TEXT,
vl_length           INOUT    INTEGER
)
RETURN RECORD;
```

**Table 13-128** DBE_SQL.GET_RESULT_LONG interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| lgth | Length of a return value |
| off_set | Start position of a return value |
| vl | Return value |
| vl_length | Length of a return value |

- DBE_SQL.GET_RESULT_RAW

  This stored procedure returns the value of the RAW type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULT_RAW** stored procedure is as follows:

  ```
  DBE_SQL.GET_RESULT_RAW(
  context_id          IN  INTEGER,
  pos                 IN      INTEGER,
  tr                INOUT     RAW,
  err               INOUT     NUMERIC,
  actual_length       INOUT INTEGER
  );
  ```

  **Table 13-129** DBE_SQL.GET_RESULT_RAW interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| tr | Returned column value |
| err | Error No. It is an output parameter. The input parameter must be a variable. Currently, the output value is **–1** regardless of the input parameter. |

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| Parameter | Description |
| --- | --- |
| actual_length | Length of a return value. The value longer than this length will be truncated. |

The overloaded function of the **DBE_SQL.GET_RESULT_RAW** function is as follows:

```
DBE_SQL.GET_RESULT_RAW(
context_id          IN  INTEGER,
pos                 IN          INTEGER,
tr                  INOUT       RAW
);
```

**Table 13-130** DBE_SQL.GET_RESULT_RAW interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| tr | Returned column value |

- DBE_SQL.GET_RESULT_TEXT

  This function returns the value of the **TEXT** type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULT_TEXT** function is as follows:

  ```
  DBE_SQL.GET_RESULT_TEXT(
  context_id          IN  INTEGER,
  pos                 IN          INTEGER
  )
  RETURN TEXT;
  ```

  **Table 13-131** DBE_SQL.GET_RESULT_TEXT interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be executed |
  | pos | Position of a dynamically defined column in the query |

- DBE_SQL.GET_RESULT_UNKNOWN

  This function returns the value of an unknown type in a specified position of a cursor. It serves as an error handling interface when the type is not unknown.

  The prototype of the **DBE_SQL.GET_RESULT_UNKNOWN** function is as follows:

  ```
  DBE_SQL.GET_RESULT_UNKNOWN(
  context_id          IN    INTEGER,
  pos                 IN          INTEGER,
  col_type            IN      TEXT
  ```

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```
)
RETURN TEXT;
```

**Table 13-132** DBE_SQL.GET_RESULT_UNKNOWN interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |
| col_type | Returned parameter type |

- DBE_SQL.DBE_SQL_GET_RESULT_CHAR

  This function returns the value of the **CHAR** type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**. Different from **DBE_SQL.GET_RESULT_CHAR**, the length of the return value is not set and the entire string is returned.

  The prototype of the **DBE_SQL.DBE_SQL_GET_RESULT_CHAR** function is as follows:

  ```
  DBE_SQL.DBE_SQL_GET_RESULT_CHAR(
  context_id     IN    INTEGER,
  pos            IN    INTEGER
  )
  RETURN CHARACTER;
  ```

  **Table 13-133** DBE_SQL.GET_RESULT_CHAR interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be executed |
  | pos | Position of a dynamically defined column in the query |

- DBE_SQL.DBE_SQL_GET_RESULT_LONG

  This function returns the value of a long type (not **LONG** or **BIGINT**) in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  Different from **DBE_SQL.GET_RESULT_LONG**, the length of the return value is not set and the entire BIGINT value is returned.

  The prototype of the **DBE_SQL.DBE_SQL_GET_RESULT_LONG** function is as follows:

  ```
  DBE_SQL.DBE_SQL_GET_RESULT_LONG(
  context_id          IN INTEGER,
  pos                 IN INTEGER
  )
  RETURN BIGINT;
  ```

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**Table 13-134** DBE_SQL.DBE_SQL_GET_RESULT_LONG interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |

- DBE_SQL.DBE_SQL_GET_RESULT_RAW

  This function returns the value of the **RAW** type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  Different from **DBE_SQL.GET_RESULT_RAW**, the length of the return value is not set and the entire string is returned.

  The prototype of the **DBE_SQL.DBE_SQL_GET_RESULT_RAW** function is as follows:

```
DBE_SQL.GET_RESULT_RAW(
context_id          IN  INTEGER,
pos                 IN      INTEGER,
tr                  INOUT   RAW
)
RETURN RAW;
```

**Table 13-135** DBE_SQL.GET_RESULT_RAW interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be executed |
| pos | Position of a dynamically defined column in the query |

- DBE_SQL.IS_ACTIVE

This function returns the status of a cursor. The status can be **open**, **parse**, **execute**, or **define**. If the status is **open**, the value is **TRUE**. If the status is unknown, an error is reported. In other cases, the value is **FALSE**.

The prototype of the **DBE_SQL.IS_ACTIVE** function is as follows:

```
DBE_SQL.IS_ACTIVE(
context_id              IN    INTEGER
)
RETURN BOOLEAN;
```

**Table 13-136** DBE_SQL.IS_ACTIVE interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |

- DBE_SQL.SQL_BIND_VARIABLE

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This function is used to bind a parameter to an SQL statement. When an SQL statement is executed, the SQL statement is executed based on the bound value.

The prototype of the **DBE_SQL.SQL_BIND_VARIABLE** function is as follows:

```
DBE_SQL.SQL_BIND_VARIABLE(
    context_id in int,
    query_string in text,
    language_flag in anyelement,
    out_value_size in int default null
)
RETURNS void;
```

**Table 13-137** DBE_SQL.SQL_BIND_VARIABLE interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| query_string | Name of the bound variable |
| language_flag | Bound value |
| out_value_size | Size of the return value. Default: **null** |

- DBE_SQL.SQL_BIND_ARRAY

  This function is used to bind a set of parameters to an SQL statement. When an SQL statement is executed, the SQL statement is executed based on the bound array.

  The prototype of the **DBE_SQL.SQL_BIND_ARRAY** function is as follows:

```
DBE_SQL.SQL_BIND_ARRAY(
    IN context_id int,
    IN query_string text,
    IN value anyarray
)
RETURNS void;
DBE_SQL.SQL_BIND_ARRAY(
    IN context_id int,
    IN query_string text,
    IN value anyarray,
    IN lower_index int,
    IN higher_index int
)
RETURNS void;
```

**Table 13-138** DBE_SQL.SQL_BIND_ARRAY interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| query_string | Name of the bound variable |
| value | Bound array |
| lower_index | Minimum subscript of the bound array |

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| Parameter | Description |
| --- | --- |
| higher_index | Maximum subscript of the bound array |

- DBE_SQL.SET_RESULT_TYPE_INTS

  This function defines columns of the **INT** array type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_INTS** function is as follows:

```
DBE_SQL.SET_RESULT_TYPE_INTS(
    IN context_id int,
    IN pos int,
    IN column_ref anyarray,
    IN cnt int,
    IN lower_bnd int
)
RETURNS integer;
```

  **Table 13-139** DBE_SQL.SET_RESULT_TYPE_INTS interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_ref | Type of the returned array |
| cnt | Number of values obtained at a time |
| lower_bnd | The start subscript when an array is returned |

- DBE_SQL.SET_RESULT_TYPE_TEXTS

  This function defines columns of the **TEXT** array type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_TEXTS** function is as follows:

```
DBE_SQL.SET_RESULT_TYPE_TEXTS(
    IN context_id int,
    IN pos int,
    IN column_ref anyarray,
    IN cnt int,
    IN lower_bnd int,
    IN maxsize int
)
RETURNS integer;
```

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**Table 13-140** DBE_SQL.SET_RESULT_TYPE_TEXTS interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_ref | Type of the returned array |
| cnt | Number of values obtained at a time |
| lower_bnd | The start subscript when an array is returned |
| maxsize | Maximum length of the defined **TEXT** type |

- DBE_SQL.SET_RESULT_TYPE_RAWS

  This function defines columns of the **RAW** array type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_RAWS** function is as follows:

```
DBE_SQL.set_result_type_raws(
    IN context_id int,
    IN pos int,
    IN column_ref anyarray,
    IN cnt int,
    IN lower_bnd int,
    IN column_size int
)
RETURNS integer;
```

**Table 13-141** DBE_SQL.SET_RESULT_TYPE_RAWS interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_ref | Type of the returned array |
| cnt | Number of values obtained at a time |
| lower_bnd | The start subscript when an array is returned |
| column_size | Column length |

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- DBE_SQL.SET_RESULT_TYPE_BYTEAS

  This function defines columns of the **BYTEA** array type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_BYTEAS** function is as follows:

```
DBE_SQL.set_result_type_byteas(
    IN context_id int,
    IN pos int,
    IN column_ref anyarray,
    IN cnt int,
    IN lower_bnd int,
    IN column_size int
)
RETURNS integer;
```

  **Table 13-142** DBE_SQL.SET_RESULT_TYPE_BYTEAS interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_ref | Type of the returned array |
| cnt | Number of values obtained at a time |
| lower_bnd | The start subscript when an array is returned |
| column_size | Column length |

- DBE_SQL.SET_RESULT_TYPE_CHARS

  This function defines columns of the **CHAR** array type returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULT_TYPE_CHARS** function is as follows:

```
DBE_SQL.SET_RESULT_TYPE_CHARS(
    IN context_id int,
    IN pos int,
    IN column_ref anyarray,
    IN cnt int,
    IN lower_bnd int,
    IN column_size int
)
RETURNS integer;
```

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**Table 13-143** DBE_SQL.SET_RESULT_TYPE_CHARS interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_ref | Type of the returned array |
| cnt | Number of values obtained at a time |
| lower_bnd | The start subscript when an array is returned |
| column_size | Column length |

- DBE_SQL.SET_RESULTS_TYPE

  This function defines columns returned from a given cursor and can be used only for the cursors defined by **SELECT**. The defined columns are identified by the relative positions in the query list. The data type of an input variable determines the corresponding column type.

  The prototype of the **DBE_SQL.SET_RESULTS_TYPE** function is as follows:

```
DBE_SQL.SET_RESULTS_TYPE(
    IN context_id int,
    IN pos int,
    IN column_ref anyarray,
    IN cnt int,
    IN lower_bnd int,
    IN maxsize int  DEFAULT 1024
) returns void;
```

**Table 13-144** DBE_SQL.SET_RESULTS_TYPE interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_ref | Type of the returned array |
| cnt | Number of values obtained at a time |
| lower_bnd | The start subscript when an array is returned |
| maxsize | Maximum length of the defined type |

- DBE_SQL.GET_RESULTS_INT

  This function returns the value of the **INT** array type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

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The prototype of the **DBE_SQL.GET_RESULTS_INT** function is as follows:

```
DBE_SQL.GET_RESULTS_INT(
   IN context_id int,
   IN pos int,
   INOUT column_value anyarray
);
```

**Table 13-145** DBE_SQL.GET_RESULTS_INT interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_value | Return value |

- DBE_SQL.GET_RESULTS_TEXT

  This function returns the value of the **TEXT** array type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULTS_TEXT** function is as follows:

  ```
  DBE_SQL.GET_RESULTS_TEXT(
     IN context_id int,
     IN pos int,
     INOUT column_value anyarray
  );
  ```

  **Table 13-146** DBE_SQL.GET_RESULTS_TEXT interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be queried |
  | pos | Position of a dynamically defined column in the query |
  | column_value | Return value |

- DBE_SQL.GET_RESULTS_RAW

  This function returns the value of the **RAW** array type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULTS_RAW** function is as follows:

  ```
  DBE_SQL.GET_RESULTS_RAW(
     IN context_id int,
     IN pos int,
     INOUT column_value anyarray
  );
  ```

  **Table 13-147** DBE_SQL.GET_RESULTS_RAW interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be queried |

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| Parameter | Description |
| --- | --- |
| pos | Position of a dynamically defined column in the query |
| column_value | Return value |

- DBE_SQL.GET_RESULTS_BYTEA

  This function returns the value of the **BYTEA** array type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULTS_BYTEA** function is as follows:

```
DBE_SQL.GET_RESULTS_BYTEA(
    IN context_id int,
    IN pos int,
    INOUT column_value anyarray
);
```

  **Table 13-148** DBE_SQL.GET_RESULTS_BYTEA interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_value | Return value |

- DBE_SQL.GET_RESULTS_CHAR

  This function returns the value of the **CHAR** array type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

  The prototype of the **DBE_SQL.GET_RESULTS_CHAR** function is as follows:

```
DBE_SQL.GET_RESULTS_CHAR(
    IN context_id int,
    IN pos int,
    INOUT column_value anyarray
);
```

  **Table 13-149** DBE_SQL.GET_RESULTS_CHAR interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_value | Return value |

- DBE_SQL.GET_RESULTS

  This function returns the value of the array type in a specified position of a cursor and accesses the data obtained by **DBE_SQL.NEXT_ROW**.

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> **NOTE**
>
> The bottom-layer mechanism of DBE_SQL.GET_RESULTS is implemented through arrays. When different arrays are used to obtain the return value of the same column, NULL values are filled in the array due to discontinuous internal indexes to ensure the continuity of array indexes. As a result, the length of the returned result array is different from that of the Oracle database.

The prototype of the **DBE_SQL.GET_RESULTS** function is as follows:

```
DBE_SQL.GET_RESULTS(
    IN context_id int,
    IN pos int,
    INOUT column_value anyarray
);
```

**Table 13-150** DBE_SQL.GET_RESULTS interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_value | Return value |

- DBE_SQL.SQL_DESCRIBE_COLUMNS

  This function is used to describe column information and can be used only for cursors defined by **SELECT**.

  The prototype of the **DBE_SQL.SQL_DESCRIBE_COLUMNS** function is as follows:

```
DBE_SQL.SQL_DESCRIBE_COLUMNS(
    context_id in int,
    col_cnt inout int,
    desc_t inout dbe_sql.desc_tab
)RETURNS record ;
```

**Table 13-151** DBE_SQL.SQL_DESCRIBE_COLUMNS interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| col_cnt | Number of columns returned |
| desc_t | Description of the returned column |

- DBE_SQL.DESC_REC

  This type is a composite type and is used to store the description of the **SQL_DESCRIBE_COLUMNS** API.

  The prototype of the **DBE_SQL.DESC_REC** function is as follows:

```
CREATE TYPE DBE_SQL.DESC_REC AS (
    col_type          int,
    col_max_len       int,
    col_name          VARCHAR2(32),
    col_name_len      int,
```

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```
    col_schema_name     VARCHAR2(32),
    col_schema_name_len int,
    col_precision       int,
    col_scale           int,
    col_charsetid       int,
    col_charsetform     int,
    col_null_ok         BOOLEAN
);
```

- DBE_SQL.DESC_TAB

  This type is the TABLE type of DESC_REC and is implemented through the TABLE OF syntax.

  The prototype of the **DBE_SQL.DESC_TAB** function is as follows:

  ```
  CREATE TYPE DBE_SQL.DESC_TAB AS TABLE OF DBE_SQL.DESC_REC;
  ```

- DBE_SQL.DATE_TABLE

  This type is the TABLE type of DATE and is implemented through the TABLE OF syntax.

  The prototype of the **DBE_SQL.DATE_TABLE** function is as follows:

  ```
  CREATE TYPE DBE_SQL.DATE_TABLE AS TABLE OF DATE;
  ```

- DBE_SQL.NUMBER_TABLE

  This type is the TABLE type of NUMBER and is implemented through the TABLE OF syntax.

  The prototype of the **DBE_SQL.NUMBER_TABLE** function is as follows:

  ```
  CREATE TYPE DBE_SQL.NUMBER_TABLE AS TABLE OF NUMBER;
  ```

- DBE_SQL.VARCHAR2_TABLE

  This type is the TABLE type of VARCHAR2 and is implemented through the TABLE OF syntax.

  The prototype of the **DBE_SQL.VARCHAR2** function is as follows:

  ```
  CREATE TYPE DBE_SQL.VARCHAR2_TABLE AS TABLE OF VARCHAR2(2000);
  ```

- DBE_SQL.BIND_VARIABLE

  This function is used to bind parameters. You are advised to use **DBE_SQL.SQL_BIND_VARIABLE**.

- DBE_SQL.SQL_SET_RESULTS_TYPE_C

  This function is used to dynamically define a column of the array type. You are not advised to use it.

  The prototype of the **DBE_SQL.SQL_SET_RESULTS_TYPE_C** function is as follows:

  ```
  DBE_SQL.sql_set_results_type_c(
     context_id in int,
     pos in int,
     column_ref in anyarray,
     cnt in int,
     lower_bnd in int,
     col_type in anyelement,
     maxsize in int
  )return integer;
  ```

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**Table 13-152** DBE_SQL.SQL_SET_RESULTS_TYPE_C parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Position of a dynamically defined column in the query |
| column_ref | Type of the returned array |
| cnt | Number of values obtained at a time |
| lower_bnd | Start subscript when an array is returned |
| col_type | Variable type corresponding to the returned array type |
| maxsize | Maximum length of the defined type |

- DBE_SQL.SQL_GET_VALUES_C

  This function is used to read a dynamically defined column value. You are not advised to use it.

  The prototype of the **DBE_SQL.SQL_GET_VALUES_C** function is as follows:

```
DBE_SQL.sql_get_values_c(
    context_id in int,
    pos in int,
    results_type inout anyarray,
    result_type in anyelement
)return anyarray;
```

**Table 13-153** DBE_SQL.SQL_GET_VALUES_C parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Parameter position |
| results_type | Obtained result |
| result_type | Type of the obtained result |

- DBE_SQL.GET_VARIABLE_RESULT

  This function is used to return the value of the bound OUT parameter and obtain the OUT parameter in a stored procedure.

  The prototype of the **DBE_SQL.GET_VARIABLE_RESULT** function is as follows:

```
DBE_SQL.get_variable_result(
    IN context_id int,
    IN pos VARCHAR2,
    INOUT column_value anyelement
);
```

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**Table 13-154** DBE_SQL.GET_VARIABLE_RESULT interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Name of the bound parameter |
| column_value | Return value |

- DBE_SQL.GET_VARIABLE_RESULT_CHAR

  This function is used to return the value of the bound OUT parameter of the **CHAR** type and obtain the OUT parameter in a stored procedure.

  The prototype of the **DBE_SQL.GET_VARIABLE_RESULT_CHAR** function is as follows:

```
DBE_SQL.get_variable_result_char(
    IN context_id int,
    IN pos VARCHAR2
)
RETURNS char
```

**Table 13-155** DBE_SQL.GET_VARIABLE_RESULT_CHAR interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Name of the bound parameter |

- DBE_SQL.GET_VARIABLE_RESULT_RAW

  This function is used to return the value of the bound OUT parameter of the **RAW** type and obtain the OUT parameter in a stored procedure.

  The prototype of the **DBE_SQL.GET_VARIABLE_RESULT_RAW** function is as follows:

```
CREATE OR REPLACE FUNCTION DBE_SQL.get_variable_result_raw(
    IN context_id int,
    IN pos VARCHAR2,
    INOUT value anyelement
)
RETURNS anyelement
```

**Table 13-156** DBE_SQL.GET_VARIABLE_RESULT_RAW interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Name of the bound parameter |
| value | Return value |

- DBE_SQL.GET_VARIABLE_RESULT_TEXT

  This function is used to return the value of the bound OUT parameter of the **TEXT** type and obtain the OUT parameter in a stored procedure.

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The prototype of the **DBE_SQL.GET_VARIABLE_RESULT_TEXT** function is as follows:

```
CREATE OR REPLACE FUNCTION DBE_SQL.get_variable_result_text(
    IN context_id int,
    IN pos VARCHAR2
)
RETURNS text
```

**Table 13-157** DBE_SQL.GET_VARIABLE_RESULT_TEXT interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Name of the bound parameter |

- DBE_SQL.GET_VARIABLE_RESULT_INT

  This function is used to return the value of the bound OUT parameter of the **INT** type and obtain the OUT parameter in a stored procedure.

  The prototype of the **DBE_SQL.GET_VARIABLE_RESULT_INT** function is as follows:

  ```
  DBE_SQL.get_variable_result_int(
      IN context_id int,
      IN pos VARCHAR2,
      INOUT value anyelement
  )
  RETURNS anyelement
  ```

  **Table 13-158** DBE_SQL.GET_VARIABLE_RESULT_INT interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be queried |
  | pos | Name of the bound parameter |
  | value | Return value |

- DBE_SQL.GET_ARRAY_RESULT_TEXT

  This function is used to return the value of the bound OUT parameter of the **TEXT** array type and obtain the OUT parameter in a stored procedure.

  The prototype of the **DBE_SQL.GET_ARRAY_RESULT_TEXT** function is as follows:

  ```
  DBE_SQL.get_array_result_text(
      IN context_id int,
      IN pos VARCHAR2,
      INOUT column_value anyarray
  )
  ```

  **Table 13-159** DBE_SQL.GET_ARRAY_RESULT_TEXT interface parameters

  | Parameter | Description |
  | --- | --- |
  | context_id | ID of the cursor to be queried |

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| Parameter | Description |
| --- | --- |
| pos | Name of the bound parameter |
| column_value | Return value |

- DBE_SQL.GET_ARRAY_RESULT_RAW

  This function is used to return the value of the bound OUT parameter of the **RAW** array type and obtain the OUT parameter in a stored procedure.

  The prototype of the **DBE_SQL.GET_ARRAY_RESULT_RAW** function is as follows:

```
DBE_SQL.get_array_result_raw(
    IN context_id int,
    IN pos VARCHAR2,
    INOUT column_value anyarray
)
```

  **Table 13-160** DBE_SQL.GET_ARRAY_RESULT_RAW interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Name of the bound parameter |
| column_value | Return value |

- DBE_SQL.GET_ARRAY_RESULT_CHAR

  This function is used to return the value of the bound OUT parameter of the **CHAR** array type and obtain the OUT parameter in a stored procedure.

  The prototype of the **DBE_SQL.GET_ARRAY_RESULT_CHAR** function is as follows:

```
DBE_SQL.get_array_result_char(
    IN context_id int,
    IN pos VARCHAR2,
    INOUT column_value anyarray
)
```

  **Table 13-161** DBE_SQL.GET_ARRAY_RESULT_CHAR interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Name of the bound parameter |
| column_value | Return value |

- DBE_SQL.GET_ARRAY_RESULT_INT

  This function is used to return the value of the bound OUT parameter of the **INT** array type and obtain the OUT parameter in a stored procedure.

  The prototype of the **DBE_SQL.GET_ARRAY_RESULT_INT** function is as follows:

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```
DBE_SQL.get_array_result_int(
    IN context_id int,
    IN pos VARCHAR2,
    INOUT column_value anyarray
)
```

**Table 13-162** DBE_SQL.GET_ARRAY_RESULT_INT interface parameters

| Parameter | Description |
| --- | --- |
| context_id | ID of the cursor to be queried |
| pos | Name of the bound parameter |
| column_value | Return value |

## Examples

```
-- Perform operations on RAW data in a stored procedure.
openGauss=# create or replace procedure pro_dbe_sql_all_02(in_raw raw,v_in int,v_offset int)
as
context_id int;
v_id int;
v_info bytea :=1;
query varchar(2000);
execute_ret int;
define_column_ret_raw bytea :='1';
define_column_ret int;
begin
drop table if exists pro_dbe_sql_all_tb1_02 ;
create table pro_dbe_sql_all_tb1_02(a int ,b blob);
insert into pro_dbe_sql_all_tb1_02 values(1,HEXTORAW('DEADBEEE'));
insert into pro_dbe_sql_all_tb1_02 values(2,in_raw);
query := 'select * from pro_dbe_sql_all_tb1_02 order by 1';
-- Open a cursor.
context_id := dbe_sql.register_context();
-- Compile the cursor.
dbe_sql.sql_set_sql(context_id, query, 1);
-- Define columns.
define_column_ret:= dbe_sql.set_result_type(context_id,1,v_id);
define_column_ret_raw:= dbe_sql.set_result_type_raw(context_id,2,v_info,10);
-- Execute the cursor.
execute_ret := dbe_sql.sql_run(context_id);
loop
exit when (dbe_sql.next_row(cursorid) <= 0);
-- Obtain values.
dbe_sql.get_result(context_id,1,v_id);
dbe_sql.get_result_raw(context_id,2,v_info,v_in,v_offset);
-- Output the result.
dbe_output.print_line('id:'|| v_id || ' info:' || v_info);
end loop;
-- Close the cursor.
dbe_sql.sql_unregister_context(context_id);
end;
/
-- Call the stored procedure.
openGauss=# call pro_dbe_sql_all_02(HEXTORAW('DEADBEEF'),0,1);

-- Delete the stored procedure.
openGauss=# DROP PROCEDURE pro_dbe_sql_all_02;
```

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### 13.12.2.8 DBE_FILE

## Interface Description

Table 13-163 lists all interfaces supported by the **DBE_FILE** package.

**Table 13-163** DBE_FILE

| Interface | Description |
| --- | --- |
| DBE_FILE.OPEN | Opens a file based on the specified directory and file name. |
| DBE_FILE.IS_CLOSE | Checks whether a file handle is opened. |
| DBE_FILE.READ_LINE | Reads a line of data from an open file handle based on the specified length. |
| DBE_FILE.WRITE | Writes the data specified in the buffer to a file. |
| DBE_FILE.NEW_LINE | Writes one or more line terminators to an open file. |
| DBE_FILE.WRITE_LINE | Writes a string from the buffer to an open file. |
| DBE_FILE.FORMAT_WRITE | This is a formatted **PUT** stored procedure similar to **printf()**. |
| DBE_FILE.GET_RAW | Reads binary data from an open file handle. |
| DBE_FILE.PUT_RAW | Writes the input binary data to the file. |
| DBE_FILE.FLUSH | Writes data from a file handle to a physical file. |
| DBE_FILE.CLOSE | Closes an open file handle. |
| DBE_FILE.CLOSE_ALL | Closes all file handles opened in a session. |
| DBE_FILE.REMOVE | Deletes a disk file. To perform this operation, you must have required permissions. |
| DBE_FILE.RENAME | Renames files on the disk, similar to **mv** in Unix. |
| DBE_FILE.COPY | Copies data in a continuous area to a new file. If **start_line** and **end_line** are omitted, the entire file is copied. |
| DBE_FILE.GET_ATTR | Reads and returns the attributes of a disk file. |
| DBE_FILE.SEEK | Adjusts the position of a file pointer forward or backward based on the specified number of bytes. |
| DBE_FILE.GET_POS | Specifies the offset of a returned file, in bytes. |

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- DBE_FILE.OPEN

  This function opens a file. You can specify the maximum number of characters in each line. A maximum of 50 files can be opened at a time. This function returns a handle of the **INTEGER** type.

  The prototype of the **DBE_FILE.OPEN** function is as follows:

```
DBE_FILE.OPEN (
dir            IN    VARCHAR2,
file_name      IN   VARCHAR2,
open_mode      IN    VARCHAR2,
max_line_size  IN    INTEGER DEFAULT 1024)
RETURN INTEGER;
```

  **Table 13-164** DBE_FILE.OPEN interface parameters

| Parameter | Description |
| --- | --- |
| dir | Directory of a file. It is a string, indicating an object name.<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
| file_name | File name with an extension (file type), excluding the path name. A path contained in a file name is ignored in the **OPEN** function. In Unix, the file name cannot end with the combination of a slash and a dot (/.). |
| open_mode | File opening mode, including **r** (read), **w** (write), and **a** (append).<br>**NOTE**<br>For the write operation, the system checks the file type. If the ELF file is written, an error is reported and the system exits. |
| max_line_size | Maximum number of characters in each line, including newline characters. The minimum value is **1** and the maximum is **32767**. If this parameter is not specified, the default value **1024** is used. |

- DBE_FILE.IS_CLOSE

  This function detects a file handle to check whether the file is opened. A Boolean value is returned. If an invalid file handle is detected, the **INVALID_FILEHANDLE** exception is thrown.

  The prototype of the **DBE_FILE.IS_CLOSE** function is as follows:

```
DBE_FILE.IS_CLOSE (
file     IN     INTEGER)
RETURN BOOLEAN;
```

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**Table 13-165** DBE_FILE.IS_CLOSE interface parameters

| Parameter | Description |
| --- | --- |
| file IN INTEGER | File handle to be detected |

- DBE_FILE.READ_LINE

  This stored procedure reads text from an open file handle and stores the result in the buffer. The procedure reads data until a line end (excluding line terminator), file end, or the value specified by the **len** parameter. The length of the read data cannot exceed the value of the **max_line_size** parameter in the **OPEN** function.

  The prototype of the **DBE_FILE.READ_LINE** function is as follows:

  ```
  DBE_FILE.READ_LINE (
  file      IN   INTEGER,
  buffer    OUT  VARCHAR2,
  len       IN   INTEGER DEFAULT NULL)
  ```

  **Table 13-166** DBE_FILE.READ_LINE interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | File handle opened by calling the **OPEN** function. The file must be opened in read mode. Otherwise, the **INVALID_OPERATION** exception is thrown. |
  | buffer | Buffer used to receive data |
  | len | Number of bytes read from a file. The default value is **NULL**. If the default value **NULL** is used, **max_linesize** is used to specify the line size. |

- DBE_FILE.WRITE

  This stored procedure writes data in the buffer to a file. The file must be opened in write mode. Line terminators are not written.

  The prototype of the **DBE_FILE.WRITE** function is as follows:

  ```
  DBE_FILE.WRITE (
  file     IN     INTEGER,
  buffer   IN     TEXT);
  ```

  **Table 13-167** DBE_FILE.WRITE interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | This stored procedure writes data in the buffer to a file. The file must be opened in write mode. Line terminators are not written. |

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| Parameter | Description |
| --- | --- |
| buffer | Text data to be written to a file. The maximum buffer size is 32767 bytes. If no value is specified in the open state, the default value is 1024 bytes. Before the writing is performed, the buffer occupied by **WRITE** operations cannot exceed 32767 bytes.<br>**NOTE**<br>For the write operation, the system checks the file type. If the ELF file is written, an error is reported and the system exits. |

- DBE_FILE.NEW_LINE

  This stored procedure writes one or more line terminators to an open file. The procedure is split from the **WRITE** function because line terminators are related to platforms.

  The prototype of the **DBE_FILE.NEW_LINE** function is as follows:

```
DBE_FILE.NEW_LINE (
file        IN     INTEGER,
line_nums   IN     INTEGER := 1);
```

  **Table 13-168** DBE_FILE.NEW_LINE interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |
| line_nums | Number of terminators written to a file |

- DBE_FILE.WRITE_LINE

  This stored procedure writes strings in the buffer to an open file. The file must be opened in write mode.

  The prototype of the **DBE_FILE.WRITE_LINE** function is as follows:

```
DBE_FILE.WRITE_LINE(
file      IN     INTEGER,
buffer    IN     TEXT,
flush     IN     BOOLEAN DEFAULT FALSE);
```

  **Table 13-169** DBE_FILE.WRITE_LINE interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |
| buffer | Text data to be written to a file. The maximum buffer size is 32767 bytes. If no value is specified in the open state, the default value is 1024 bytes. Before the writing is performed, the buffer occupied by **PUT** operations cannot exceed 32767 bytes.<br>**NOTE**<br>For the write operation, the system checks the file type. If the ELF file is written, an error is reported and the system exits. |

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| Parameter | Description |
| --- | --- |
| flush | Whether to flush data to the disk after the writing |

- DBE_FILE.FORMAT_WRITE

  This is a formatted **PUT** stored procedure similar to **printf()**.

  The prototype of the **DBE_FILE.FORMAT_WRITE** function is as follows:

```
DBE_FILE.FORMAT_WRITE (
file   IN INTEGER,
format IN VARCHAR2,
arg1   IN VARCHAR2 DEFAULT NULL,
. . .
arg6 IN VARCHAR2 DEFAULT NULL]);
```

  **Table 13-170** DBE_FILE.FORMAT_WRITE interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |
| format | A string to be formatted, containing the text and format characters \n and %s |
| [arg1. . .arg6] | Six optional parameters. The parameters and the positions of characters to be formatted are in one-to-one correspondence. If the parameter corresponding to a character to be formatted is not provided, an empty string is used to replace %s. |

- DBE_FILE.GET_RAW

  This function reads binary data from the opened file descriptor and returns the data using **r**.

  The prototype of the **DBE_FILE.GET_RAW** function is as follows:

```
DBE_FILE.GET_RAW (
file    IN   INTEGER,
r       OUT  RAW,
length  IN   INTEGER DEFAULT NULL);
```

  **Table 13-171** DBE_FILE.GET_RAW interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |
| r | Output binary data |
| length | Length of the file to be read. The default value is **NULL**. All data in the file is read. The maximum length is 1 GB. |

- DBE_FILE.PUT_RAW

  This function writes binary data to a file.

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The prototype of the **DBE_FILE.PUT_RAW** function is as follows:

```
DBE_FILE.PUT_RAW (
file    IN  INTEGER,
r       IN  RAW,
flush   IN  BOOLEAN DEFAULT FALSE);
```

**Table 13-172** DBE_FILE.PUT_RAW interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |
| r | Output binary data<br>**NOTE**<br>For the write operation, the system checks the file type. If the ELF file is written, an error is reported and the system exits. |
| flush | Specifies whether to flush data to a file. The default value is **false**. |

- DBE_FILE.FLUSH

  Data in a file handle must be written into a physical file. Data in the buffer must have a line terminator. Refresh is important if a file must be read when it is opened. For example, debugging information can be refreshed to a file so that it can be read immediately.

  The prototype of the **DBE_FILE.FLUSH** function is as follows:

  ```
  DBE_FILE.FLUSH (
  file    IN     INTEGER);
  ```

  **Table 13-173** DBE_FILE.FLUSH interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |

- DBE_FILE.CLOSE

  This stored procedure closes an open file handle. When the stored procedure is called, exception is thrown if there is data to be written into the buffer.

  The prototype of the **DBE_FILE.CLOSE** function is as follows:

  ```
  DBE_FILE.CLOSE (
  file IN INTEGER
  )RETURN INTEGER;
  ```

  **Table 13-174** DBE_FILE.CLOSE interface parameters

  | Parameter | Description |
  | --- | --- |
  | file | Opened file handle |

- DBE_FILE.CLOSE_ALL

  This stored procedure closes all file handles opened in a session and can be used for emergency cleanup.

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The prototype of the **DBE_FILE.CLOSE_ALL** function is as follows:

```
DBE_FILE.CLOSE_ALL;
```

**Table 13-175** DBE_FILE.CLOSE_ALL interface parameters

| Parameter | Description |
| --- | --- |
| None | None |

- DBE_FILE.REMOVE

  This stored procedure deletes a disk file. To perform this operation, you must have required permissions for the directories and files.

  The prototype of the **DBE_FILE.REMOVE** function is as follows:

  ```
  DBE_FILE.REMOVE (
  dir          IN     VARCHAR2,
  file_name    IN     VARCHAR2);
  ```

  **Table 13-176** DBE_FILE.REMOVE interface parameters

  | Parameter | Description |
  | --- | --- |
  | dir | File directory<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
  | file_name | File to be deleted |

- DBE_FILE.RENAME

  This function renames files on the disk, similar to **mv** in Unix.

  The prototype of the **DBE_FILE.RENAME** function is as follows:

  ```
  DBE_FILE.RENAME (
  src_dir        IN   VARCHAR2,
  src_file_name  IN   VARCHAR2,
  dest_dir       IN   VARCHAR2,
  dest_file_name IN   VARCHAR2,
  overwrite      IN   BOOLEAN DEFAULT FALSE);
  ```

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**Table 13-177** DBE_FILE.RENAME interface parameters

| Parameter | Description |
| --- | --- |
| src_dir | Directory of the original file (case-sensitive)<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
| src_file_name | Original file to be renamed |
| dest_dir | Destination directory (case-sensitive)<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
| dest_file_name | New file name |
| overwrite | The default value is **false**. If a file with the same name exists in the destination directory, the file will not be rewritten. |

- DBE_FILE.COPY

  This stored procedure copies data in a continuous area to a new file. If **start_line** and **end_line** are omitted, the entire file is copied.

  The prototype of the **DBE_FILE.COPY** function is as follows:

```
DBE_FILE.COPY (
src_dir          IN     VARCHAR2,
src_file_name    IN     VARCHAR2,
dest_dir         IN     VARCHAR2,
dest_file_name   IN     VARCHAR2,
start_line       IN     INTEGER DEFAULT 1,
end_line         IN     INTEGER DEFAULT NULL);
```

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**Table 13-178** DBE_FILE.COPY interface parameters

| Parameter | Description |
| --- | --- |
| src_dir | Directory of the original file<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
| src_file_name | File to be copied |
| dest_dir | Directory of the destination file<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
| dest_file_name | Destination file to which data is to be written<br>**NOTE**<br>For the write operation, the system checks the file type. If the ELF file is written, an error is reported and the system exits. |
| start_line | Number of the line where the copy starts. The default value is **1**. |
| end_line | Number of the line where the copy ends. The default value is **NULL**, indicating the end of the file. |

- DBE_FILE.GET_ATTR

  This stored procedure reads and returns the attributes of a disk file.

  The prototype of the **DBE_FILE.GET_ATTR** function is as follows:

```
DBE_FILE.GET_ATTR(
location IN text,
filename IN text,
OUT fexists boolean,
OUT file_length bigint,
OUT block_size integer);
```

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**Table 13-179** DBE_FILE.GET_ATTR interface parameters

| Parameter | Description |
| --- | --- |
| location | File directory<br>**NOTE**<br>• File directories need to be added to the system catalog **15.2.55 PG_DIRECTORY**. If the input path does not match the path in **15.2.55 PG_DIRECTORY**, an error indicating that the path does not exist will be reported. Functions that involve **location** as parameters also comply with this rule.<br>• When the GUC parameter **safe_data_path** is enabled, you can only use the advanced package to read and write files in the file path specified by **safe_data_path**. |
| filename | Name of the file to be checked |
| fexists | Whether the file exists |
| file_length | File length (unit: bytes). If the file does not exist, **NULL** is returned. |
| block_size | Block size of the file system (unit: byte). If the file does not exist, **NULL** is returned. |

- DBE_FILE.SEEK

  This stored procedure adjusts the position of a file pointer forward or backward based on the specified number of bytes.

  The prototype of the **DBE_FILE.SEEK** function is as follows:

```
DBE_FILE.SEEK (
file            IN INTEGER,
absolute_start  IN     BIGINT DEFAULT NULL,
relative_start  IN     BIGINT DEFAULT NULL);
```

**Table 13-180** DBE_FILE.SEEK interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |
| absolute_start | Absolute offset of a file. The default value is **NULL**. |
| relative_start | Relative offset of a file. A positive number indicates forward offset and a negative number indicates backward offset. The default value is **NULL**. If both **absolute_start** and this parameter are specified, the **absolute_start** parameter is used. |

- DBE_FILE.GET_POS

  This function returns file offset in bytes.

  The prototype of the **DBE_FILE.FGETPOS** function is as follows:

```
DBE_FILE.GET_POS (
file    IN     INTEGER)
RETURN BIGINT;
```

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**Table 13-181** DBE_FILE.GET_POS interface parameters

| Parameter | Description |
| --- | --- |
| file | Opened file handle |

## Examples

```
-- Add the /temp/ directory to the PG_DIRECTORY system catalog as a system administrator.
CREATE OR REPLACE DIRECTORY dir AS '/tmp/';
-- Open a file and write data into the file.
DECLARE
  f integer;
  dir text := 'dir';
BEGIN
  f := dbe_file.open(dir, 'sample.txt', 'w');
  PERFORM dbe_file.write_line(f, 'ABC');
  PERFORM dbe_file.write_line(f, '123'::numeric);
  PERFORM dbe_file.write_line(f, '-----');
  PERFORM dbe_file.new_line(f);
  PERFORM dbe_file.write_line(f, '*******');
  PERFORM dbe_file.new_line(f, 0);
  PERFORM dbe_file.write_line(f, '++++++++');
  PERFORM dbe_file.new_line(f, 2);
  PERFORM dbe_file.write_line(f, '########');
  PERFORM dbe_file.write(f, 'A');
  PERFORM dbe_file.write(f, 'B');
  PERFORM dbe_file.new_line(f);
  PERFORM dbe_file.format_write(f, '[1 -> %s, 2 -> %s, 3 -> %s, 4 -> %s, 5 -> %s]', 'gaussdb', 'dbe', 'file',
'get', 'line');
  PERFORM dbe_file.new_line(f);
  PERFORM dbe_file.write_line(f, '1234567890');
  f := dbe_file.close(f);
END;
/
-- Read data from the file mentioned above.
DECLARE
  f integer;
  dir text := 'dir';
BEGIN
  f := dbe_file.open(dir, 'sample.txt', 'r');
  FOR i IN 1..11 LOOP
       RAISE INFO '[%] : %', i, dbe_file.read_line(f);
  END LOOP;
END;
/
-- Offset the file handle and obtain the current file location.
DECLARE
      l_file   integer;
      l_buffer VARCHAR2(32767);
      dir text := 'dir';
      abs_offset number := 100;
      rel_offset number := NULL;
BEGIN
      l_file := dbe_file.open(dir  => dir,  file_name  => 'sample.txt',open_mode => 'R');
      dbe_output.print_line('before seek: current position is ' || dbe_file.get_pos(file => l_file)); -- before seek:
current position is 0
      dbe_file.seek(file => l_file, absolute_start=>abs_offset, relative_start=>rel_offset);
      dbe_output.print_line('fseek: current position is ' || dbe_file.get_pos(file => l_file)); -- seek: current
position is 100
      l_file := dbe_file.close(file => l_file);
END;
/
```

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## 13.12.2.9 DBE_SESSION

## Interface Description

Table 13-182 provides all interfaces supported by the **DBE_SESSION** package. **DBE_SESSION** takes effect at the session level.

**Table 13-182** DBE_SESSION

| Interface | Description |
| --- | --- |
| DBE_SESSION.SET_CONTEXT | Sets the value of an attribute in a specified context. |
| DBE_SESSION.CLEAR_CONTEXT | Clears the value of an attribute in a specified context. |
| DBE_SESSION.SEARCH_CONTEXT | Queries the value of an attribute in a specified context. |

- DBE_SESSION.SET_CONTEXT

Sets the value of an attribute in a specified namespace (context). The **DBE_SESSION.SET_CONTEXT** function prototype is as follows:

```
DBE_SESSION.SET_CONTEXT(
    namespace text,
    attribute text,
    value text
)returns void;
```

**Table 13-183** DBE_SESSION.SET_CONTEXT interface parameters

| Parameter | Description |
| --- | --- |
| namespace | Name of the context to be set. If the context does not exist, create a context. The value contains a maximum of 128 characters. |
| attribute | Attribute name. The value contains a maximum of 128 characters. |
| value | Name of the value to be set. The value contains a maximum of 128 characters. |

- DBE_SESSION.CLEAR_CONTEXT

Clears the value of an attribute in a specified namespace (context). The **DBE_SESSION.CLEAR_CONTEXT** function prototype is as follows:

```
DBE_SESSION.CLEAR_CONTEXT (
    namespace text,
    client_identifier text default 'null',
    attribute text
)returns void ;
```

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**Table 13-184** DBE_SESSION.CLEAR_CONTEXT interface parameters

| Parameter | Description |
| --- | --- |
| namespace | User-specified context. |
| client_identifier | Client authentication. The default value is **null**. Generally, you do not need to manually set this parameter. |
| attribute | Attribute to be cleared. |

- DBE_SESSION.SEARCH_CONTEXT

Queries the value of an attribute in a specified namespace (context). The **DBE_SESSION.SEARCH_CONTEXT** function prototype is:

```
DBE_SESSION.SEARCH_CONTEXT (
    namespace text,
    attribute text
)returns text;
```

**Table 13-185** DBE_SESSION.SEARCH_CONTEXT interface parameters

| Parameter | Description |
| --- | --- |
| namespace | User-specified context. |
| attribute | Attribute to be queried. |

## Example

```
BEGIN
    select DBE_SESSION.set_context('test', 'gaussdb', 'one');    -- Set the gaussdb attribute of the test context to one.
    select DBE_SESSION.search_context('test', 'gaussdb');
    select DBE_SESSION.clear_context('test', 'test','gaussdb');
END;
/
```

## 13.12.2.10 DBE_MATCH

## Interface Description

Table 13-186 provides all interfaces supported by the **DBE_MATCH** package.

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**Table 13-186** DBE_MATCH

| Interface | Description |
| --- | --- |
| DBE_MATCH.EDIT_DISTANCE_SIMILARITY | Compares the difference between two character strings (minimum steps of deletion, addition, and conversion) and normalizes the difference to a value ranging from 0 to 100. The value **100** indicates that the two character strings are the same, and the value **0** indicates that the two character strings are different. |

- DBE_MATCH.EDIT_DISTANCE_SIMILARITY

Compares the difference between two character strings (minimum steps of deletion, addition, and conversion) and normalizes the difference to a value ranging from 0 to 100. The value **100** indicates that the two character strings are the same, and the value **0** indicates that the two character strings are different. The **DBE_MATCH.EDIT_DISTANCE_SIMILARITY** function prototype is as follows:

```
DBE_MATCH.EDIT_DISTANCE_SIMILARITY(
    str1 IN text,
    str2 IN text
)returns integer ;
```

**Table 13-187** DBE_MATCH.EDIT_DISTANCE_SIMILARITY interface parameters

| Parameter | Description |
| --- | --- |
| str1 | First character string. If the value is **null**, **0** is returned. |
| str2 | Second character string. If the value is **null**, **0** is returned. |

## 13.12.2.11 DBE_SCHEDULER

## Interface Description

The advanced package **DBE_SCHEDULER** supports more flexible creation of scheduled tasks through scheduling and programing. For details about all the supported interfaces, see **Table 13-188**.

**NOTICE**

The DBE_SCHEDULER does not support scheduled tasks for synchronizing data between nodes. To create scheduled tasks for multiple nodes, use the **13.12.2.5 DBE_TASK** API.

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**Table 13-188** DBE_SCHEDULER

| Interface | Description |
| --- | --- |
| •CREATE_JOB | Creates a scheduled task. |
| •DROP_JOB | Deletes a scheduled task. |
| •DROP_SINGLE_JOB | Deletes a single scheduled task. |
| •SET_ATTRIBUTE | Sets object attributes. |
| •RUN_JOB | Executes a scheduled task. |
| •RUN_BACKEND_JOB | Runs a scheduled task in the background. |
| •RUN_FOREGROUND_JOB | Runs a scheduled task in the foreground. |
| •STOP_JOB | Stops a scheduled task. |
| •STOP_SINGLE_JOB | Stops a single scheduled task. |
| •GENERATE_JOB_NAME | Generates the name of a scheduled task. |
| •CREATE_PROGRAM | Creates a program. |
| •DEFINE_PROGRAM_ARGUMENT | Defines program parameters. |
| •DROP_PROGRAM | Deletes a program. |
| •DROP_SINGLE_PROGRAM | Deletes a single program. |
| •SET_JOB_ARGUMENT_VALUE | Sets the parameters of a scheduled task. |
| •CREATE_SCHEDULE | Creates a schedule. |
| •DROP_SCHEDULE | Deletes a schedule. |
| •DROP_SINGLE_SCHEDULE | Deletes a single schedule. |
| •CREATE_JOB_CLASS | Creates the class of a scheduled task. |
| •DROP_JOB_CLASS | Deletes the class of a scheduled task. |

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| Interface | Description |
| --- | --- |
| •DROP_SINGLE_JOB_CLASS | Deletes the class of a single scheduled task. |
| •GRANT_USER_AUTHORIZATIO... | Grants special permissions to a user. |
| •REVOKE_USER_AUTHORIZATI... | Revokes special permissions from a user. |
| •CREATE_CREDENTIAL | Creates a certificate. |
| •DROP_CREDENTIAL | Destroys a certificate. |
| •ENABLE | Enables an object. |
| •ENABLE_SINGLE | Enables a single object. |
| •DISABLE | Disables an object. |
| •DISABLE_SINGLE | Disables a single object. |
| •EVAL_CALENDAR_STRING | Analyzes character strings in the Calendar format. |
| •EVALUATE_CALENDAR_STRIN... | Analyzes character strings in the Calendar format. |

- DBE_SCHEDULER.CREATE_JOB

  Creates a scheduled task.

  The prototypes of the **DBE_SCHEDULER.CREATE_JOB** function are as follows:

```
-- Scheduled tasks of an inline schedule and a program.
DBE_SCHEDULER.CREATE_JOB(
job_name TEXT,
job_type TEXT,
job_action TEXT,
number_of_arguments INTEGER             DEFAULT 0,
start_date TIMESTAMP WITH TIME ZONE     DEFAULT NULL,
repeat_interval TEXT                    DEFAULT NULL,
end_date TIMESTAMP WITH TIME ZONE       DEFAULT NULL,
job_class TEXT          DEFAULT 'DEFAULT_JOB_CLASS',
enabled BOOLEAN                         DEFAULT FALSE,
auto_drop BOOLEAN                       DEFAULT TRUE,
comments TEXT                           DEFAULT NULL,
credential_name TEXT                    DEFAULT NULL,
destination_name TEXT                   DEFAULT NULL
)

-- Reference the created scheduled tasks of the schedule and the program.
DBE_SCHEDULER.CREATE_JOB(
job_name TEXT,
program_name TEXT,
schedule_name TEXT,
job_class TEXT          DEFAULT 'DEFAULT_JOB_CLASS',
enabled BOOLEAN                         DEFAULT FALSE,
auto_drop BOOLEAN                       DEFAULT TRUE,
```

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```
comments TEXT                    DEFAULT NULL,
job_style TEXT                   DEFAULT 'REGULAR',
credential_name TEXT             DEFAULT NULL,
destination_name TEXT            DEFAULT NULL
)

-- Reference the created program and the scheduled task of the inline schedule.
DBE_SCHEDULER.CREATE_JOB(
job_name text,
program_name TEXT,
start_date TIMESTAMP WITH TIME ZONE     DEFAULT NULL,
repeat_interval TEXT                DEFAULT NULL,
end_date TIMESTAMP WITH TIME ZONE       DEFAULT NULL,
job_class TEXT          DEFAULT 'DEFAULT_JOB_CLASS',
enabled BOOLEAN                  DEFAULT FALSE,
auto_drop BOOLEAN                DEFAULT TRUE,
comments TEXT                    DEFAULT NULL,
job_style TEXT                   DEFAULT 'REGULAR',
credential_name TEXT             DEFAULT NULL,
destination_name TEXT            DEFAULT NULL
)

-- Reference the created schedule and the scheduled task of the inline program.
DBE_SCHEDULER.CREATE_JOB(
job_name TEXT,
schedule_name TEXT,
job_type TEXT,
job_action TEXT,
number_of_arguments INTEGER          DEFAULT 0,
job_class TEXT          DEFAULT 'DEFAULT_JOB_CLASS',
enabled BOOLEAN                  DEFAULT FALSE,
auto_drop BOOLEAN                DEFAULT TRUE,
comments TEXT                    DEFAULT NULL,
credential_name TEXT             DEFAULT NULL,
destination_name TEXT            DEFAULT NULL
)
```

NOTE

The scheduled task created through **DBE_SCHEDULER** does not conflict with the scheduled task in **DBE_TASK**.

The scheduled task created by **DBE_SCHEDULER** generates the corresponding **job_id**. However, the **job_id** is meaningless.

**Table 13-189** DBE_SCHEDULER.CREATE_JOB interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| job_name | text | IN | No | Name of a scheduled task. |

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| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| job_type | text | IN | No | Inline program type of a scheduled task. The options are as follows:<br>**PLSQL_BLOCK**: fast anonymous stored procedure<br>**STORED_PROCEDURE**: stored procedure that is saved<br>**EXTERNAL_SCRIPT**: external script |
| job_action | text | IN | No | Content executed by an inline program of a scheduled task. |
| number_of_arguments | integer | IN | No | Number of inline program parameters of a scheduled task. |
| program_name | text | IN | No | Name of the program referenced by a scheduled task. |
| start_date | timestamp with time zone | IN | Yes | Inline scheduling start time of a scheduled task. |
| repeat_interval | text | IN | Yes | Inline scheduling period of a scheduled task. |
| end_date | timestamp with time zone | IN | Yes | Inline scheduling expiration time of a scheduled task. |
| schedule_name | text | IN | No | Name of the schedule referenced by a scheduled task. |
| job_class | text | IN | No | Class name of a scheduled task. |
| enabled | boolean | IN | No | Status of a scheduled task. |
| auto_drop | boolean | IN | No | Automatic deletion of a scheduled task. |
| comments | text | IN | Yes | Comments. |

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| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| job_style | text | IN | No | Behavior pattern of a scheduled task. Only **REGULAR** is supported. |
| credential_name | text | IN | Yes | Certificate name of a scheduled task. |
| destination_name | text | IN | Yes | Target name of a scheduled task. |

**NOTICE**

To create a scheduled task of the EXTERNAL_SCRIPT type, the administrator must assign related permissions and certificates and the user who starts the database must have the read permission on the external script.

- DBE_SCHEDULER.DROP_JOB

  Deletes a scheduled task.

  The prototype of the **DBE_SCHEDULER.DROP_JOB** function is as follows:

```
DBE_SCHEDULER.drop_job(
job_name text,
force boolean                   default false,
defer boolean                   default false,
commit_semantics text      default 'STOP_ON_FIRST_ERROR'
)
```

  **NOTE**

  **DBE_SCHEDULER.DROP_JOB** can specify one or more tasks, or specify a task class to delete a scheduled task.

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**Table 13-190** DBE_SCHEDULER.DROP_JOB interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| job_name | text | IN | No | Name or class of a scheduled task. You can specify one or more scheduled tasks. If you specify multiple scheduled tasks, separate them with commas (,). |
| force | boolean | IN | No | Specifies whether to delete a scheduled task.<br>**true**: The current scheduled task is stopped and then deleted.<br>**false**: The scheduled task fails to be deleted if it is running. |
| defer | boolean | IN | No | Specifies whether to delete a scheduled task.<br>**true**: A scheduled task can be deleted after it is complete. |
| commit_semantics | text | IN | No | Commit rules:<br>**STOP_ON_FIRST_ERROR**: The deletion operation performed before the first error is reported is committed.<br>**TRANSACTIONAL**: Transaction-level commit. The deletion operation performed before an error is reported will be rolled back.<br>**ABSORB_ERRORS**: Attempt to bypass an error and commit the deletion operation that is performed successfully. |

**NOTICE**

The **TRANSACTIONAL** option in **commit_semantic** takes effect only when **force** is set to **false**.

- DBE_SCHEDULER.DROP_SINGLE_JOB

  Deletes a scheduled task.

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The prototype of the **DBE_SCHEDULER.DROP_SINGLE_JOB** function is as follows:

```
DBE_SCHEDULER.drop_single_job(
job_name text,
force boolean                   default false,
defer boolean                   default false
)
```

- DBE_SCHEDULER.SET_ATTRIBUTE

  Modifies the attributes of a scheduled task.

  The prototypes of the **DBE_SCHEDULER.SET_ATTRIBUTE** function are as follows:

```
DBE_SCHEDULER.set_attribute(
name              text,
attribute         text,
value             boolean
)

DBE_SCHEDULER.set_attribute(
name              text,
attribute         text,
value             text
)

DBE_SCHEDULER.set_attribute(
name              text,
attribute         text,
value             timestamp
)

DBE_SCHEDULER.set_attribute(
name              text,
attribute         text,
value             timestamp with time zone
)

DBE_SCHEDULER.set_attribute(
name text,
attribute text,
value text,
value2 text                     default NULL
)
```

  NOTE

  **name** specifies any object in **DBE_SCHEDULE**.

**Table 13-191** DBE_SCHEDULER.SET_ATTRIBUTE interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| name | text | IN | No | Object name. |

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| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| attribute | text | IN | No | Attribute name. |
| value | boolean/date/timestamp/timestamp with time zone/text | IN | No | Attribute value. The options are as follows:<br>Scheduled task-related:<br>job_type, job_action, number_of_arguments, start_date, repeat_interval, end_date, job_class, enabled, auto_drop, comments, credential_name, destination_name, program_name, schedule_name, job_style<br>Scheduling-related:<br>program_action, program_type, number_of_arguments, comments<br>Program-related:<br>start_date, repeat_interval, end_date, comments |
| value2 | text | IN | Yes | Additional attribute value. Reserved parameter bit. Currently, the target attribute with extra attribute values is not supported. |

**NOTICE**

Do not use **DBE_SCHEDULER.SET_ATTRIBUTE** to leave the parameters empty.

The object name cannot be changed using **DBE_SCHEDULER.SET_ATTRIBUTE**.

Inline objects cannot be changed by DBE_SCHEDULER.SET_ATTRIBUTE.

- DBE_SCHEDULER.RUN_JOB

  Executes a scheduled task.

  The prototype of the **DBE_SCHEDULER.RUN_JOB** function is as follows:

```
DBE_SCHEDULER.run_job(
job_name text,
use_current_session boolean             default true
)
```

**NOTE**

**DBE_SCHEDULER.RUN_JOB** is used to run scheduled tasks immediately. It is independent of the scheduling of scheduled tasks and can even run at the same time.

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**Table 13-192** DBE_SCHEDULER.RUN_JOB interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| job_name | text | IN | No | Name of a scheduled task. You can specify one or more scheduled tasks. If you specify multiple scheduled tasks, separate them with commas (,). |
| use_current_session | boolean | IN | No | Specifies whether to run a scheduled task.<br>**true**: Use the current session to check whether the scheduled task can run properly.<br>**false**: Start the scheduled task in the background. The execution result is recorded in logs. |

**NOTICE**

Currently, **use_current_session** applies only to scheduled tasks whose **job_type** is set to **EXTERNAL_SCRIPT**.

- DBE_SCHEDULER.RUN_BACKEND_JOB

  Runs a scheduled task in the background.

  The prototype of the **DBE_SCHEDULER.RUN_BACKEND_JOB** function is as follows:

  ```
  DBE_SCHEDULER.run_backend_job(
  job_name text
  )
  ```

- DBE_SCHEDULER.RUN_FOREGROUND_JOB

  Executes a scheduled task in the current session.

  Only external tasks can be executed.

  Return value: text

  The prototype of the **DBE_SCHEDULER.RUN_FOREGROUND_JOB** function is as follows:

  ```
  DBE_SCHEDULER.run_foreground_job(
  job_name text
  )return text
  ```

- DBE_SCHEDULER.STOP_JOB

  Stops a scheduled task.

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The prototype of the **DBE_SCHEDULER.STOP_JOB** function is as follows:

```
DBE_SCHEDULER.stop_job(
job_name text,
force boolean                   default false,
commit_semantics text               default 'STOP_ON_FIRST_ERROR'
)
```

**Table 13-193** DBE_SCHEDULER.STOP_JOB interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| job_name | text | IN | No | Name or class of a scheduled task. You can specify one or more scheduled tasks. If you specify multiple scheduled tasks, separate them with commas (,). |
| force | boolean | IN | No | Specifies whether to delete a scheduled task.<br>**true**: The scheduler sends a termination signal to end the task thread immediately.<br>**false**: The scheduler attempts to use the interrupt signal to terminate the scheduled task thread. |
| commit_semantics | text | IN | No | Commit rules:<br>'**STOP_ON_FIRST_ERROR**': The interrupt operation performed before the first error is reported is committed.<br>'**ABSORB_ERRORS**': The system attempts to bypass an error and commit the interrupt operation that is performed successfully. |

- DBE_SCHEDULER.STOP_SINGLE_JOB

  Stops a single scheduled task.

  The prototype of the **DBE_SCHEDULER.STOP_SINGLE_JOB** function is as follows:

  ```
  DBE_SCHEDULER.stop_single_job(
  job_name text,
  force boolean                   default false
  )
  ```

- DBE_SCHEDULER.GENERATE_JOB_NAME

  Generates the name of a scheduled task.

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The prototype of the **DBE_SCHEDULER.GENERATE_JOB_NAME** function is as follows:

```
DBE_SCHEDULER.generate_job_name(
prefix text                    default 'JOB$_'
)return text
```

**Table 13-194** DBE_SCHEDULER.GENERATE_JOB_NAME interface parameters

| Parameter | Type | Input/Output Parameter | Can Be Empty | Description |
| --- | --- | --- | --- | --- |
| prefix | text | IN | No | Prefix of the generated name. The default value is **'JOB$_'**. Scheduled tasks that are repeatedly executed are named as follows:<br>job$_1, job$_2, job$_3 ... |

**NOTICE**

When DBE_SCHEDULER.GENERATE_JOB_NAME is executed for the first time, a temporary sequence is created in **public** to store the sequence number of the current name. A common user does not have the create permission in **public**. Therefore, if a common user calls the function for the first time in the current database, the function fails to be called. In this case, you need to grant the create permission in **public** to the common user or call the API as a user with the create permission to create a temporary sequence.

- DBE_SCHEDULER.CREATE_PROGRAM

  Creates a program.

  The prototype of the **DBE_SCHEDULER.CREATE_PROGRAM** function is as follows:

  ```
  DBE_SCHEDULER.create_program(
  program_name text,
  program_type text,
  program_action text,
  number_of_arguments integer          default 0,
  enabled boolean                   default false,
  comments text                     default NULL
  )
  ```

- DBE_SCHEDULER.DEFINE_PROGRAM_ARGUMENT

  Defines program parameters.

  The **DBE_SCHEDULER.DEFINE_PROGRAM_ARGUMENT** function prototype is as follows:

  ```
  DBE_SCHEDULER.define_program_argument(
  program_name text,
  ```

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```
argument_position integer,
argument_name text                  default NULL,
argument_type text,
out_argument boolean                default false
)

-- With a default value --
DBE_SCHEDULER.define_program_argument(
program_name text,
argument_position integer,
argument_name text                  default NULL,
argument_type text,
default_value text,
out_argument boolean                default false
)
```

- DBE_SCHEDULER.DROP_PROGRAM

  Deletes a program.

  The prototype of the **DBE_SCHEDULER.DROP_PROGRAM** function is as follows:

  ```
  DBE_SCHEDULER.drop_program(
  program_name text,
  force boolean                     default false
  )
  ```

- DBE_SCHEDULER.DROP_SINGLE_PROGRAM

  Deletes a single program.

  The prototype of the **DBE_SCHEDULER.DROP_SINGLE_PROGRAM** function is as follows:

  ```
  DBE_SCHEDULER.drop_single_program(
  program_name text,
  force boolean                     default false
  )
  ```

- DBE_SCHEDULER.SET_JOB_ARGUMENT_VALUE

  Sets the parameters of a scheduled task.

  The prototype of the **DBE_SCHEDULER.SET_JOB_ARGUMENT_VALUE** function is as follows:

  ```
  DBE_SCHEDULER.set_job_argument_value(
  job_name text,
  argument_position integer,
  argument_value text
  )

  DBE_SCHEDULER.set_job_argument_value(
  job_name text,
  argument_name text,
  argument_value text
  )
  ```

- DBE_SCHEDULER.CREATE_SCHEDULE

  Creates a schedule.

  The prototype of the **DBE_SCHEDULER.CREATE_SCHEDULE** function is as follows:

  ```
  DBE_SCHEDULER.create_schedule(
  schedule_name text,
  start_date timestamp with time zone     default NULL,
  repeat_interval text,
  end_date timestamp with time zone       default NULL,
  comments text                       default NULL
  )
  ```

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- DBE_SCHEDULER.DROP_SCHEDULE

  Deletes a schedule.

  The prototype of the **DBE_SCHEDULER.DROP_SCHEDULE** function is as follows:

  ```
  DBE_SCHEDULER.drop_schedule(
  schedule_name text,
  force boolean                 default false
  )
  ```

- DBE_SCHEDULER.DROP_SINGLE_SCHEDULE

  Deletes a single schedule.

  The prototype of the **DBE_SCHEDULER.DROP_SINGLE_SCHEDULE** function is as follows:

  ```
  DBE_SCHEDULER.drop_single_schedule(
  schedule_name text,
  force boolean                 default false
  )
  ```

- DBE_SCHEDULER.CREATE_JOB_CLASS

  Creates the class of a scheduled task.

  The prototype of the **DBE_SCHEDULER.CREATE_JOB_CLASS** function is as follows:

  ```
  DBE_SCHEDULER.create_job_class(
  job_class_name text,
  resource_consumer_group text          default NULL,
  service text                        default NULL,
  logging_level integer                 default 0,
  log_history integer                   default NULL,
  comments text                         default NULL
  )
  ```

- DBE_SCHEDULER.DROP_JOB_CLASS

  Deletes the class of a scheduled task.

  The prototype of the **DBE_SCHEDULER.DROP_JOB_CLASS** function is as follows:

  ```
  DBE_SCHEDULER.drop_job_class(
  job_class_name text,
  force boolean                 default false
  )
  ```

- DBE_SCHEDULER.DROP_SINGLE_JOB_CLASS

  Deletes the class of a single scheduled task.

  The prototype of the **DBE_SCHEDULER.DROP_SINGLE_JOB_CLASS** function is as follows:

  ```
  DBE_SCHEDULER.drop_single_job_class(
  job_class_name text,
  force boolean                 default false
  )
  ```

- DBE_SCHEDULER.GRANT_USER_AUTHORIZATION

  Grants the scheduled task permissions to the database user. The user who calls this function must have the SYSADMIN permission.

  The prototype of the **DBE_SCHEDULER.GRANT_USER_AUTHORIZATION** function is as follows:

  ```
  DBE_SCHEDULER.grant_user_authorization(
  username              text,
  privilege           text
  )
  ```

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- DBE_SCHEDULER.REVOKE_USER_AUTHORIZATION

  Revokes the scheduled task permissions from the database user. The user who calls this function must have the SYSADMIN permission.

  The prototype of the **DBE_SCHEDULER.REVOKE_USER_AUTHORIZATION** function is as follows:

  ```
  DBE_SCHEDULER.revoke_user_authorization(
  username              text,
  privilege             text
  )
  ```

- DBE_SCHEDULER.CREATE_CREDENTIAL

  Creates an authorization certificate. The user who calls this function must have the SYSADMIN permission.

  The prototype of the **DBE_SCHEDULER.CREATE_CREDENTIAL** function is as follows:

  ```
  DBE_SCHEDULER.create_credential(
  credential_name       text,
  username              text,
  password              text          default NULL,
  database_role         text          default NULL,
  windows_domain        text          default NULL,
  comments              text          default NULL
  )
  ```

**NOTICE**

The **password** parameter of **DBE_SCHEDULER.CREATE_CREDENTIAL** must be set to **NULL** or **'******'**. This parameter is used only for compatibility and does not indicate any actual meaning. Do not use the OS username corresponding to the installation user to create a certificate.

- DBE_SCHEDULER.DROP_CREDENTIAL

  Destroys an authorization certificate. The user who calls this function must have the SYSADMIN permission.

  The prototype of the **DBE_SCHEDULER.DROP_CREDENTIAL** function is as follows:

  ```
  DBE_SCHEDULER.drop_credential(
  credential_name       text,
  force boolean default false
  )
  ```

- DBE_SCHEDULER.ENABLE

  Enables an object.

  The prototype of the **DBE_SCHEDULER.ENABLE** function is as follows:

  ```
  DBE_SCHEDULER.enable(
  name text,
  commit_semantics text                 default 'STOP_ON_FIRST_ERROR'
  )
  ```

- DBE_SCHEDULER.ENABLE_SINGLE

  Enables a single object.

  The prototype of the **DBE_SCHEDULER.ENABLE_SINGLE** function is as follows:

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```
DBE_SCHEDULER.enable_single(
name text
)
```

- DBE_SCHEDULER.DISABLE

  Disables multiple objects. The value of name is a character string separated by commas (,). Each character string separated by commas (,) is an object.

  The prototype of the **DBE_SCHEDULER.DISABLE** function is as follows:

```
DBE_SCHEDULER.disable(
name text,
force boolean                   default false,
commit_semantics text               default 'STOP_ON_FIRST_ERROR'
)
```

- DBE_SCHEDULER.DISABLE_SINGLE

  Disables a single object.

  The prototype of the **DBE_SCHEDULER.DISABLE_SINGLE** function is as follows:

```
DBE_SCHEDULER.disable_single(
name text,
force boolean                   default false
)
```

- DBE_SCHEDULER.EVAL_CALENDAR_STRING

  Analyzes the scheduling task period.

  Return type: timestamp with time zone

  The prototype of the **DBE_SCHEDULER.EVAL_CALENDAR_STRING** function is as follows:

```
DBE_SCHEDULER.evaluate_calendar_string(
IN calendar_string text,
IN start_date timestamp with time zone,
IN return_date_after timestamp with time zone
)return timestamp with time zone
```

- DBE_SCHEDULER.EVALUATE_CALENDAR_STRING

  Analyzes the scheduling task period.

  The prototype of the **DBE_SCHEDULER.EVALUATE_CALENDAR_STRING** function is as follows:

```
DBE_SCHEDULER.evaluate_calendar_string(
IN calendar_string text,
IN start_date timestamp with time zone,
IN return_date_after timestamp with time zone,
OUT next_run_date timestamp with time zone
)return timestamp with time zone
```

### 13.12.2.12 DBE_APPLICATION_INFO

## Interface Description

**Table 13-195** provides all interfaces supported by the **DBE_APPLICATION_INFO** package. **DBE_APPLICATION_INFO** applies to the current session.

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**Table 13-195** DBE_APPLICATION_INFO

| Interface | Description |
| --- | --- |
| DBE_APPLICATION_INFO.SET_CLIENT_INFO | Writes client information. |
| DBE_APPLICATION_INFO.READ_CLIENT_INFO | Reads client information. |

- DBE_APPLICATION_INFO.SET_CLIENT_INFO

Writes client information. The **DBE_APPLICATION_INFO.SET_CLIENT_INFO** function prototype is as follows:

```
DBE_APPLICATION_INFO.SET_CLIENT_INFO(
   str text
)returns void;
```

**Table 13-196** DBE_APPLICATION_INFO.SET_CLIENT_INFO interface parameters

| Parameter | Description |
| --- | --- |
| str | Writes client information. |

- DBE_APPLICATION_INFO.READ_CLIENT_INFO

The **DBE_APPLICATION_INFO.READ_CLIENT_INFO** function prototype is as follows:

```
DBE_APPLICATION_INFO.READ_CLIENT_INFO(
 OUT client_info text);
```

**Table 13-197** DBE_APPLICATION_INFO.READ_CLIENT_INFO interface parameters

| Parameter | Description |
| --- | --- |
| client_info | Client information |

# 13.13 Retry Management

Retry is a process in which the database executes a SQL statement or stored procedure (including anonymous block) again in the case of execution failure, improving the execution success rate and user experience. The database checks the error code and retry configuration to determine whether to retry.

- If the execution fails, the system rolls back the executed statements and executes the stored procedure again.

  Example:

  ```
  openGauss=# CREATE OR REPLACE PROCEDURE retry_basic ( IN  x INT)
  AS
  ```

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```
BEGIN
    INSERT INTO t1 (a) VALUES (x);
    INSERT INTO t1 (a) VALUES (x+1);
END;
/

openGauss=# CALL retry_basic(1);
```

# 13.14 Debugging

## Syntax

**RAISE** has the following five syntax formats:

**Figure 13-34** raise_format::=

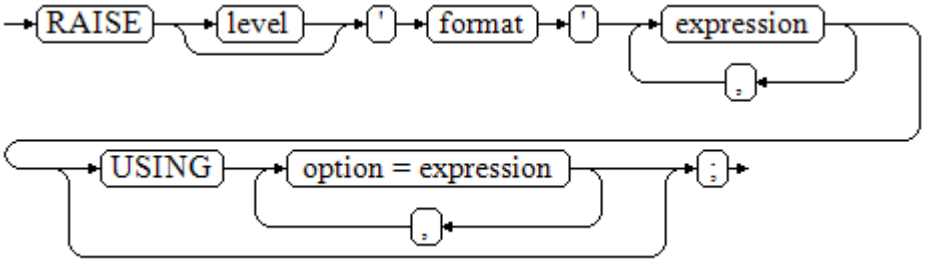


**Figure 13-35** raise_condition::=

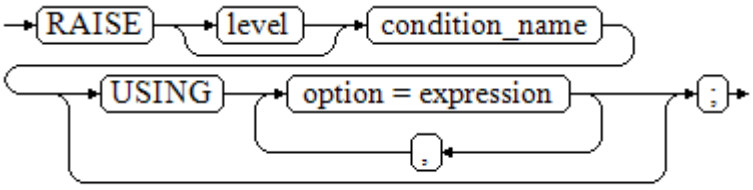


**Figure 13-36** raise_sqlstate::=

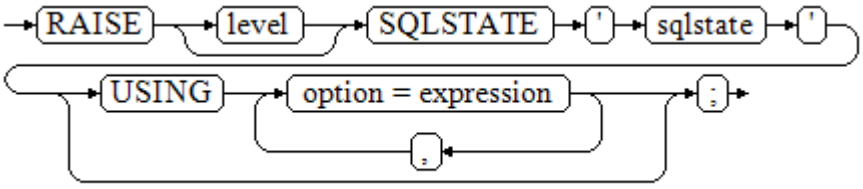


**Figure 13-37** raise_option::=

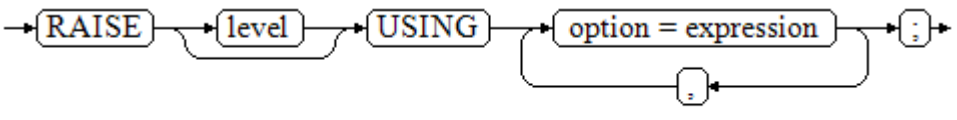


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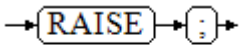
**Figure 13-38** raise::=




Parameter description:

- The level option is used to specify the error level, that is, **DEBUG**, **LOG**, **INFO**, **NOTICE**, **WARNING**, or **EXCEPTION** (default value). **EXCEPTION** throws an error that normally terminates the current transaction and the others only generate information at their levels. The **log_min_messages** and **client_min_messages** parameters control whether the error messages of specific levels are reported to the client and are written to the server log.
- **format**: specifies the error message text to be reported. It is a format string that can be appended with an expression for insertion to the message text. In a format string, **%** is replaced by the parameter value attached to format and **%%** is used to print **%**. For example:

```
--v_job_id replaces % in the string.
RAISE NOTICE 'Calling cs_create_job(%)',v_job_id;
```

- **option = expression**: inserts additional information to an error report. The keyword option can be **MESSAGE**, **DETAIL**, **HINT**, or **ERRCODE**, and each expression can be any string.
  - **MESSAGE**: specifies the error message text. This option cannot be used in a **RAISE** statement that contains a format character string in front of **USING**.
  - **DETAIL**: specifies detailed information of an error.
  - **HINT**: outputs hint information.
  - **ERRCODE**: designates an error code (**SQLSTATE**) to a report. A condition name or a five-character **SQLSTATE** error code can be used.
- **condition_name**: specifies the condition name corresponding to the error code.
- **sqlstate**: specifies the error code.

If neither a condition name nor **SQLSTATE** is specified in a **RAISE EXCEPTION** command, the **RAISE EXCEPTION (P0001)** is used by default. If no message text is designated, the condition name or **SQLSTATE** is used as the message text by default.

**NOTICE**

- If **SQLSTATE** designates an error code, the error code is not limited to a defined error code. It can be any error code containing five digits or ASCII (uppercase) rather than **00000**. Do not use an error code ended with three zeros because error codes of this kind are type codes and can be captured by the whole category.
- In O-compatible mode, SQLCODE is equivalent to SQLSTATE.

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NOTE

The syntax described in **Figure 13-38** does not append any parameter. This form is used only for the **EXCEPTION** statement in a **BEGIN** block so that the error can be re-processed.

## Examples

Display error and hint information when a transaction terminates:

```
CREATE OR REPLACE PROCEDURE proc_raise1(user_id in integer)
AS
BEGIN
RAISE EXCEPTION 'Noexistence ID --> %',user_id USING HINT = 'Please check your user ID';
END;
/

call proc_raise1(300011);

-- Execution result
ERROR:  Noexistence ID --> 300011
HINT:  Please check your user ID
```

Two methods are available for setting **SQLSTATE**:

```
CREATE OR REPLACE PROCEDURE proc_raise2(user_id in integer)
AS
BEGIN
RAISE 'Duplicate user ID: %',user_id USING ERRCODE = 'unique_violation';
END;
/

\set VERBOSITY verbose
call proc_raise2(300011);

-- Execution result
ERROR:  Duplicate user ID: 300011
SQLSTATE: 23505
```

If the main parameter is a condition name or **SQLSTATE**, the following applies:

RAISE division_by_zero;

RAISE SQLSTATE '22012';

Example:

```
CREATE OR REPLACE PROCEDURE division(div in integer, dividend in integer)
AS
DECLARE
res int;
    BEGIN
    IF dividend=0 THEN
        RAISE division_by_zero;
        RETURN;
    ELSE
        res := div/dividend;
        RAISE INFO 'division result: %', res;
        RETURN;
    END IF;
    END;
/
call division(3,0);

-- Execution result
ERROR:  division_by_zero
```

Alternatively:

```
RAISE unique_violation USING MESSAGE = 'Duplicate user ID: ' || user_id;
```

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# 14 Autonomous Transaction

An autonomous transaction is an independent transaction that is started during the execution of a primary transaction. Committing and rolling back an autonomous transaction does not affect the data that has been committed by the primary transaction. In addition, an autonomous transaction is not affected by the primary transaction.

Autonomous transactions are defined in stored procedures, functions, and anonymous blocks, and are declared using the **PRAGMA AUTONOMOUS_TRANSACTION** keyword.

## 14.1 Stored Procedure Supporting Autonomous Transaction

An autonomous transaction can be defined in a stored procedure. The identifier of an autonomous transaction is **PRAGMA AUTONOMOUS_TRANSACTION**. The syntax of an autonomous transaction is the same as that of creating a stored procedure. The following is an example.

```
-- Create a table.
create table t2(a int, b int);
insert into t2 values(1,2);
select * from t2;

-- Create a stored procedure that contains an autonomous transaction.
CREATE OR REPLACE PROCEDURE autonomous_4(a int, b int)  AS
DECLARE
    num3 int := a;
    num4 int := b;
    PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
    insert into t2 values(num3, num4);
    dbe_output.print_line('just use call.');
END;
/
-- Create a common stored procedure that invokes an autonomous transaction stored procedure.
CREATE OR REPLACE PROCEDURE autonomous_5(a int, b int)  AS
DECLARE
BEGIN
    dbe_output.print_line('just no use call.');
    insert into t2 values(666, 666);
    autonomous_4(a,b);
    rollback;
END;
```

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```
/
-- Invoke a common stored procedure.
select autonomous_5(11,22);
-- View the table result.
select * from t2 order by a;
```

In the preceding example, a stored procedure containing an autonomous transaction is finally executed in a transaction block to be rolled back, which directly illustrates a characteristic of the autonomous transaction, that is, rollback of the primary transaction does not affect content that has been committed by the autonomous transaction.

# 14.2 Anonymous Block Supporting Autonomous Transaction

An autonomous transaction can be defined in an anonymous block. The identifier of an autonomous transaction is **PRAGMA AUTONOMOUS_TRANSACTION**. The syntax of an autonomous transaction is the same as that of creating an anonymous block. The following is an example.

```
create table t1(a int ,b text);

START TRANSACTION;
DECLARE
   PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
   dbe_output.print_line('just use call.');
   insert into t1 values(1,'you are so cute,will commit!');
END;
/
insert into t1 values(1,'you will rollback!');
rollback;

select * from t1;
```

In the preceding example, an anonymous block containing an autonomous transaction is finally executed before a transaction block to be rolled back, which directly illustrates a characteristic of the autonomous transaction, that is, rollback of the primary transaction does not affect content that has been committed by the autonomous transaction.

# 14.3 Function Supporting Autonomous Transaction

An autonomous transaction can be defined in a function. The identifier of an autonomous transaction is **PRAGMA AUTONOMOUS_TRANSACTION**. The syntax of an autonomous transaction is the same as that of creating a function. The following is an example.

```
create table t4(a int, b int, c text);

CREATE OR REPLACE function autonomous_32(a int ,b int ,c text) RETURN int AS
DECLARE
   PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
   insert into t4 values(a, b, c);
   return 1;
END;
/
CREATE OR REPLACE function autonomous_33(num1 int) RETURN int AS
```

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```
DECLARE
    num3 int := 220;
    tmp int;
    PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
    num3 := num3/num1;
    return num3;
EXCEPTION
    WHEN division_by_zero THEN
        select autonomous_32(num3, num1, sqlerrm) into tmp;
        return 0;
END;
/

select autonomous_33(0);

select * from t4;
```

# 14.4 Restrictions

**CAUTION**

When an autonomous transaction is executed, an autonomous transaction session is started in the background. You can use **max_concurrent_autonomous_transactions** to set the maximum number of concurrent autonomous transactions. The value range is 0 to 1024.

Default value: **10**

When **max_concurrent_autonomous_transactions** is set to **0**, autonomous transactions cannot be executed.

After a new session is started for an autonomous transaction, the default session parameters are used and objects (including session-level variables, local temporary variables, and global temporary table data) of the primary session are not shared.

- A trigger function does not support autonomous transactions.

```
CREATE TABLE test_trigger_des_tbl(id1 INT, id2 INT, id3 INT);

CREATE OR REPLACE FUNCTION tri_insert_func() RETURNS TRIGGER AS
$$
DECLARE
 PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
INSERT INTO test_trigger_des_tbl VALUES(NEW.id1, NEW.id2, NEW.id3);
RETURN NEW;
END
$$ LANGUAGE PLPGSQL;
```

- Autonomous transactions cannot be invoked by non-top-layer anonymous blocks (but can only be invoked by top-layer autonomous transactions, including stored procedures, functions, and anonymous blocks).

```
create table t1(a int ,b text);

DECLARE
 --PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
 DECLARE
  PRAGMA AUTONOMOUS_TRANSACTION;
 BEGIN
  dbe_output.print_line('just use call.');
  insert into t1 values(1,'can you rollback!');
```

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```
 END;
 insert into t1 values(2,'I will rollback!');
 rollback;
END;
/

select * from t1;
```

- Autonomous transactions do not support **ref_cursor** parameter transfer.

```
create table sections(section_ID int);
insert into sections values(1);
insert into sections values(1);
insert into sections values(1);
insert into sections values(1);

CREATE OR REPLACE function proc_sys_ref()
return SYS_REFCURSOR
IS
declare
  PRAGMA AUTONOMOUS_TRANSACTION;
        C1 SYS_REFCURSOR;
BEGIN
 OPEN C1 FOR SELECT section_ID FROM sections ORDER BY section_ID;
 return C1;
END;
/

CREATE OR REPLACE function proc_sys_ref(OUT C2 SYS_REFCURSOR, OUT a int)
return SYS_REFCURSOR
IS
declare
  PRAGMA AUTONOMOUS_TRANSACTION;
        C1 SYS_REFCURSOR;
BEGIN
 OPEN C1 FOR SELECT section_ID FROM sections ORDER BY section_ID;
 return C1;
END;
/
```

- Distributed autonomous transactions of the IMMUTABLE and STABLE types cannot be pushed down.

```
CREATE OR REPLACE procedure autonomous_test_in_p_116(num1 int )
IMMUTABLE
AS
DECLARE
PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
perform pg_sleep(1);
END;
/

CREATE OR REPLACE procedure autonomous_test_in_p_117(num1 int ) STABLE AS
DECLARE
PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
perform pg_sleep(1);
END;
/
```

- The distributed system does not support detection. When a deadlock occurs, a lock waiting timeout error is reported.

```
create table test_lock (id int,a date);
insert into test_lock values (10,sysdate),(11,sysdate),(12,sysdate);
CREATE OR REPLACE FUNCTION autonomous_test_lock(num1 int,num2 int) RETURNS
integer LANGUAGE plpgsql AS $$
DECLARE num3 int := 4;
PRAGMA AUTONOMOUS_TRANSACTION;
BEGIN
update test_lock set a=sysdate where id =11;
RETURN num1+num2+num3;
```

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```
END;
$$;
start transaction;
update test_lock set a=sysdate where id =11;
call autonomous_test_lock(1,1);
END;
```

- Autonomous transaction functions only return records in the out format.
- The isolation level of an autonomous transaction cannot be changed.
- Autonomous transactions do not support the **setof** return type.

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# 15 System Catalogs and System Views

## 15.1 Overview of System Catalogs and System Views

System catalogs store the structured metadata of GaussDB. They are the source of information used by GaussDB to control system running and are a core component of the database system.

System views provide ways to query the system catalogs and internal database status.

System catalogs and views are visible to either system administrators or all users. Some system catalogs and views have marked the need of administrator permissions, so they are accessible only to administrators.

You can delete and re-create system catalogs, add columns to them, and insert and update values in them, but doing so may make system information inconsistent and cause system faults. Generally, users should not modify system catalogs or system views, or rename their schemas. They are automatically maintained by the system.

**NOTICE**

- You are not advised to modify the permissions on system catalogs or system views.
- Do not add, delete, or modify system catalogs because doing so will result in exceptions or even cluster unavailability.
- The **gs_package** system catalog is used only in a centralized system. It can be queried in a distributed system but is meaningless.
- For details about field types in system catalogs and system views, see section **12.3 Data Type**.

## 15.2 System Catalogs

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## 15.2.1 GS_AUDITING_POLICY

**GS_AUDITING_POLICY** records the main information about the unified audit. Each record corresponds to a design policy. Only the system administrator or security policy administrator can access this system catalog.

**Table 15-1** GS_AUDITING_POLICY columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| polname | name | Policy name, which must be unique |
| polcomments | name | Policy description field, which records policy-related description information and is represented by the **COMMENTS** keyword |
| modifydate | timestamp without time zone | The latest timestamp when a policy is created or modified |
| polenabled | boolean | Specifies whether to enable the policy.<br>• **t** (true): enabled.<br>• **f** (false): disabled. |

## 15.2.2 GS_AUDITING_POLICY_ACCESS

**GS_AUDITING_POLICY_ACCESS** records the DML database operations about the unified audit. Only the system administrator or security policy administrator can access this system catalog.

**Table 15-2** GS_AUDITING_POLICY_ACCESS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| accesstype | name | DML database operation type. For example, SELECT, INSERT, and DELETE. |
| labelname | name | Specifies the resource label name. This parameter corresponds to the **polname** column in the system catalog in **15.2.1 GS_AUDITING_POLICY**. |

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| Name | Type | Description |
| --- | --- | --- |
| policyoid | oid | OID of the audit policy, corresponding to the OID in the **GS_AUDITING_POLICY** system catalog. |
| modifydate | timestamp without time zone | Latest creation or modification timestamp. |

## 15.2.3 GS_AUDITING_POLICY_FILTERS

**GS_AUDITING_POLICY_FILTERS** records the filtering policies about the unified audit. Each record corresponds to a design policy. Only the system administrator or security policy administrator can access this system catalog.

**Table 15-3** GS_AUDITING_POLICY_FILTERS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| filtertype | name | Filter type. Currently, the value is **logical_expr**. |
| labelname | name | Name. Currently, the value is **logical_expr**. |
| policyoid | oid | OID of the audit policy, corresponding to the OID in the system catalog in **15.2.1 GS_AUDITING_POLICY**. |
| modifydate | timestamp without time zone | Latest creation or modification timestamp. |
| logicaloperator | text | Logical character string of a filter criterion. |

## 15.2.4 GS_AUDITING_POLICY_PRIVILEGES

**GS_AUDITING_POLICY_PRIVILEGES** records the DDL database operations about the unified audit. Each record corresponds to a design policy. Only the system administrator or security policy administrator can access this system catalog.

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**Table 15-4** GS_AUDITING_POLICY_PRIVI columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| privilegetype | name | DDL database operation type. For example, CREATE, ALTER, and DROP. |
| labelname | name | Specifies the resource label name. This parameter corresponds to the **polname** column in the **GS_AUDITING_POLICY** system catalog. |
| policyoid | oid | This parameter corresponds to OIDs in the **GS_AUDITING_POLICY** system catalog. |
| modifydate | timestamp without time zone | Latest creation or modification timestamp. |

## 15.2.5 GS_ASP

**GS_ASP** displays the persistent ACTIVE SESSION PROFILE samples. This system catalog can be queried only in the system library.

**Table 15-5** GS_ASP columns

| Name | Type | Description |
| --- | --- | --- |
| sampleid | bigint | Sample ID. |
| sample_time | timestamp with time zone | Sampling time. |
| need_flush_sample | boolean | Specifies whether the sample needs to be flushed to disks.<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| databaseid | oid | Database ID. |
| thread_id | bigint | Thread ID. |
| sessionid | bigint | Session ID. |
| start_time | timestamp with time zone | Start time of a session. |
| event | text | Specified event name. |

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| Name | Type | Description |
| --- | --- | --- |
| lwtid | integer | Lightweight thread ID of the current thread. |
| psessionid | bigint | Parent thread of the streaming thread. |
| tlevel | integer | Level of the streaming thread. The value corresponds to the level (ID) of the execution plan. |
| smpid | integer | Concurrent thread ID in SMP execution mode. |
| userid | oid | ID of a session user. |
| application_name | text | Name of the application. |
| client_addr | inet | IP address of a client. |
| client_hostname | text | Name of a client. |
| client_port | integer | TCP port number used by a client to communicate with the backend. |
| query_id | bigint | Debug query ID. |
| unique_query_id | bigint | Unique query ID. |
| user_id | oid | User ID in the key of the unique query. |
| cn_id | integer | A CN ID indicates a CN from which the unique SQL statement is obtained. The **cn_id** is in the key of the unique query. |
| unique_query | text | Standardized UniqueSQL text string. |
| locktag | text | Information of a lock that the session waits for. It can be parsed using **locktag_decode**. |
| lockmode | text | Mode of a lock that the session waits for.<br>• **LW_EXCLUSIVE**: exclusive lock.<br>• **LW_SHARED**: shared lock.<br>• **LW_WAIT_UNTIL_FREE**: waits for the **LW_EXCLUSIVE** to be available. |

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| Name | Type | Description |
| --- | --- | --- |
| block_sessionid | bigint | Blocks a session from obtaining the session ID of a lock if the session is waiting for the lock. |
| wait_status | text | Provides more details about the event column. |
| global_sessionid | text | Global session ID. |
| xact_start_time | timestamp with time zone | Start time of the transaction. |
| query_start_time | timestamp with time zone | Time when the statement starts to be executed. |
| state | text | Current statement state.<br>The value can be **active**, **idle in transaction**, **fastpath function call**, **idle in transaction (aborted)**, **disabled**, or **retrying**. |

## 15.2.6 GS_CLIENT_GLOBAL_KEYS

**GS_CLIENT_GLOBAL_KEYS** records information about the CMK in the encrypted equality feature. Each record corresponds to a CMK.

**Table 15-6** GS_CLIENT_GLOBAL_KEYS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden column) |
| global_key_name | name | CMK name |
| key_namespace | oid | A namespace OID that contains this CMK |
| key_owner | oid | CMK owner |
| key_acl | aclitem[] | Access permissions that this key should have on creation |
| create_date | timestamp without time zone | Time when a key is created |

## 15.2.7 GS_CLIENT_GLOBAL_KEYS_ARGS

**GS_CLIENT_GLOBAL_KEYS_ARGS** records the metadata about the CMK in the encrypted equality feature. Each record corresponds to a key-value pair of the CMK.

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**Table 15-7** GS_CLIENT_GLOBAL_KEYS_ARGS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden column) |
| global_key_id | oid | CMK OID |
| function_name | name | The value is **encryption**. |
| key | name | CMK metadata name |
| value | bytea | Value of the CMK metadata name |

## 15.2.8 GS_COLUMN_KEYS

**GS_COLUMN_KEYS** records information about the CEK in the encrypted equality feature. Each record corresponds to a CEK.

**Table 15-8** GS_COLUMN_KEYS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden column) |
| column_key_name | name | CEK name |
| column_key_distributed_id | oid | ID obtained based on the hash value of the fully qualified domain name (FQDN) of the CEK |
| global_key_id | oid | A foreign key, which is the CMK OID. |
| key_namespace | oid | A namespace OID that contains this CEK |
| key_owner | oid | CEK owner |
| create_date | timestamp with time zone | Time when a CEK is created |
| key_acl | aclitem[] | Access permissions that this CEK should have on creation |

## 15.2.9 GS_COLUMN_KEYS_ARGS

**GS_COLUMN_KEYS_ARGS** records the metadata about the CMK in the encrypted equality feature. Each record corresponds to a key-value pair of the CMK.

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**Table 15-9** GS_COLUMN_KEYS_ARGS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden column) |
| column_key_id | oid | CEK OID |
| function_name | name | The value is **encryption**. |
| key | name | CEK metadata name |
| value | bytea | Value of the CEK metadata name |

## 15.2.10 GS_DB_PRIVILEGE

**GS_DB_PRIVILEGE** records the granting of ANY permissions. Each record corresponds to a piece of authorization information.

**Table 15-10** GS_DB_PRIVILEGE columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| roleid | oid | User ID |
| privilege_type | text | ANY permission of a user. For details about the value, see **Table 12-124**. |
| admin_option | boolean | Whether the ANY permission recorded in the **privilege_type** column can be re-granted<br>• **t**: yes<br>• **f**: no |

## 15.2.11 GS_ENCRYPTED_COLUMNS

**GS_ENCRYPTED_COLUMNS** records information about encrypted columns in the encrypted equality feature. Each record corresponds to an encrypted column.

**Table 15-11** GS_ENCRYPTED_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| rel_id | oid | Table OID |
| column_name | name | Name of an encrypted column. |

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| Name | Type | Description |
| --- | --- | --- |
| column_key_id | oid | A foreign key, which is the CEK OID |
| encryption_type | tinyint | Encryption type. The value can be **2(DETERMINISTIC)** or **1(RANDOMIZED)**. |
| data_type_original_oid | oid | ID of the original data type of the encrypted column. For details about the values, see the oid columns in the **15.2.101 PG_TYPE** system catalog. |
| data_type_original_mod | integer | Modifiers of the original data type of the encrypted column. For details about the values, see the atttypmod columns in the **15.2.41 PG_ATTRIBUTE** system catalog. |
| create_date | timestamp with time zone | Time when an encrypted column is created |

## 15.2.12 GS_ENCRYPTED_PROC

**GS_ENCRYPTED_PROC** provides information such as the parameters of encrypted functions and stored procedure functions, original data type of return values, and encrypted columns.

**Table 15-12** GS_ENCRYPTED_PROC columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden column) |
| func_id | oid | OID of the function, corresponding to the OID row identifier in the **pg_proc** system catalog. |
| prorettype_orig | integer | Original data type of the return value. |
| last_change | timestamp without time zone | Last modification time of the encrypted function |
| proargcachedcol | oidvector | OID of the encrypted column corresponding to the **INPUT** parameter of the function, corresponding to the OID row identifier in the **gs_encrypted_columns** system catalog. |
| proallargtypes_orig | oid[] | Original data type of all function parameters. |

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## 15.2.13 GS_GLOBAL_CHAIN

**GS_GLOBAL_CHAIN** records information about modification operations performed by users on the tamper-proof user table. Each record corresponds to a table-level modification operation. Users with the audit administrator permission can query this system catalog, but no user is allowed to modify this system catalog.

**Table 15-13** GS_GLOBAL_CHAIN columns

| Name | Type | Description |
| --- | --- | --- |
| blocknum | bigint | Block number, which is the sequence number of the current user operation recorded in the ledger. |
| dbname | name | Name of the database to which the modified tamper-proof user table belongs. |
| username | name | Username, which is the name of the user who performs the operation of modifying the user table. |
| starttime | timestamp with time zone | Time when a user performs an operation. |
| relid | oid | OID of the modified tamper-proof user table. |
| relnsp | name | Schema name, which is the name of the schema to which the modified tamper-proof user table belongs. |
| relname | name | User table name, which is the name of the modified tamper-proof user table. |
| relhash | hash16 | Table-level hash change amount generated by operations. |
| globalhash | hash32 | Global digest, which is calculated based on the information of the current row and the **globalhash** of the previous row. It connects the entire table to verify the integrity of **GS_GLOBAL_CHAIN** data. |
| txcommand | text | SQL statement whose operations are recorded. |

## 15.2.14 GS_GLOBAL_CONFIG

**GS_GLOBAL_CONFIG** records the parameter values specified by users during cluster initialization. In addition, it also stores weak passwords set by users. Initial database users can write, modify, and delete parameters in system catalogs by using **ALTER** and **DROP**.

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**Table 15-14** GS_GLOBAL_CONFIG columns

| Name | Type | Description |
| --- | --- | --- |
| name | name | Specifies the preset parameter name, weak password name, or parameter required by users during cluster initialization. |
| value | text | Specifies the preset parameter value, weak password name, or parameter value required by users during cluster initialization. |

## 15.2.15 GS_JOB_ATTRIBUTE

GS_JOB_ATTRIBUTE records attributes of DBE_SCHEDULER scheduled tasks, including basic attributes of scheduled tasks, scheduled task classes, certificates, authorization, programs, and schedules.

**Table 15-15** GS_JOB_ATTRIBUTE columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden column) |
| job_name | text | Names of scheduled tasks, scheduled task classes, certificates, programs, and schedules, and authorized user names. |
| attribute_name | text | Attribute names of scheduled tasks, scheduled task classes, certificates, programs, and schedules, and authorized content. |
| attribute_value | text | Attribute values of scheduled tasks, scheduled task classes, certificates, programs, and schedules. |

## 15.2.16 GS_JOB_ARGUMENT

GS_JOB_ARGUMENT provides the parameter attributes of DBE_SCHEDULER scheduled tasks and programs.

**Table 15-16** GS_JOB_ARGUMENT columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden column) |
| argument_position | integer | Location of a parameter of a scheduled task or program. |

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| Name | Type | Description |
| --- | --- | --- |
| argument_type | name | Parameter type of a scheduled task or program. |
| job_name | text | Name of a scheduled task or program. |
| argument_name | text | Parameter name of a scheduled task or program. The scheduled task inherits the parameter name of the program. Therefore, this parameter is null. |
| argument_value | text | Parameter value of a scheduled task. (The program cannot bind a value.) |
| default_value | text | Default parameter value of a program. |

## 15.2.17 GS_MASKING_POLICY

**GS_MASKING_POLICY** records the main information about dynamic data masking policies. Each record corresponds to a masking policy. Only the system administrator or security policy administrator can access this system catalog.

**Table 15-17** GS_MASKING_POLICY columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| polname | name | Policy name, which must be unique. |
| polcomments | name | Policy description field, which records policy-related description information and is represented by the **COMMENTS** keyword |
| modifydate | timestamp without time zone | Latest timestamp when a policy is created or modified. |
| polenabled | boolean | Specifies whether to enable the policy.<br>• **t** (true): enabled<br>• **f** (false): disabled |

## 15.2.18 GS_MASKING_POLICY_ACTIONS

**GS_MASKING_POLICY_ACTIONS** records the masking actions of a masking policy in the dynamic data masking policies. One masking policy corresponds to one or

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more rows of records in the catalog. Only the system administrator or security policy administrator can access this system catalog.

**Table 15-18** GS_MASKING_POLICY_ACTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| actiontype | name | Name of a masking function used by a masking policy |
| actparams | name | Parameter information transferred to a masking function |
| actlabelname | name | Name of a masked label |
| policyoid | oid | OID of a masking policy to which a record belongs, corresponding to the OID in **15.2.17 GS_MASKING_POLICY**. |
| actmodifydate | timestamp without time zone | Latest timestamp when a record is created or modified |

## 15.2.19 GS_MASKING_POLICY_FILTERS

**GS_MASKING_POLICY_FILTERS** records the user filtering criteria corresponding to the dynamic data masking policies. The corresponding masking policy takes effect only when the user information meets the filter criteria. Only the system administrator or security policy administrator can access this system catalog.

**Table 15-19** GS_MASKING_POLICY_FILTERS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| filtertype | name | Filter type. Currently, the value is **logical_expr**. |
| filterlabelname | name | Filtering range. Currently, the value is **logical_expr**. |
| policyoid | oid | OID of a masking policy to which a record belongs, corresponding to the OID in **15.2.17 GS_MASKING_POLICY**. |
| modifydate | timestamp without time zone | Latest timestamp when a user filter criterion is created or modified. |

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| Name | Type | Description |
| --- | --- | --- |
| logicaloperator | text | Polish notation of the filter criteria. |

## 15.2.20 GS_MATVIEW

**GS_MATVIEW** provides information about each materialized view in the database.

**Table 15-20** GS_MATVIEW columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| matviewid | oid | OID of a materialized view. |
| mapid | oid | OID of a map table associated with a materialized view. Each map table corresponds to one materialized view. If a full materialized view does not correspond to a map table, the value of this column is **0**. |
| ivm | boolean | Type of a materialized view. The value **t** indicates an incremental materialized view, and the value **f** indicates a full materialized view. |
| needrefresh | boolean | Reserved column. |
| refreshtime | timestamp | Last time when a materialized view was refreshed. If the materialized view is not refreshed, the value is null. This column is maintained only for incremental materialized views on DNs. In other cases, the value is null. |

## 15.2.21 GS_MATVIEW_DEPENDENCY

**GS_MATVIEW_DEPENDENCY** provides association information about each incremental materialized view, base table, and Mlog table in the database. The Mlog table corresponding to the base table does not exist in the full materialized view. Therefore, no record is written into the Mlog table.

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**Table 15-21** GS_MATVIEW_DEPENDENCY columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| matviewid | oid | OID of a materialized view. |
| relid | oid | OID of a base table of a materialized view. |
| mlogid | oid | OID of a Mlog table which is the log table of a materialized view. Each Mlog table corresponds to one base table. |
| mxmin | int4 | Reserved column. |

## 15.2.22 GS_MODEL_WAREHOUSE

**GS_MODEL_WAREHOUSE** stores AI engine training models, including the models and detailed description of the training process.

**Table 15-22** GS_MODEL_WAREHOUSE columns

| Name | Data Type | Description |
| --- | --- | --- |
| oid | oid | Hidden column |
| modelname | name | Unique constraint |
| modelowner | oid | OID of a model owner |
| createtime | timestamp without time zone | Time when a model is created |
| processedtuples | integer | Number of tuples involved in training |
| discardedtuples | integer | Number of unqualified tuples not involved in training |
| preprocesstime | real | Data preprocessing time |
| exectime | real | Training duration |
| iterations | integer | Iteration round |
| outputtype | oid | OID of the output data type |
| modeltype | text | AI operator type |

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| Name | Data Type | Description |
| --- | --- | --- |
| query | text | Query statement executed to create a model |
| modeldata | bytea | Stored binary model information |
| weight | real[] | Currently, this column applies only to GD operator models. |
| hyperparametersnames | text[] | Involved hyperparameter name |
| hyperparametersvalues | text[] | Hyperparameter value |
| hyperparametersoids | oid[] | OID of the data type corresponding to a hyperparameter |
| coefnames | text[] | Model parameter |
| coefvalues | text[] | Value of a model parameter |
| coefoids | oid[] | OID of the data type corresponding to a model parameter |
| trainingscoresname | text[] | Method used to measure model performance |
| trainingscoresvalue | real[] | Value used to measure model performance |
| modeldescribe | text[] | Model description |

## 15.2.23 GS_OBSSCANINFO

**GS_OBSSCANINFO** defines OBS runtime information scanned in cluster acceleration scenarios. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) Each record corresponds to a piece of runtime information of a foreign table on OBS in a query. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 15-23** GS_OBSSCANINFO columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| query_id | bigint | - | Query ID |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| user_id | text | - | Database user who performs the query |
| table_name | text | - | Name of a foreign table on OBS |
| file_type | text | - | Format of the file that stores underlying data |
| time_stamp | timestamp with time zone | - | Scanning start time |
| actual_time | double precision | - | Scanning execution time, in seconds |
| file_scanned | bigint | - | Number of files scanned |
| data_size | double precision | - | Size of data scanned, in bytes |
| billing_info | text | - | Reserved |

## 15.2.24 GS_OPT_MODEL

**GS_OPT_MODEL** is a data table used when the AI engine is enabled to predict the planned time. It records the configurations, training results, features, corresponding system functions, and training history of machine learning models.

NOTE

In the distributed scenario, this system catalog is provided, but the AI capabilities are unavailable.

## 15.2.25 GS_POLICY_LABEL

**GS_POLICY_LABEL** records the resource label configuration information. One resource label corresponds to one or more records, and each record identifies the resource label to which a database resource belongs. Only the system administrator or security policy administrator can access this system catalog.

Fully Qualified Domain Name (FQDN) identifies an absolute path of a database resource.

**Table 15-24** GS_POLICY_LABEL columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| labelname | name | Specifies the resource label name. |

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| Name | Type | Description |
| --- | --- | --- |
| labeltype | name | Resource tag type. Currently, the value is **RESOURCE**. |
| fqdnnamespace | oid | OID of a namespace to which an identified database resource belongs. |
| fqdnid | oid | OID of an identified database resource. If the database resource is a column, this column is the OID of the catalog. |
| relcolumn | name | Column name. If the identified database resource is a column, this column indicates the column name. Otherwise, this column is empty. |
| fqdntype | name | Type of the identified database resource, for example, schema, table, column, or view. |

## 15.2.26 GS_RECYCLEBIN

**GS_RECYCLEBIN** records details about objects in the recycle bin of the flashback feature. Currently, the distributed system does not support the flashback feature.

## 15.2.27 GS_SQL_PATCH

**GS_SQL_PATCH** stores the status information about all SQL_PATCH statements. Currently, this function is not supported in distributed mode.

**Table 15-25** GS_SQL_PATCH columns

| Name | Type | Description |
| --- | --- | --- |
| patch_name | name | Patch name. |
| unique_sql_id | bigint | Queries the global unique ID. |
| owner | oid | ID of the user who creates the patch. |
| enable | bool | Determines whether the patch takes effect. |
| status | "char" | Patch status (reserved field). |
| abort | bool | Determines whether the value is **AbortHint**. |
| hint_string | text | Hint text. |
| hint_node | pg_node_tree | Hint parsing and serialization result. |

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| Name | Type | Description |
| --- | --- | --- |
| original_query | text | Original statement (reserved field). |
| patched_query | text | Patched statement (reserved column). |
| original_query_tree | pg_node_tree | Original statement parsing result (reserved column). |
| patched_query_tree | pg_node_tree | Patched statement parsing result (reserved column). |
| description | text | Patch description. |

## 15.2.28 GS_TXN_SNAPSHOT

**GS_TXN_SNAPSHOT** is a timestamp-CSN mapping table. It periodically samples and maintains an appropriate time range to estimate the CSN corresponding to the timestamp in the range. Currently, the distributed system does not support the flashback feature.

## 15.2.29 GS_UID

**GS_UID** records the unique identification meta information of the **hasuids** attribute table in the database.

**Table 15-26** GS_UID columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of a table |
| uid_backup | bigint | Largest unique identifier that can be assigned to a table |

## 15.2.30 GS_WLM_EC_OPERATOR_INFO

**GS_WLM_EC_OPERATOR_INFO** records operator information after an Extension Connector job ends. If the GUC parameter **enable_resource_record** is set to **on**, the system imports records from **15.3.78 GS_WLM_EC_OPERATOR_HISTORY** to this system catalog every 3 minutes. This operation occupies storage space and affects performance. Only users with the sysadmin permission can query this system catalog. The current feature is a lab feature. Contact Huawei technical support before using it.

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**Table 15-27** GS_WLM_EC_OPERATOR_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for Extension Connector statement execution |
| plan_node_id | integer | Plan node ID of the execution plan of an Extension Connector operator |
| start_time | timestamp with time zone | Time when the Extension Connector operator starts to process the first data record |
| duration | bigint | Total execution time of the Extension Connector operator, in ms |
| tuple_processed | bigint | Number of elements returned by the Extension Connector operator |
| min_peak_memory | integer | Minimum peak memory used by the Extension Connector operator on all DNs, in MB |
| max_peak_memory | integer | Maximum peak memory used by the Extension Connector operator on all DNs, in MB |
| average_peak_memory | integer | Average peak memory used by the Extension Connector operator on all DNs, in MB |
| ec_status | text | Status of the Extension Connector job |
| ec_execute_datanode | text | Name of the DN executing the Extension Connector job |
| ec_dsn | text | DSN used by the Extension Connector job |
| ec_username | text | Username used by the Extension Connector job to access the remote cluster. This parameter is null if the remote cluster type is SPARK. |
| ec_query | text | Statement sent by the Extension Connector job to a remote cluster |
| ec_libodbc_type | text | Type of the unixODBC driver used by the Extension Connector job |

## 15.2.31 GS_WLM_INSTANCE_HISTORY

**GS_WLM_INSTANCE_HISTORY** stores information about resource usage related to CNs or DNs. Each record in this system catalog indicates resource usage of an instance at a specific time point, including the memory, number of CPU cores, disk I/O, physical I/O of the process, and logical I/O of the process. This system catalog can be queried by users with the **sysadmin** permission only in Postgres.

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**Table 15-28** GS_WLM_INSTANCE_HISTORY columns

| Name | Type | Description |
| --- | --- | --- |
| instancename | text | Instance name |
| timestamp | timestamp with time zone | Timestamp |
| used_cpu | integer | CPU usage of the instance |
| free_mem | integer | Unused memory of the instance, in MB |
| used_mem | integer | Used memory of the instance, in MB |
| io_await | real | Average wait time for an I/O operation on the disk used by the instance. The average value is within 10 seconds. |
| io_util | real | io_util value of the disk used by the instance. The average value is within 10 seconds. |
| disk_read | real | Disk read rate of the instance, in KB/s. The average value is within 10 seconds. |
| disk_write | real | Disk write rate of the instance, in KB/s. The average value is within 10 seconds. |
| process_read | bigint | Read rate (excluding the number of bytes read from the disk pagecache) of the corresponding instance process that reads data from a disk within 10 seconds, in KB/s |
| process_write | bigint | Write rate (excluding the number of bytes written to the disk pagecache) of the corresponding instance process that writes data to a disk within 10 seconds, in KB/s |
| logical_read | bigint | CN: N/A<br>DN: logical read byte rate of the instance within the statistical interval (10 seconds), in KB/s |
| logical_write | bigint | CN: N/A<br>DN: logical write byte rate of the instance within the statistical interval (10 seconds), in KB/s |
| read_counts | bigint | CN: N/A<br>DN: total number of logical read operations of the instance within the statistical interval (10 seconds) |

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| Name | Type | Description |
| --- | --- | --- |
| write_counts | bigint | CN: N/A<br>DN: total number of logical write operations of the instance within the statistical interval (10 seconds) |

## 15.2.32 GS_WLM_OPERATOR_INFO

**GS_WLM_OPERATOR_INFO** displays records about operators of completed jobs. The data is dumped from the kernel to the system catalog. If **enable_resource_record** is set to **on**, the system imports records from **15.3.83 GS_WLM_SESSION_HISTORY** to this system catalog every 3 minutes. You are not advised to enable this function, because it occupies storage space and affects performance. This system catalog can be queried by users with the **sysadmin** permission only in Postgres.

**Table 15-29** GS_WLM_OPERATOR_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for statement execution |
| pid | bigint | Backend thread ID |
| plan_node_id | integer | Plan node ID of the execution plan of a query |
| plan_node_name | text | Name of the operator corresponding to the plan node ID |
| start_time | timestamp with time zone | Time when an operator starts to process the first data record |
| duration | bigint | Total execution time of the operator, in ms |
| query_dop | integer | DOP of the operator |
| estimated_rows | bigint | Number of rows estimated by the optimizer |
| tuple_processed | bigint | Number of elements returned by the operator |
| min_peak_memory | integer | Minimum peak memory used by the operator on all DNs, in MB |
| max_peak_memory | integer | Maximum peak memory used by the operator on all DNs, in MB |
| average_peak_memory | integer | Average peak memory used by the operator on all DNs, in MB |
| memory_skew_percent | integer | Memory usage skew of the operator among DNs |

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| Name | Type | Description |
| --- | --- | --- |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_cpu_time | bigint | Minimum execution time of the operator on all DNs, in ms |
| max_cpu_time | bigint | Maximum execution time of the operator on all DNs, in ms |
| total_cpu_time | bigint | Total execution time of the operator on all DNs, in ms |
| cpu_skew_percent | integer | Skew of the execution time among DNs |
| warning | text | The following warnings are displayed:<br>• Sort/SetOp/HashAgg/HashJoin spill<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |

## 15.2.33 GS_WLM_SESSION_QUERY_INFO_ALL

**GS_WLM_SESSION_QUERY_INFO_ALL** records load management information about a completed job executed on the current CN. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Data is dumped from the kernel to this system catalog. If the GUC parameter **enable_resource_record** is set to **on**, query information in the kernel is imported to the system catalog **GS_WLM_SESSION_QUERY_INFO_ALL** every 3 minutes. This system catalog can be queried by users with the **sysadmin** permission only in Postgres.

NOTE

If no data is displayed in the queried view, contact Huawei technical support.

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**Table 15-30** GS_WLM_SESSION_QUERY_INFO_ALL columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the backend is connected to |
| dbname | text | Name of the database that the backend is connected to |
| schemaname | text | Schema name |
| nodename | text | Name of the CN where the statement is executed |
| username | text | Username used for connecting to the backend |
| application_name | text | Name of the application connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is **NULL**, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as **AUTOVACUUM**. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with this backend (**-1** if a Unix socket is used) |
| query_band | text | Job type, which is specified by the GUC parameter **query_band**. The default value is a null string. |
| block_time | bigint | Duration that the statement is blocked before being executed, including the statement parsing and optimization duration (unit: ms) |
| start_time | timestamp with time zone | Time when the statement starts to be executed |
| finish_time | timestamp with time zone | Time when the statement execution ends |
| duration | bigint | Execution time of the statement, in ms |
| estimate_total_time | bigint | Estimated execution time of the statement, in ms |

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| Name | Type | Description |
| --- | --- | --- |
| status | text | Final statement execution status, which can be **finished** (normal) or **aborted** (abnormal) |
| abort_info | text | Exception information displayed if the final statement execution status is **aborted** |
| resource_pool | text | Resource pool used by the user |
| control_group | text | Cgroup used by the statement |
| estimate_memory | integer | Estimated memory size of the statement |
| min_peak_memory | integer | Minimum peak memory of the statement across all DNs, in MB |
| max_peak_memory | integer | Maximum peak memory of the statement across all DNs, in MB |
| average_peak_memory | integer | Average memory usage during statement execution, in MB |
| memory_skew_percent | integer | Memory usage skew of the statement among each DN |
| spill_info | text | Statement spill information on all DNs:<br>● **None**: No data is spilled to disks.<br>● **All**: Data is spilled to disks on all DNs.<br>● **[*a*:*b*]**: The statement has been spilled to disks on *a* of *b* DNs. |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_dn_time | bigint | Minimum execution time of the statement across all DNs, in ms |
| max_dn_time | bigint | Maximum execution time of the statement across all DNs, in ms |
| average_dn_time | bigint | Average execution time of the statement across all DNs, in ms |
| dntime_skew_percent | integer | Execution time skew of the statement among each DN |

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| Name | Type | Description |
| --- | --- | --- |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs, in ms |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs, in ms |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs, in ms |
| cpu_skew_percent | integer | CPU time skew of the statement among DNs |
| min_peak_iops | integer | Minimum IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| max_peak_iops | integer | Maximum IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| average_peak_iops | integer | Average IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| iops_skew_percent | integer | I/O skew of the statement among DNs |
| warning | text | Warning. The following warnings and warnings related to **10.3.6.1 Optimizing SQL Self-Diagnosis** are displayed:<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |
| queryid | bigint | Internal query ID used for statement execution |
| query | text | Statement executed |
| query_plan | text | Execution plan of the statement |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

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| Name | Type | Description |
| --- | --- | --- |
| cpu_top1_node_name | text | Name of the node with the highest CPU usage |
| cpu_top2_node_name | text | Name of the node with the second highest CPU usage |
| cpu_top3_node_name | text | Name of the node with the third highest CPU usage. |
| cpu_top4_node_name | text | Name of the node with the fourth highest CPU usage. |
| cpu_top5_node_name | text | Name of the node with the fifth highest CPU usage. |
| mem_top1_node_name | text | Name of the node with the highest memory usage |
| mem_top2_node_name | text | Name of the node with the second highest memory usage |
| mem_top3_node_name | text | Name of the node with the third highest memory usage |
| mem_top4_node_name | text | Name of the node with the fourth highest memory usage |
| mem_top5_node_name | text | Name of the node with the fifth highest memory usage. |
| cpu_top1_value | bigint | CPU usage |
| cpu_top2_value | bigint | CPU usage |
| cpu_top3_value | bigint | CPU usage |
| cpu_top4_value | bigint | CPU usage |
| cpu_top5_value | bigint | CPU usage |
| mem_top1_value | bigint | Memory usage |
| mem_top2_value | bigint | Memory usage |
| mem_top3_value | bigint | Memory usage |
| mem_top4_value | bigint | Memory usage |
| mem_top5_value | bigint | Memory usage |
| top_mem_dn | text | Top *N* memory usage |

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| Name | Type | Description |
| --- | --- | --- |
| top_cpu_dn | text | Top *N* CPU usage |
| n_returned_rows | bigint | Number of rows in the result set returned by the **SELECT** statement |
| n_tuples_fetched | bigint | Number of rows randomly scanned |
| n_tuples_returned | bigint | Number of rows sequentially scanned |
| n_tuples_inserted | bigint | Number of rows inserted |
| n_tuples_updated | bigint | Number of rows updated |
| n_tuples_deleted | bigint | Number of rows deleted |
| n_blocks_fetched | bigint | Number of cache loading times |
| n_blocks_hit | bigint | Cache hits |
| db_time | bigint | Valid DB time, which is accumulated if multiple threads are involved (unit: μs) |
| cpu_time | bigint | CPU time (unit: μs) |
| execution_time | bigint | Execution time in the executor (unit: μs) |
| parse_time | bigint | SQL parsing time (unit: μs) |
| plan_time | bigint | SQL plan generation time (unit: μs) |
| rewrite_time | bigint | SQL rewriting time (unit: μs) |
| pl_execution_time | bigint | Execution time of PL/pgSQL (unit: μs) |
| pl_compilation_time | bigint | Compilation time of PL/pgSQL (unit: μs) |
| net_send_time | bigint | Network time (unit: μs) |
| data_io_time | bigint | I/O time (unit: μs) |
| is_slow_query | bigint | Specifies whether the query is a slow query.<br>The value **1** indicates a slow query. |

## 15.2.34 GS_WLM_USER_RESOURCE_HISTORY

**GS_WLM_USER_RESOURCE_HISTORY** stores information about resources used by users and is valid only on CNs. Each record in this table indicates resource usage of

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a user at a time point, including the memory, number of CPU cores, storage space, temporary space, operator flushing space, logical I/O traffic, number of logical I/O operations, and logical I/O rate. The memory, CPU, and I/O monitoring items record only resource usage of complex jobs. For I/O monitoring items, this parameter is valid only when **enable_logical_io_statistics** is set to **on**. The function of saving user monitoring data is enabled only when **enable_user_metric_persistent** is set to **on**. Data in the system catalog **GS_WLM_USER_RESOURCE_HISTORY** comes from the **PG_TOTAL_USER_RESOURCE_INFO** view. This system catalog can be queried by users with the **sysadmin** permission only in Postgres.

**Table 15-31** GS_WLM_USER_RESOURCE_HISTORY

| Name | Type | Description |
| --- | --- | --- |
| username | text | Username |
| timestamp | timestamp with time zone | Timestamp |
| used_memory | integer | Used memory, in MB |
| total_memory | integer | Available memory, in MB. The value **0** indicates that the available memory is not limited and depends on the maximum memory available in the database. |
| used_cpu | real | Number of CPU cores in use |
| total_cpu | integer | Total number of CPU cores of the Cgroup associated with the user on the node |
| used_space | bigint | Used storage space, in KB |
| total_space | bigint | Available storage space, in KB. The value **-1** indicates that the storage space is not limited. |
| used_temp_space | bigint | Used temporary storage space, in KB |
| total_temp_space | bigint | Available temporary storage space, in KB. The value **-1** indicates that the maximum temporary storage space is not limited. |
| used_spill_space | bigint | Used space of operator flushing, in KB |
| total_spill_space | bigint | Available storage space for operator flushing, in KB. The value **-1** indicates that the maximum operator flushing space is not limited. |
| read_kbytes | bigint | Byte traffic of read operations in a monitoring period, in KB |

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| Name | Type | Description |
| --- | --- | --- |
| write_kbytes | bigint | Byte traffic of write operations in a monitoring period, in KB |
| read_counts | bigint | Number of read operations in a monitoring period |
| write_counts | bigint | Number of write operations in a monitoring period |
| read_speed | real | Byte rate of read operations in a monitoring period, in KB |
| write_speed | real | Byte rate of write operations in a monitoring period, in KB |

## 15.2.35 PG_AGGREGATE

PG_AGGREGATE records information about aggregate functions. Each entry in **PG_AGGREGATE** is an extension of an entry in **PG_PROC**. The **PG_PROC** entry carries the aggregate's name, input and output data types, and other information that is similar to ordinary functions.

**Table 15-32** PG_AGGREGATE columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| aggfnoid | regproc | 15.2.78 PG_PROC.proname | 15.2.78 PG_PROC proname of the aggregate function |
| aggtransfn | regproc | 15.2.78 PG_PROC.proname | Transition function |
| aggcollectfn | regproc | 15.2.78 PG_PROC.proname | Collect function |
| aggfinalfn | regproc | 15.2.78 PG_PROC.proname | Final function (**0** if none) |
| aggsortop | oid | 15.2.74 PG_OPERATOR.oid | Associated sort operator (**0** if none) |
| aggtranstype | oid | 15.2.101 PG_TYPE.oid | Data type of the aggregate function's internal transition (state) data<br>The possible values and their meanings are defined by the types in **pg_type.h**. The main two types are polymorphic (isPolymorphicType) and non-polymorphic. |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| agginitval | text | - | Initial value of the transition state. This is a text column containing the initial value in its external string representation. If this column is null, the transition state value starts from null. |
| agginitcollect | text | - | Initial value of the collection state. This is a text column containing the initial value in its external string representation. If this column is null, the collection state value starts from null. |
| aggkind | "char" | - | Type of the aggregate function:<br>• **n**: normal aggregate<br>• **o**: ordered set aggregate |
| aggnumdirectargs | smallint | - | Number of direct parameters (non-aggregation-related parameters) of the aggregate function of the ordered set aggregate type. For an aggregate function of the normal aggregate type, the value is **0**. |

## 15.2.36 PG_AM

**PG_AM** records information about index access methods. There is one row for each index access method supported by the system.

**Table 15-33** PG_AM columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| amname | name | - | Name of the access method |
| amstrategies | smallint | - | Number of operator strategies for the access method (**0** if the access method does not have a fixed set of operator strategies) |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| amsupport | smallint | - | Number of support routines for the access method |
| amcanorder | boolean | - | Whether the access method supports ordered scans sorted by the indexed column's value<br>• **t (true)**: supported.<br>• **f (false)**: not supported. |
| amcanorderbyop | boolean | - | Whether the access method supports ordered scans sorted by the result of an operator on the indexed column<br>**t (true)**: supported.<br>**f (false)**: not supported. |
| amcanbackward | boolean | - | Whether the access method supports backward scanning<br>• **t (true)**: supported.<br>• **f (false)**: not supported. |
| amcanunique | boolean | - | Whether the access method supports unique indexes<br>• **t (true)**: supported.<br>• **f (false)**: not supported. |
| amcanmulticol | boolean | - | Whether the access method supports multi-column indexes<br>• **t (true)**: supported.<br>• **f (false)**: not supported. |
| amoptionalkey | boolean | - | Whether the access method supports scanning without any constraint for the first index column<br>• **t (true)**: supported.<br>• **f (false)**: not supported. |
| amsearcharray | boolean | - | Whether the access method supports **ScalarArrayOpExpr** searches<br>**t (true)**: supported.<br>**f (false)**: not supported. |
| amsearchnulls | boolean | - | Whether the access method supports **IS NULL/NOT NULL** searches<br>• **t (true)**: supported.<br>• **f (false)**: not supported. |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| amstorage | boolean | - | Whether the index storage data type can differ from the column data type<br>• **t (true)**: same.<br>• **f (false)**: different. |
| amclusterable | boolean | - | Whether an index of this type can be clustered on<br>• **t (true)**: allowed.<br>• **f (false)**: not allowed. |
| ampredlocks | boolean | - | Whether an index of this type manages fine-grained predicate locks<br>• **t (true)**: allowed.<br>• **f (false)**: not allowed. |
| amkeytype | oid | OID in **15.2.101 PG_TYPE** | Type of data stored in index (**0** if it is not a fixed type) |
| aminsert | regproc | **proname** in **15.2.78 PG_PROC** | "Insert this tuple" function |
| ambeginscan | regproc | **proname** in **15.2.78 PG_PROC** | "Prepare for index scan" function |
| amgettuple | regproc | **proname** in **15.2.78 PG_PROC** | "Next valid tuple" function (**0** if none) |
| amgetbitmap | regproc | **proname** in **15.2.78 PG_PROC** | "Fetch all valid tuples" function (**0** if none) |
| amrescan | regproc | **proname** in **15.2.78 PG_PROC** | "(Re)start index scan" function |
| amendscan | regproc | **proname** in **15.2.78 PG_PROC** | "Clean up after index scan" function |
| ammarkpos | regproc | **proname** in **15.2.78 PG_PROC** | "Mark current scan position" function |
| amrestrpos | regproc | **proname** in **15.2.78 PG_PROC** | "Restore marked scan position" function |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| ammerge | regproc | **proname** in **15.2.78 PG_PROC** | "Merge multiple indexes" function |
| ambuild | regproc | **proname** in **15.2.78 PG_PROC** | "Build new index" function |
| ambuildempty | regproc | **proname** in **15.2.78 PG_PROC** | "Build empty index" function |
| ambulkdelete | regproc | **proname** in **15.2.78 PG_PROC** | Bulk-delete function |
| amvacuumcleanup | regproc | **proname** in **15.2.78 PG_PROC** | Post-**VACUUM** cleanup function |
| amcanreturn | regproc | **proname** in **15.2.78 PG_PROC** | Function to check whether the index supports index-only scans (**0** if none) |
| amcostestimate | regproc | **proname** in **15.2.78 PG_PROC** | Function to estimate cost of an index scan |
| amoptions | regproc | **proname** in **15.2.78 PG_PROC** | Function to parse and validate **reloptions** for an index |

## 15.2.37 PG_AMOP

**PG_AMOP** records information about operators associated with access method operator families. There is one row for each operator that is a member of an operator family. A family member can be either a search operator or an ordering operator. An operator can appear in more than one family, but cannot appear in more than one search position nor more than one ordering position within a family.

**Table 15-34** PG_AMOP columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| amopfamily | oid | **15.2.75 PG_OPFAMILY**.oid | Operator family of this entry |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| amoplefttype | oid | 15.2.101 PG_TYPE.oid | Left-hand input data type of the operator For details about the possible values and their description, see **pg_type.h**. |
| amoprighttype | oid | 15.2.101 PG_TYPE.oid | Right-hand input data type of the operator For details about the possible values and their description, see **pg_type.h**. |
| amopstrategy | smallint | - | Number of operator strategies |
| amoppurpose | "char" | - | Operator purpose, either **s** for search or **o** for ordering |
| amopopr | oid | 15.2.74 PG_OPERATOR.oid | OID of the operator |
| amopmethod | oid | 15.2.36 PG_AM.oid | Operator family of the index access method |
| amopsortfamily | oid | 15.2.75 PG_OPFAMILY.oid | The B-tree operator family according to which this entry sorts for an ordering operator (**0** for a search operator) |

A search operator entry indicates that an index of this operator family can be searched to find all rows satisfying **WHERE indexed_column operator constant**. Obviously, such an operator must return a Boolean value, and its left-hand input type must match the index's column data type.

An ordering operator entry indicates that an index of this operator family can be scanned to return rows in the order represented by **ORDER BY indexed_column operator constant**. Such an operator could return any sortable data type, though again its left-hand input type must match the index's column data type. The exact semantics of **ORDER BY** are specified by the **amopsortfamily** column, which must reference the B-tree operator family for the operator's result type.

## 15.2.38 PG_AMPROC

**PG_AMPROC** records information about the support procedures associated with the access method operator families. There is one row for each support procedure that belongs to an operator family.

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**Table 15-35** PG_AMPROC columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| amprocfamily | oid | 15.2.75 PG_OPFAMILY.oid | Operator family of this entry |
| amproclefttype | oid | 15.2.101 PG_TYPE.oid | Left-hand input data type of the associated operator<br>For details about common data types, see 12.3 Data Type. |
| amprocrighttype | oid | 15.2.101 PG_TYPE.oid | Right-hand input data type of the associated operator<br>For details about common data types, see 12.3 Data Type. |
| amprocnum | smallint | - | Support procedure number |
| amproc | regproc | 15.2.78 PG_PROC .proname | OID of the procedure |

The usual interpretation of the **amproclefttype** and **amprocrighttype** columns is that they identify the left and right input types of the operator(s) that a particular support procedure supports. For some access methods, these match the input data type(s) of the support procedure itself; for others not. There is a notion of "default" support procedures for an index, which are those with **amproclefttype** and **amprocrighttype** both equal to the index opclass's **opcintype**.

## 15.2.39 PG_APP_WORKLOADGROUP_MAPPING

**PG_APP_WORKLOADGROUP_MAPPING** provides load mapping group information in the database.

**Table 15-36** PG_APP_WORKLOADGROUP_MAPPING columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| appname | name | Application name |
| workload_gpname | name | Mapped workload group name |

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## 15.2.40 PG_ATTRDEF

**PG_ATTRDEF** records default values of columns.

**Table 15-37** PG_ATTRDEF columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| adrelid | oid | Table to which a column belongs |
| adnum | smallint | Number of columns |
| adbin | pg_node_tree | Internal representation of the default value of the column |
| adsrc | text | Internal representation of the human-readable default value |
| adgencol | "char" | Specifies whether a column is a generated column. The value **s** indicates that the column is a generated column, and the value **'\0** indicates that the column is a common column. The default value is **'\0**. |

## 15.2.41 PG_ATTRIBUTE

**PG_ATTRIBUTE** records information about table columns.

**Table 15-38** PG_ATTRIBUTE columns

| Name | Type | Description |
| --- | --- | --- |
| attrelid | oid | Table to which a column belongs |
| attname | name | Column name |
| atttypid | oid | Column type |

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| Name | Type | Description |
| --- | --- | --- |
| attstattarget | integer | Level of details of statistics collected for this column by **ANALYZE**.<br>• The value **0** indicates that no statistics should be collected.<br>• A negative value indicates that the system default statistic object is used.<br>• The exact meaning of positive values is data type-dependent.<br>For scalar data types, **attstattarget** is both the target number of "most common values" to collect, and the target number of histogram bins to create. |
| attlen | smallint | Copy of **typlen** in **PG_TYPE** of the column's type |
| attnum | smallint | Number of the column |
| attndims | integer | Number of dimensions if the column is an array (**0** in other cases) |
| attcacheoff | integer | This column is always **-1** on disk. When it is loaded into a row descriptor in the memory, it may be updated to cache the offset of the columns in the row. |
| atttypmod | integer | Type-specific data supplied at the table creation time (for example, the maximum length of a **varchar** column). This column is used as the third parameter when passing to type-specific input functions and length coercion functions. The value will generally be **-1** for types that do not need ATTTYPMOD. |
| attbyval | boolean | Copy of **typbyval** in **PG_TYPE** of this column's type |
| attstorage | "char" | Copy of **typstorage** in **PG_TYPE** of this column's type |
| attalign | "char" | Copy of **typalign** in **PG_TYPE** of this column's type |
| attnotnull | boolean | A non-null constraint. It is possible to change this column to enable or disable the constraint. |
| atthasdef | boolean | This column has a default value, in which case there will be a corresponding entry in the **PG_ATTRDEF** table that actually defines the value. |
| attisdropped | boolean | Indicates that this column has been deleted and is no longer valid. A deleted column is still physically present in the table but is ignored by the analyzer, so it cannot be accessed through SQL. |
| attislocal | boolean | Indicates that this column is locally defined in the relationship. Note that a column can be locally defined and inherited simultaneously. |

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| Name | Type | Description |
| --- | --- | --- |
| attcmprmode | tinyint | Compressed modes for a specific column. The compressed mode includes:<br>• ATT_CMPR_NOCOMPRESS<br>• ATT_CMPR_DELTA<br>• ATT_CMPR_DICTIONARY<br>• ATT_CMPR_PREFIX<br>• ATT_CMPR_NUMSTR |
| attinhcount | integer | Number of direct ancestors that this column has. A column with an ancestor cannot be dropped nor renamed. |
| attcollation | oid | Defined collation of a column |
| attacl | aclitem[] | Permissions for column-level access |
| attoptions | text[] | Column attribute. Currently, the following attributes are supported:<br>• **n_distinct**: number of **distinct** values of a column (excluding subtables).<br>• **n_distinct_inherited**: number of **distinct** values of a column (including subtables). |
| attfdwoptions | text[] | Column attribute of a foreign table. Currently, **dist_fdw**, **file_fdw**, and **log_fdw** do not use foreign table column attributes. |
| attinitdefval | bytea | **attinitdefval** stores the default value expression. **ADD COLUMN** in the row-store table must use this column. |
| attkvtype | tinyint | Specifies a key value type for a column. Types include:<br>0. ATT_KV_UNDEFINED: default value<br>1. ATT_KV_TAG: dimension<br>2. ATT_KV_FIELD: indicator<br>3. ATT_KV_TIMETAG: time column<br>4. ATT_KV_HIDETAG: hidden distribution column |

## 15.2.42 PG_AUTHID

**PG_AUTHID** records information about database authentication identifiers (roles). The concept of users is contained in that of roles. A user is actually a role whose **rolcanlogin** has been set. Any role, whether its **rolcanlogin** is set or not, can use other roles as members.

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For a cluster, only one **PG_AUTHID** exists, which is not available for every database. This system catalog is accessible only to system administrators.

**Table 15-39** PG_AUTHID columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| rolname | name | Name of a role |
| rolsuper | boolean | Whether the role is the initial system administrator with the highest permission<br>• **t** (true): yes<br>• **f** (false): no |
| rolinherit | boolean | Whether the role automatically inherits permissions of roles of which it is a member<br>• **t** (true): automatically inherited<br>• **f** (false): not automatically inherited |
| rolcreaterole | boolean | Whether the role can create more roles<br>• **t** (true): yes<br>• **f** (false): no |
| rolcreatedb | boolean | Whether the role can create databases<br>• **t** (true): yes<br>• **f** (false): no |
| rolcatupdate | boolean | Whether the role can directly update system catalogs. Only the initial system administrator whose **usesysid** is **10** has this permission. It is unavailable for other users.<br>• **t** (true): yes<br>• **f** (false): no |
| rolcanlogin | boolean | Whether the role can log in (whether this role can be given as the initial session authorization identifier)<br>• **t** (true): yes<br>• **f** (false): no |
| rolreplication | boolean | Whether a role has the replication permission<br>• **t** (true): yes<br>• **f** (false): no |

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| Name | Type | Description |
| --- | --- | --- |
| rolauditadmin | boolean | Whether the role has the audit administrator permission<br>• **t** (true): yes<br>• **f** (false): no |
| rolsystemadmin | boolean | Whether the role has system administrator permission<br>• **t** (true): yes<br>• **f** (false): no |
| rolconnlimit | integer | Maximum number of concurrent connections that this role can make (valid for roles that can log in)<br>The value **–1** indicates there is no limit. |
| rolpassword | text | Password (possibly encrypted) (null if no password) |
| rolvalidbegin | timestamp with time zone | Account validity start time (null if no start time) |
| rolvaliduntil | timestamp with time zone | Password expiry time (null if no expiration) |
| rolrespool | name | Resource pool that a user can use |
| roluseft | boolean | Whether the role can perform operations on foreign tables<br>• **t** (true): yes<br>• **f** (false): no |
| rolparentid | oid | OID of a group user to which the user belongs |
| roltabspace | text | Maximum size of a user data table |
| rolkind | "char" | Special type of user, including private users, logical cluster administrators, permanent users, and common users. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| rolnodegroup | oid | OID of a node group associated with a user. The node group must be a logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| roltempspace | text | Maximum size of a user's temporary table, in KB. |

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| Name | Type | Description |
| --- | --- | --- |
| rolspillspace | text | Maximum size of data that can be written to disks when a user executes a job, in KB. |
| rolexcpdata | text | Query rules that can be set by users (reserved) |
| rolmonitoradmin | boolean | Whether the role has monitor administrator permission<br>• **t** (true): yes<br>• **f** (false): no |
| roloperatoradmin | boolean | Whether the role has the O&M administrator permission<br>• **t** (true): yes<br>• **f** (false): no |
| rolpolicyadmin | boolean | Whether the role has the security policy administrator permission<br>• **t** (true): yes<br>• **f** (false): no |

## 15.2.43 PG_AUTH_HISTORY

**PG_AUTH_HISTORY** records the authentication history of a role. This system catalog is accessible only to system administrators.

**Table 15-40** PG_AUTH_HISTORY columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| roloid | oid | ID of a role |
| passwordtime | timestamp with time zone | Time of password creation and change |
| rolpassword | text | Ciphertext of the role password. The encryption mode is determined by the GUC parameter **password_encryption_type**. |

## 15.2.44 PG_AUTH_MEMBERS

**PG_AUTH_MEMBERS** records the membership between roles.

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**Table 15-41** PG_AUTH_MEMBERS columns

| Name | Type | Description |
| --- | --- | --- |
| roleid | oid | ID of a role that has a member |
| member | oid | ID of a role that is a member of ROLEID |
| grantor | oid | ID of a role that grants this membership |
| admin_option | boolean | Whether a member can grant membership in ROLEID to others<br>The value cannot be false. |

## 15.2.45 PG_CAST

**PG_CAST** records the conversion relationship between data types.

**Table 15-42** PG_CAST columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| castsource | oid | OID of the source data type |
| casttarget | oid | OID of the target data type |
| castfunc | oid | OID of the conversion function (**0** if no conversion function is required) |
| castcontext | "char" | Conversion mode between the source and target data types.<br>● **e**: Only explicit conversion can be performed (using the CAST or :: syntax).<br>● **'i'**: Implicit conversion can be performed.<br>● **a**: Both explicit and implicit conversion can be performed between data types. |
| castmethod | "char" | Conversion method.<br>● **f**: Conversion is performed using the specified function in the **castfunc** column.<br>● 'b': Binary forcible conversion rather than the specified function in the **castfunc** column is performed between data types. |

## 15.2.46 PG_CLASS

**PG_CLASS** records database objects and their relationship.

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**Table 15-43** PG_CLASS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| relname | name | Name of an object, such as a table, index, or view |
| relnamespace | oid | OID of the namespace that contains the relationship |
| reltype | oid | Data type that corresponds to the table's row type. The index is 0 because the index does not have **PG_TYPE** records. |
| reloftype | oid | OID of the composite type (**0** for other types) |
| relowner | oid | Owner of the relationship |
| relam | oid | Access method used, such as B-tree and hash, if this is an index |
| relfilenode | oid | Name of the on-disk file of this relationship (**0** if such file does not exist) |
| reltablespace | oid | Tablespace in which this relationship is stored. If the value is **0**, the default tablespace in this database is used. This column is meaningless if the relationship has no on-disk file. |
| relpages | double precision | Size of the on-disk representation of the table in pages (of size BLCKSZ). This is only an estimate used by the optimizer. |
| reltuples | double precision | Number of rows in the table. This is only an estimate used by the optimizer. |
| relallvisible | integer | Number of pages marked as all visible in the table. This column is used by the optimizer for optimizing SQL execution. It is updated by **VACUUM**, **ANALYZE**, and a few DDL statements such as **CREATE INDEX**. |
| reltoastrelid | oid | OID of the TOAST table associated with the table (**0** if no TOAST table exists).<br>The TOAST table stores large columns "offline" in a secondary table. |
| reltoastidxid | oid | OID of the index for a TOAST table (**0** for a table other than a TOAST table) |
| reldeltarelid | oid | OID of a Delta table<br>Delta tables are attached to column-store tables. They store long tail data generated during storage data import. |

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| Name | Type | Description |
| --- | --- | --- |
| reldeltaidx | oid | OID of the index for a Delta table |
| relcudescrelid | oid | OID of a CU description table.<br>CU description tables (Desc tables) belong to column-store tables. They control whether storage data in the HDFS table directory is visible. |
| relcudescidx | oid | OID of the index for a CU description table |
| relhasindex | boolean | Its value is **true** if this column is a table and has (or recently had) at least one index.<br>It is set by **CREATE INDEX** but is not immediately cleared by **DROP INDEX**. If the **VACUUM** process detects that a table has no index, it clears the **relhasindex** column and sets the value to **false**. |
| relisshared | boolean | Its value is **true** if the table is shared across all databases in the entire cluster. Otherwise, the value is **false**. Only certain system catalogs (such as **PG_DATABASE**) are shared. |
| relpersistence | "char" | • **p**: permanent table<br>• **u**: non-log table<br>• **t**: temporary table |
| relkind | "char" | • **r**: ordinary table<br>• **i**: index<br>• **s**: sequence<br>• **v**: view<br>• **c**: composite type<br>• **t**: TOAST table<br>• **f**: foreign table<br>• **m**: materialized view.<br>• **e**: STREAM object.<br>• **o**: CONTVIEW object. |
| relnatts | smallint | Number of user columns in the relationship (excluding system columns). **PG_ATTRIBUTE** has the same number of rows as the user columns. |
| relchecks | smallint | Number of check constraints in the table. For details, see the system catalog **PG_CONSTRAINT**. |
| relhasoids | boolean | Its value is **true** if an OID is generated for each row of the relationship. Otherwise, the value is **false**. |
| relhaspkey | boolean | Its value is **true** if the table has (or once had) a primary key. Otherwise, the value is **false**. |

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| Name | Type | Description |
| --- | --- | --- |
| relhasrules | boolean | Its value is **true** if the table has rules. For details, see the system catalog **PG_REWRITE**. |
| relhastriggers | boolean | The value is **true** if the table has (or once had) triggers. Triggers of the table and view are recorded in the system catalog **PG_TRIGGER**. |
| relhassubclass | boolean | Its value is **true** if the table has (or once had) any inheritance child table. Otherwise, the value is **false**. |
| relcmprs | tinyint | Whether the compression feature is enabled for the table. Note that only batch insertion triggers compression, so ordinary CRUD does not trigger compression.<br>● **0**: Tables that do not support compression (primarily system catalogs, on which the compression attribute cannot be modified).<br>● **1**: The compression feature of the table data is NOCOMPRESS or has no specified keyword.<br>● **2**: The compression feature of the table data is COMPRESS. |
| relhasclusterkey | boolean | Whether the local cluster storage is used<br>● **true**: yes<br>● **false**: no |
| relrowmovement | boolean | Whether row migration is allowed when the partitioned table is updated.<br>● **true**: Row migration is allowed.<br>● **false**: Row migration is not allowed. |
| parttype | "char" | Whether the table or index has the property of a partitioned table<br>● **p**: The table or index has the property of a partitioned table.<br>● **n**: The table or index does not have the property of a partitioned table. |

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| Name | Type | Description |
| --- | --- | --- |
| relfrozenxid | xid32 | All transaction IDs before this one have been replaced with a permanent ("frozen") transaction ID in the table. This column is used to track whether the table needs to be vacuumed to prevent transaction ID wraparound (or to allow **PG_CLOG** to be shrunk). The value is **0** (**InvalidTransactionId**) if the relationship is not a table.<br>To ensure forward compatibility, this column is reserved. The **relfrozenxid64** column is added to record the information. |
| relacl | aclitem[] | Access permission.<br>The command output of the query is as follows:<br>`rolename=xxxx/yyyy --Assigning permissions to a role`<br>`=xxxx/yyyy --Assigning the permission to public`<br>*xxxx* indicates assigned permissions, and *yyyy* indicates roles with the assigned permissions. For details on permission descriptions, see **Table 15-44**. |
| reloptions | text[] | Table or index access method, using character strings in the format of "keyword=value" |
| relreplident | "char" | Identifier of a decoding column in logical decoding:<br>• **d**: default (primary key, if any)<br>• **n**: none<br>• **f**: all columns<br>• **i**: The indisreplident of the index is specified or the default index is used. |
| relfrozenxid64 | xid | All transaction IDs before this one have been replaced with a permanent ("frozen") transaction ID in the table. This column is used to track whether the table needs to be vacuumed to prevent transaction ID wraparound (or to allow **PG_CLOG** to be shrunk). The value is **0** (**InvalidTransactionId**) if the relationship is not a table. |
| relbucket | oid | Specifies whether the current catalog contains hash bucket shards. A valid OID points to the specific shard information recorded in the **PG_HASHBUCKET** catalog. **NULL** indicates that hash bucket shards are not included. |
| relbucketkey | int2vector | Hash partition column information. **NULL** indicates that the column information is not included. |

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| Name | Type | Description |
| --- | --- | --- |
| relminmxid | xid | All multi-transaction IDs before this one have been replaced with a transaction ID in the table. This column is used to track whether the table needs to be vacuumed in order to prevent multi-transaction ID wraparound or to allow **pg_clog** to be shrunk. The value is **0** (**InvalidTransactionId**) if the relationship is not a table. |

**Table 15-44** Description of permissions

| Parameter | Parameter Description |
| --- | --- |
| r | SELECT (read) |
| w | UPDATE (write) |
| a | INSERT (insert) |
| d | DELETE |
| D | TRUNCATE |
| x | REFERENCES |
| t | TRIGGER |
| X | EXECUTE |
| U | USAGE |
| C | CREATE |
| c | CONNECT |
| T | TEMPORARY |
| A | ALTER |
| P | DROP |
| m | COMMENT |
| i | INDEX |
| v | VACUUM |
| * | Authorization options for preceding permissions |

## 15.2.47 PG_COLLATION

**PG_COLLATION** describes available collations, which are essentially mappings from an SQL name to operating system locale categories.

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**Table 15-45** PG_COLLATION columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| collname | name | - | Collation name (unique per namespace and encoding) |
| collnamespace | oid | 15.2.70 PG_NAMESPACE.oid | OID of the namespace that contains this collation |
| collowner | oid | 15.2.42 PG_AUTHID.oid | Owner of the collation |
| collencoding | integer | - | Encoding in which the collation is applicable, or **-1** if it works for any encoding. It is compatible with PostgreSQL. |
| collcollate | name | - | **LC_COLLATE** for this collation object |
| collctype | name | - | **LC_CTYPE** for this collation object |

## 15.2.48 PG_CONSTRAINT

**PG_CONSTRAINT** records check, primary key, unique, and foreign key constraints on tables.

**Table 15-46** PG_CONSTRAINT columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| conname | name | Constraint name (not necessarily unique) |
| connamespace | oid | OID of the namespace that contains the constraint |

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| Name | Type | Description |
| --- | --- | --- |
| contype | "char" | • **c**: check constraint<br>• **p**: primary key constraint<br>• **u**: unique constraint<br>• **t**: trigger constraint<br>• **x**: mutual exclusion constraint<br>• **f**: foreign key constraint<br>• **s**: clustering constraint<br>• **i**: invalid constraint |
| condeferrable | boolean | Whether the constraint can be deferrable<br>• **true**: yes<br>• **false**: no |
| condeferred | boolean | Whether the constraint can be deferrable by default<br>• **true**: yes<br>• **false**: no |
| convalidated | boolean | Whether the constraint is valid. Currently, it can be set to **false** only for foreign key and check constraints.<br>• **true**: valid<br>• **false**: invalid |
| conrelid | oid | Table containing this constraint (**0** if it is not a table constraint) |
| contypid | oid | Domain containing this constraint (**0** if it is not a domain constraint) |
| conindid | oid | ID of the index associated with the constraint |
| confrelid | oid | Referenced table if this constraint is a foreign key. Otherwise, the value is **0**. |
| confupdtype | "char" | Foreign key update action code<br>• **a**: no action<br>• **r**: restriction<br>• **c**: cascading<br>• **n**: The parameter is set to **null**.<br>• **d**: The default value is used. |

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| Name | Type | Description |
| --- | --- | --- |
| confdeltype | "char" | Foreign key deletion action code<br>• **a**: no action<br>• **r**: restriction<br>• **c**: cascading<br>• **n**: The parameter is set to **null**.<br>• **d**: The default value is used. |
| confmatchtype | "char" | Foreign key match type<br>• **f**: full match<br>• **p**: partial match<br>• **u**: unspecified (The NULL value can be matched if **f** is specified.) |
| conislocal | boolean | Whether the local constraint is defined for the relationship<br>• **true**: yes<br>• **false**: no |
| coninhcount | integer | Number of direct inheritance parent tables that this constraint has. When the value is not **0**, the constraint cannot be deleted or renamed. |
| connoinherit | boolean | Whether the constraint can be inherited<br>• **true**: yes<br>• **false**: no |
| consoft | boolean | Whether the column indicates an informational constraint<br>• **true**: yes<br>• **false**: no |
| conopt | boolean | Whether you can use the informational constraint to optimize the execution plan<br>• **true**: yes<br>• **false**: no |
| conkey | smallint[] | Column list of the constrained control if this column is a table constraint |
| confkey | smallint[] | List of referenced columns if this column is a foreign key. |
| conpfeqop | oid[] | ID list of the equality operators for PK = FK comparisons if this column is a foreign key. |
| conppeqop | oid[] | ID list of the equality operators for PK = PK comparisons if this column is a foreign key. |

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| Name | Type | Description |
| --- | --- | --- |
| conffeqop | oid[] | ID list of the equality operators for FK = FK comparisons if this column is a foreign key. |
| conexclop | oid[] | ID list of the per-column exclusion operators if this column is an exclusion constraint |
| conbin | pg_node_tree | Internal representation of the expression if this column is a check constraint |
| consrc | text | Human-readable representation of the expression if this column is a check constraint |
| conincluding | smallint[] | Not for constraint, but will be included in the attribute column of **INDEX**. |

NOTICE

- **consrc** is not updated when referenced objects change and does not track new column names. You are advised to use **pg_get_constraintdef()** to extract the definition of a check constraint.
- **pg_class.relchecks** must agree with the number of check-constraint entries found in the table for each relationship.

## 15.2.49 PG_CONVERSION

**PG_CONVERSION** describes encoding conversion information.

**Table 15-47** PG_CONVERSION columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| conname | name | - | Conversion name (unique within a namespace) |
| connamespace | oid | OID in **15.2.70 PG_NAMESPACE** | OID of the namespace that contains this conversion |
| conowner | oid | OID in **15.2.42 PG_AUTHID** | Owner of the conversion |
| conforencoding | integer | - | Source encoding ID |
| contoencoding | integer | - | Destination encoding ID |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| conproc | regproc | **proname** in 15.2.78 PG_PROC | Conversion procedure |
| condefault | boolean | - | If this is the default conversion, the value is **true**. Otherwise, the value is **false**. |

## 15.2.50 PG_DATABASE

**PG_DATABASE** records information about available databases.

**Table 15-48** PG_DATABASE columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| datname | name | Database name |
| datdba | oid | Owner of the database, usually the user who created it |
| encoding | integer | Character encoding for the database |
| datcollate | name | Sequence used by the database |
| datctype | name | Character type used by the database |
| datistemplate | boolean | Whether the database can be used as a template database<br>• **true**: allowed.<br>• **false**: not allowed. |
| datallowconn | boolean | If the value is **true**, users can connect to the database. If the value is **false**, no one can connect to this database. This column is used to protect the **template0** database from being altered. |
| datconnlimit | integer | Maximum number of concurrent connections allowed on this database. The value **-1** indicates no limit. |
| datlastsysoid | oid | Last system OID in the database |

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| Name | Type | Description |
| --- | --- | --- |
| datfrozenxid | xid32 | Tracks whether the database needs to be vacuumed to prevent transaction ID wraparound. This column is discarded in the current version. To ensure forward compatibility, this column is reserved. The **datfrozenxid64** column is added to record the information. |
| dattablespace | oid | Default tablespace of the database |
| datcompatibility | name | Database compatibility mode Currently, four compatible modes are supported: PG, ORA, MYSQL, and TD. |
| datacl | aclitem[] | Access permission |
| datfrozenxid64 | xid | Tracks whether the database needs to be vacuumed to prevent transaction ID wraparound. |
| datminmxid | xid | All multi-transaction IDs before this one have been replaced with a transaction ID in the database. This is used to track whether the database needs to be vacuumed in order to prevent transaction ID wraparound or to allow **pg_clog** to be shrunk. It is the minimum value of **pg_class.relminmxid** of all tables in the database. |

## 15.2.51 PG_DB_ROLE_SETTING

**PG_DB_ROLE_SETTING** records the default values of configuration items bound to each role and database when the database is running.

**Table 15-49** PG_DB_ROLE_SETTING columns

| Name | Type | Description |
| --- | --- | --- |
| setdatabase | oid | Database corresponding to the configuration items (**0** if no database is specified) |
| setrole | oid | Role corresponding to the configuration items (**0** if no role is specified) |
| setconfig | text[] | Default value of the configuration item during running. For details about the configuration method, see **Table 11-2**. |

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## 15.2.52 PG_DEFAULT_ACL

**PG_DEFAULT_ACL** records initial permissions assigned to newly created objects.

**Table 15-50** PG_DEFAULT_ACL columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| defaclrole | oid | ID of the role associated with the permission |
| defaclnamespace | oid | Namespace associated with the permission (**0** if no ID) |
| defaclobjtype | "char" | Object type of the permission<br>**r** indicates a table or view, **S** indicates a sequence, **f** indicates a function, **T** indicates a type, **K** indicates a client master key, and **k** indicates a column encryption key. |
| defaclacl | aclitem[] | Access permissions that this type of object should have on creation |

## 15.2.53 PG_DEPEND

**PG_DEPEND** records the dependency between database objects. This information allows **DROP** commands to find which other objects must be dropped by **DROP CASCADE** or prevent dropping in the **DROP RESTRICT** case.

See also **15.2.87 PG_SHDEPEND**, which performs a similar function for dependencies involving objects that are shared across a database cluster.

**Table 15-51** PG_DEPEND columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| classid | oid | **15.2.46 PG_CLASS**.oid | OID of the system catalog where a dependent object resides |
| objid | oid | Any OID column | OID of the dependent object |
| objsubid | integer | - | Column number for a table column (**objid** and **classid** refer to the table itself); **0** for all other object types |
| refclassid | oid | **15.2.46 PG_CLASS**.oid | OID of the system catalog where a referenced object resides |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| refobjid | oid | Any OID column | OID of the referenced object |
| refobjsubid | integer | - | Column number for a table column (**refobjid** and **refclassid** refer to the table itself); **0** for all other object types |
| deptype | "char" | - | A code defining the specific semantics of this dependency |

In all cases, a **PG_DEPEND** entry indicates that the referenced object cannot be dropped without also dropping the dependent object. However, there are several subflavors identified by **deptype**:

- DEPENDENCY_NORMAL (n): A normal relationship between separately created objects. The dependent object can be dropped without affecting the referenced object. The referenced object can only be dropped by specifying **CASCADE**, in which case the dependent object is dropped too. Example: a table column has a normal dependency on its data type.
- DEPENDENCY_AUTO (a): The dependent object can be dropped separately from the referenced object, and should be automatically dropped (regardless of RESTRICT or CASCADE mode) if the referenced object is dropped. Example: a named constraint on a table is made autodependent on the table, so that it will go away if the table is dropped.
- DEPENDENCY_INTERNAL (i): The dependent object was created as part of creation of the referenced object, and is only a part of its internal implementation. A DROP of the dependent object will be disallowed outright (We'll tell the user to issue a DROP against the referenced object, instead). A **DROP** of the referenced object will be propagated through to drop the dependent object whether **CASCADE** is specified or not. Example: A trigger created to enforce a foreign-key constraint is made internally dependent on the constraint's **15.2.48 PG_CONSTRAINT** entry.
- DEPENDENCY_EXTENSION (e): The dependent object is a member of the extension of the referenced object (see **15.2.57 PG_EXTENSION**). The dependent object can be dropped only via **DROP EXTENSION** on the referenced object. Functionally this dependency type acts the same as an internal dependency, but it is kept separate for clarity and to simplify **GS_DUMP**.
- DEPENDENCY_PIN (p): There is no dependent object; this type of entry is a signal that the system itself depends on the referenced object, and so that object must never be deleted. Entries of this type are created only by **initdb**. The columns for the dependent object contain zeroes.

## 15.2.54 PG_DESCRIPTION

**PG_DESCRIPTION** records optional descriptions (comments) for each database object. Descriptions of many built-in system objects are provided in the initial contents of **PG_DESCRIPTION**.

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See also **15.2.88 PG_SHDESCRIPTION**, which provides a similar function for descriptions involving objects that are shared across a database cluster.

**Table 15-52** PG_DESCRIPTION columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| objoid | oid | Any OID column | OID of the object that this description pertains to |
| classoid | oid | **15.2.46 PG_CLASS**.oid | OID of the system catalog where the object appears |
| objsubid | integer | - | Column number for a comment on a table column (**objoid** and **classoid** refer to the table itself); **0** for all other object types |
| description | text | - | Arbitrary text that serves as the description of the object |

## 15.2.55 PG_DIRECTORY

**PG_DIRECTORY** stores directories added by users. You can run the **CREATE DIRECTORY** statement to add directories to the system catalog. Currently, only system administrators can perform this operation.

**Table 15-53** PG_DIRECTORY columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| dirname | name | Name of a directory object |
| owner | oid | Owner of a directory object |
| dirpath | text | Directory path. |
| diracl | aclitem[] | Access permissions. |

## 15.2.56 PG_ENUM

**PG_ENUM** contains entries showing the values and labels for each enumerated type. The internal representation of a given enumerated value is actually the OID of its associated row in **PG_ENUM**.

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**Table 15-54** PG_ENUM columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| enumtypid | oid | 15.2.101 PG_TYPE.oid | OID of the **PG_TYPE** entry owning this enumerated value |
| enumsortorder | real | - | Sort position of this enumerated value within its enumerated type |
| enumlabel | name | - | Textual label for this enumerated value |

The OIDs for **PG_ENUM** rows follow a special rule: even-numbered OIDs are guaranteed to be ordered in the same way as the sort ordering of their enumerated type. If two even OIDs belong to the same enumerated type, the smaller OID must have the smaller **enumsortorder** value. Odd-numbered OID values need bear no relationship to the sort order. This rule allows the enumerated comparison routines to avoid catalog lookups in many common cases. The routines that create and alter enumerated types attempt to assign even OIDs to enumerated values whenever possible.

When an enumerated type is created, its members are assigned sort-order positions from 1 to *n*. However, members added later might be given negative or fractional values of **enumsortorder**. The only requirement on these values is that they be correctly ordered and unique within each enumerated type.

## 15.2.57 PG_EXTENSION

**PG_EXTENSION** records information about the installed extensions. By default, GaussDB provides 14 extensions: PLPGSQL, DIST_FDW, FILE_FDW, LOG_FDW, GC_FDW, PACKAGES, ROACH_API, STREAMING, TSDB, HSTORE, DIMSEARCH, GSREDISTRIBUTE, and SECURITY_PLUGIN.

NOTE

DIMSEARCH is no longer supported in the current version due to specification changes. Do not use it.

**Table 15-55** PG_EXTENSION

| Name | Type | Description |
| --- | --- | --- |
| extname | name | Extension name |
| extowner | oid | Owner of the extension |
| extnamespace | oid | Namespace containing the extension's exported objects |

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| Name | Type | Description |
| --- | --- | --- |
| extrelocatable | boolean | Whether the extension can be relocated to another namespace. **true**: yes; **false**: no. |
| extversion | text | Version number of the extension |
| extconfig | oid[] | Configuration information about the extension |
| extcondition | text[] | Filter conditions for the extension's configuration information |

## 15.2.58 PG_EXTENSION_DATA_SOURCE

**PG_EXTENSION_DATA_SOURCE** records information about external data sources. An external data source contains information about an external database, such as its password encoding. It is mainly used with Extension Connector. By default, only the sysadmin user can query this system catalog. The current feature is a lab feature. Contact Huawei technical support before using it.

**Table 15-56** PG_EXTENSION_DATA_SOURCE columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| srcname | name | - | Name of an external data source |
| srcowner | oid | PG_AUTHID.oid | Owner of an external data source |
| srctype | text | - | Type of an external data source. It is **NULL** by default. |
| srcversion | text | - | Version of an external data source. It is **NULL** by default. |
| srcacl | aclitem[] | - | Access permissions. |
| srcoptions | text[] | - | Option used for foreign data sources, expressed in a string in the format of keyword=value |

## 15.2.59 PG_FOREIGN_DATA_WRAPPER

**PG_FOREIGN_DATA_WRAPPER** records foreign-data wrapper definitions. A foreign-data wrapper is the mechanism by which external data, residing on foreign servers, is accessed.

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**Table 15-57** PG_FOREIGN_DATA_WRAPPER columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| fdwname | name | - | Name of a foreign-data wrapper |
| fdwowner | oid | 15.2.42 PG_AUTHID.oid | Owner of the foreign-data wrapper |
| fdwhandler | oid | 15.2.78 PG_PROC.oid | References a handler function that is responsible for supplying execution routines for the foreign-data wrapper (**0** if no handler is provided) |
| fdwvalidator | oid | 15.2.78 PG_PROC.oid | References a validator function that is responsible for checking the validity of the options given to the foreign-data wrapper, as well as options for foreign servers and user mappings using the foreign-data wrapper. (**0** if no handler is provided) |
| fdwacl | aclitem[] | - | Access permissions |
| fdwoptions | text[] | - | Foreign-data wrapper specific option, expressed in a string in the format of keyword=value |

## 15.2.60 PG_FOREIGN_SERVER

**PG_FOREIGN_SERVER** records foreign server definitions. A foreign server describes a source of external data, such as a remote server. Foreign servers are accessed via foreign-data wrappers.

**Table 15-58** PG_FOREIGN_SERVER columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| srvname | name | - | Name of a foreign server |
| srvowner | oid | 15.2.42 PG_AUTHID.oid | Owner of the foreign server |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| srvfdw | oid | 15.2.59 PG_FOREIGN_DATA_WRAPPER.oid | OID of the foreign-data wrapper on this foreign server |
| srvtype | text | - | Type of the server (optional) |
| srvversion | text | - | Version of the server (optional) |
| srvacl | aclitem[] | - | Access permissions |
| srvoptions | text[] | - | Option used for foreign servers, expressed in a string in the format of keyword=value |

## 15.2.61 PG_FOREIGN_TABLE

**PG_FOREIGN_TABLE** records auxiliary information about foreign tables.

**Table 15-59** PG_FOREIGN_TABLE columns

| Name | Type | Description |
| --- | --- | --- |
| ftrelid | oid | ID of a foreign table |
| ftserver | oid | Server where the foreign table is located |
| ftwriteonly | boolean | Whether the foreign table is writable. Values are as follows:<br>• **t** (true): yes<br>• **f** (false): no |
| ftoptions | text[] | Options of a foreign table. For details, see the syntax description of CREATE FOREIGN TABLE. |

## 15.2.62 PG_HASHBUCKET

**PG_HASHBUCKET** records hash bucket information.

**Table 15-60** PG_HASHBUCKET columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |

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| Name | Type | Description |
| --- | --- | --- |
| bucketid | oid | Hash value calculated for a bucket vector. The hash value can be used to accelerate the search for a bucket vector. |
| bucketcnt | integer | Number of shards. |
| bucketmapsize | integer | Total number of shards on all DNs. |
| bucketref | integer | Reserved column with **1** as its default value |
| bucketvector | oidvector_extend | Records all bucket IDs contained in the bucket information in this row. A unique index is created in this column. Tables with the same bucket ID share the **PG_HASHBUCKET** data in the same row. |

## 15.2.63 PG_INDEX

**PG_INDEX** records part of index information. The rest is mostly recorded in **PG_CLASS**.

**Table 15-61** PG_INDEX columns

| Name | Type | Description |
| --- | --- | --- |
| indexrelid | oid | OID of the **PG_CLASS** entry for this index |
| indrelid | oid | OID of the **PG_CLASS** entry for the table that uses this index |
| indnatts | smallint | Number of columns in the index |
| indisunique | boolean | • The index is unique if the value is **true**.<br>• The index is not unique if the value is **false**. |
| indisprimary | boolean | • Primary key of the table if the value is **true**. **indisunique** should always be **true** when the value of this column is **true**.<br>• The index is not the primary key of the table if the value is **false**. |
| indisexclusion | boolean | • This index supports exclusion constraints if the value is **true**.<br>• This index does not support exclusion constraints if the value is **false**. |
| indimmediate | boolean | • A uniqueness check is performed upon data insertion if the value is **true**.<br>• A uniqueness check is not performed upon data insertion if the value is **false**. |

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| Name | Type | Description |
| --- | --- | --- |
| indiscluster ed | boolean | • The table was last clustered on this index if the value is **true**.<br>• The table was not clustered on this index if the value is **false**. |
| indisusable | boolean | • This index supports INSERT/SELECT if the value is **true**.<br>• This index does not support INSERT/SELECT if the value is **false**. |
| indisvalid | boolean | This index is valid for queries if the value is **true**. If the value is **false**, the index is possibly incomplete and must still be modified by **INSERT/UPDATE** operations, but it cannot safely be used for queries. If it is a unique index, the uniqueness property is also not **true**. |
| indcheckx min | boolean | • If the value is **true**, queries must not use indexes until the xmin of this row in **PG_INDEX** is below their **TransactionXmin**, because the table may contain broken HOT chains with incompatible rows that they can see.<br>• If the value is **false**, queries can use indexes. |
| indisready | boolean | The index is available for inserted data if the value is **true**. Otherwise, this index is ignored when data is inserted or modified. |
| indkey | int2vector | This is an array of **indnatts** values indicating that this index creates table columns. For example, a value of **1 3** indicates that the first and the third columns make up the index key. The value **0** in this array indicates that the corresponding index attribute is an expression over the table columns, rather than a simple column reference. |
| indcollatio n | oidvector | ID of each column used by the index |
| indclass | oidvector | For each column in the index key, this contains the OID of the operator class to use. See **PG_OPCLASS** for details. |
| indoption | int2vector | Array of values that store per-column flag bits. The meaning of the bits is defined by the index's access method. |
| indexprs | pg_node_tr ee | Expression trees (in **nodeToString()** representation) for index attributes that are not simple column references. It is a list with one element for each zero entry in **INDKEY**. The value is **NULL** if all index attributes are simple references. |

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| Name | Type | Description |
| --- | --- | --- |
| indpred | pg_node_tree | Expression tree (in **nodeToString()** representation) for partial index predicate. If the index is not a partial index, this column is an empty string. |
| indisreplident | boolean | • If the value is **true**, the column of this index becomes the decoded column of logical decoding.<br>• If the value is **false**, the column of this index is not the decoded column of logical decoding. |
| indnkeyatts | smallint | Total number of columns in the index. The columns that exceed the value of **indnatts** are not involved in the index query. |

## 15.2.64 PG_INHERITS

**PG_INHERITS** records information about table inheritance hierarchies. There is one entry for each direct child table in the database. Indirect inheritance can be determined by following chains of entries.

**Table 15-62** PG_INHERITS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| inhrelid | oid | 15.2.46 PG_CLASS.oid | OID of a child table |
| inhparent | oid | 15.2.46 PG_CLASS.oid | OID of a parent table |
| inhseqno | integer | - | If there is more than one direct parent for a child table (multiple inheritances), this number tells the order in which the inherited columns are to be arranged. The count starts at 1. |

## 15.2.65 PG_JOB

**PG_JOB** records detailed information about jobs created by users. Dedicated threads poll the system catalog **PG_JOB** and trigger jobs based on scheduled job execution time, and update job status in **PG_JOB**. This system catalog belongs to the Shared Relation category. All job records are visible to all databases.

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**Table 15-63** PG_JOB columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| job_id | bigint | Job ID, primary key, unique (with a unique index) |
| current_postgres_pid | bigint | postgres thread ID of the job if the job has been executed. The default value is **-1**, indicating that the job has not yet been executed. |
| log_user | name | Username of the job creator |
| priv_user | name | Username of the job executor |
| dbname | name | Name of the database in which the job will be executed |
| node_name | name | CN node on which the job will be executed |
| job_status | "char" | Status of the job. The value can be **r**, **s**, **f**, or **d**. The default value is **s**. The indications are as follows:<br>Status of job step: r=running, s=successfully finished, f=job failed, d=disable<br>If a job fails to be executed for 16 consecutive times, **job_status** is automatically set to **d**, and no more attempt will be made on this job.<br>Note: When you disable a scheduled task (by setting **job_queue_processes** to **0**), the thread that monitors the job execution is not started, and the job status will not be updated. You can ignore this status. Only when the scheduled task function is enabled (**job_queue_processes** is not **0**), the system updates the value of this column based on the real-time job status. |
| start_date | timestamp without time zone | Start time of the first job execution, accurate to millisecond |
| next_run_date | timestamp without time zone | Scheduled time of the next job execution, accurate to millisecond |
| failure_count | smallint | Number of times the job has started and failed. If a job fails to be executed for 16 consecutive times, no more attempt will be made on it. |
| interval | text | Job execution interval |
| last_start_date | timestamp without time zone | Start time of the last job execution, accurate to millisecond |

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| Name | Type | Description |
| --- | --- | --- |
| last_end_date | timestamp without time zone | End time of the last job execution, accurate to millisecond |
| last_suc_date | timestamp without time zone | Start time of the last successful job execution, accurate to millisecond |
| this_run_date | timestamp without time zone | Start time of the ongoing job execution, accurate to millisecond |
| nspname | name | Name of the schema used for job execution |
| job_name | text | Name of the DBE_SCHEDULER scheduled task. |
| end_date | timestamp without time zone | Expiration time of the DBE_SCHEDULER scheduled task, accurate to millisecond. |
| enable | boolean | The DBE_SCHEDULER scheduled task enabling status. The options are as follows:<br>**true**: enabled<br>**false**: disabled |
| failure_msg | text | Error information about the latest task execution. |

## 15.2.66 PG_JOB_PROC

**PG_JOB_PROC** records the content of each job in the **PG_JOB** table, including the PL/SQL code blocks and anonymous blocks. This part of job information is **varchar(4000)**. Storing such information in the system catalog **PG_JOB** and loading it to the shared memory will result in excessive memory usage. Therefore, such information is stored in a separate table and is retrieved when needed.

**Table 15-64** PG_JOB_PROC columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| job_id | integer | Foreign key, which is associated with job_id in the system catalog **PG_JOB** |
| what | text | Job content, which is the program content in the DBE_SCHEDULER scheduled task. |
| job_name | text | Name of the DBE_SCHEDULER scheduled task or program. |

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## 15.2.67 PG_LANGUAGE

**PG_LANGUAGE** registers programming languages. You can use them and interfaces to write functions or stored procedures.

**Table 15-65** PG_LANGUAGE columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| lanname | name | - | Language name |
| lanowner | oid | OID in **15.2.42 PG_AUTHID** | Owner of the language |
| lanispl | boolean | - | The value is **false** for internal languages (such as SQL) and **true** for user-defined languages. Currently, **gs_dump** still uses this column to determine which languages need to be dumped, but this might be replaced by a different mechanism in the future. |
| lanpltrusted | boolean | - | The value is **true** if this is a trusted language, which means that it is believed not to grant access to anything outside the normal SQL execution environment. Only the initial user can create functions in untrusted languages. Otherwise, the value is **false**. |
| lanplcallfoid | oid | OID in **15.2.78 PG_PROC** | For non-internal languages, this column references the language handler, which is a special function responsible for executing all functions that are written in the particular language. |
| laninline | oid | OID in **15.2.78 PG_PROC** | This column references a function responsible for executing "inline" anonymous code blocks (DO blocks). The value is **0** if inline blocks are not supported. |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| lanvalidator | oid | OID in 15.2.78 PG_PROC | This column references a language validator function responsible for checking the syntax and validity of new functions when they are created. The value is **0** if no validator is provided. |
| lanacl | aclitem[] | - | Access permission |

## 15.2.68 PG_LARGEOBJECT

**PG_LARGEOBJECT** records data making up large objects. A large object is identified by an OID assigned when it is created. Each large object is broken into segments or "pages" small enough to be conveniently stored as rows in **PG_LARGEOBJECT**. The amount of data per page is defined as **LOBLKSIZE**.

This system catalog is accessible only to system administrators.

**Table 15-66** PG_LARGEOBJECT columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| loid | oid | 15.2.69 PG_LARGEOBJECT_METADATA.oid | Identifier of the large object that includes this page |
| pageno | integer | - | Page number of this page within its large object (counting from zero) |
| data | bytea | - | Data stored in the large object. This will never be more than **LOBLKSIZE** bytes and might be less. |

Each row of **PG_LARGEOBJECT** holds data for one page of a large object, beginning at byte offset (**pageno * LOBLKSIZE**) within the object. The implementation allows sparse storage: pages might be missing, and might be shorter than **LOBLKSIZE** bytes even if they are not the last page of the object. Missing regions within a large object read as zeroes.

## 15.2.69 PG_LARGEOBJECT_METADATA

**PG_LARGEOBJECT_METADATA** records metadata associated with large objects. The actual large object data is stored in **PG_LARGEOBJECT**.

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**Table 15-67** PG_LARGEOBJECT_METADATA columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| lomowner | oid | 15.2.42 PG_AUTHID.oid | Owner of the large object |
| lomacl | aclitem[] | - | Access permissions |

## 15.2.70 PG_NAMESPACE

**PG_NAMESPACE** records namespaces, that is, schema-related information. If the database object isolation attribute is enabled, users can view only the schema information that they have the permission to access.

**Table 15-68** PG_NAMESPACE columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| nspname | name | Name of a namespace |
| nspowner | oid | Owner of the namespace |
| nsptimeline | bigint | Timeline when the namespace is created on the DN. This column is for internal use and valid only on the DN. |
| nspacl | aclitem[] | Access permission. For details, see 12.14.140 GRANT and 12.14.154 REVOKE. |
| in_redistribution | "char" | Specifies whether the content is in the redistribution state.<br>• **t** (true): yes<br>• **f** (false): no |
| nspblockchain | boolean | • If the value is **true**, the tamper-proof mode is used.<br>• If the value is **false**, the non-tamper-proof mode is used. |

## 15.2.71 PG_OBJECT

**PG_OBJECT** records the creator, creation time, and last modification time of objects of specified types (ordinary tables, indexes, sequences, views, stored procedures, and functions).

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**Table 15-69** PG_OBJECT columns

| Name | Type | Description |
| --- | --- | --- |
| object_oid | oid | Object identifier |
| object_type | "char" | Object type<br>• **r**: ordinary table<br>• **i**: index<br>• **s**: sequence<br>• **v**: view<br>• **p**: stored procedure and function |
| creator | oid | ID of the creator |
| ctime | timestamp with time zone | Creation time of the object |
| mtime | timestamp with time zone | Last modification time of the object. The modification operations include **ALTER**, **GRANT**, and **REVOKE**. |
| createcsn | bigint | CSN when an object is created |
| changecsn | bigint | CSN when DDL operations are performed on a table or an index |

**NOTICE**

- Objects created or modified during database initialization (initdb) cannot be recorded. **PG_OBJECT** does not contain these object records.
- A database upgraded to this version cannot record objects created before the upgrade. **PG_OBJECT** does not contain these object records.
- When the preceding two types of objects are modified again, the modification time (**mtime**) is recorded. Because the creation time of the objects cannot be obtained, **ctime** is empty.
- When an object created before the upgrade is modified again, the modification time (specified by **mtime**) is recorded. When DDL operations are performed on a table or an index, the transaction commit sequence number (specified by **changecsn**) of the transaction to which the table or index belongs is recorded. Because the creation time of the object cannot be obtained, **ctime** and **createcsn** are empty.
- The time recorded by **ctime** and **mtime** is the start time of the transaction to which the current operation belongs.
- The time of object modification due to capacity expansion is also recorded.
- **createcsn** and **changecsn** record the transaction commit sequence number of the transaction to which the current operation belongs.

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## 15.2.72 PG_OBSSCANINFO

**PG_OBSSCANINFO** defines OBS runtime information scanned in cluster acceleration scenarios. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) Each record corresponds to a piece of runtime information of a foreign table on OBS in a query. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 15-70** PG_OBSSCANINFO columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| query_id | bigint | - | Query ID |
| user_id | text | - | Database user who performs the query |
| table_name | text | - | Name of a foreign table on OBS |
| file_type | text | - | Format of the file that stores underlying data |
| time_stamp | timestamp with time zone | - | Scanning start time |
| actual_time | double precision | - | Scanning execution time, in seconds |
| file_scanned | bigint | - | Number of files scanned |
| data_size | double precision | - | Size of data scanned, in bytes |
| billing_info | text | - | Reserved |

## 15.2.73 PG_OPCLASS

**PG_OPCLASS** defines index access method operator classes.

Each operator class defines semantics for index columns of a particular data type and a particular index access method. An operator class essentially specifies that a particular operator family is applicable to a particular indexable column data type. The set of operators from the family that are actually usable with the indexed column are whichever ones accept the column's data type as their left-hand input.

**Table 15-71** PG_OPCLASS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| opcmethod | oid | OID in **15.2.36 PG_AM** | Index access method operator class served by an operator class |
| opcname | name | - | Name of the operator class |
| opcnamespace | oid | OID in **15.2.70 PG_NAMESPACE** | Namespace of the operator class |
| opcowner | oid | OID in **15.2.42 PG_AUTHID** | Owner of the operator class |
| opcfamily | oid | OID in **15.2.75 PG_OPFAMILY** | Operator family containing the operator class |
| opcintype | oid | OID in **15.2.101 PG_TYPE** | Data type that the operator class indexes |
| opcdefault | boolean | - | The value is **true** if this operator class is the default for **opcintype**. |
| opckeytype | oid | OID in **15.2.101 PG_TYPE** | Type of data stored in index, or zero if same as **opcintype** |

An operator class's **opcmethod** must match the **opfmethod** of its containing operator family.

## 15.2.74 PG_OPERATOR

**PG_OPERATOR** records information about operators.

**Table 15-72** PG_OPERATOR columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| oprname | name | - | Name of an operator |
| oprnamespace | oid | OID in **15.2.70 PG_NAMESPACE** | OID of the namespace that contains the operator |
| oprowner | oid | OID in **15.2.42 PG_AUTHID** | Owner of the operator |
| oprkind | "char" | - | • **b**: infix ("both")<br>• **l**: prefix ("left")<br>• **r**: postfix ("right") |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oprcanmerge | boolean | - | Whether the operator supports merge joins<br>• **t** (true): yes<br>• **f** (false): no |
| oprcanhash | boolean | - | Whether the operator supports hash joins<br>• **t** (true): yes<br>• **f** (false): no |
| oprleft | oid | OID in **15.2.101 PG_TYPE** | Type of the left operand |
| oprright | oid | OID in **15.2.101 PG_TYPE** | Type of the right operand |
| oprresult | oid | OID in **15.2.101 PG_TYPE** | Type of the result |
| oprcom | oid | OID in **15.2.74 PG_OPERATOR** | Commutator of this operator, if any |
| oprnegate | oid | OID in **15.2.74 PG_OPERATOR** | Negator of this operator, if any |
| oprcode | regproc | **proname** in **15.2.78 PG_PROC** | Function that implements the operator |
| oprrest | regproc | **proname** in **15.2.78 PG_PROC** | Restriction selectivity estimation function for the operator |
| oprjoin | regproc | **proname** in **15.2.78 PG_PROC** | Join selectivity estimation function for the operator |

## 15.2.75 PG_OPFAMILY

**PG_OPFAMILY** defines operator families.

Each operator family is a collection of operators and associated support routines that implement semantics specified for a particular index access method. Furthermore, the operators in a family are all compatible, in a way that is specified by the access method. The operator family allows cross-data-type operators to be used with indexes and to be reasoned about using knowledge of access method semantics.

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**Table 15-73** PG_OPFAMILY columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| opfmethod | oid | 15.2.36 PG_AM.oid | Index access method used by an operator family |
| opfname | name | - | Name of the operator family |
| opfnamespace | oid | 15.2.70 PG_NAMESPACE.oid | Namespace of the operator family |
| opfowner | oid | 15.2.42 PG_AUTHID.oid | Owner of the operator family |

The majority of the information defining an operator family is not in its **PG_OPFAMILY** row, but in the associated rows in **15.2.37 PG_AMOP**, **15.2.38 PG_AMPROC**, and **15.2.73 PG_OPCLASS**.

## 15.2.76 PG_PARTITION

**PG_PARTITION** records all partitioned tables, table partitions, TOAST tables on table partitions, and index partitions in the database. Partitioned index information is not stored in the system catalog **PG_PARTITION**.

**Table 15-74** PG_PARTITION columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| relname | name | Names of the partitioned tables, table partitions, TOAST tables on table partitions, and index partitions |
| parttype | "char" | Object type<br>• **r**: partitioned table<br>• **p**: table partition<br>• **x**: index partition<br>• **t**: TOAST table |
| parentid | oid | OID of the partitioned table in **PG_CLASS** when the object is a partitioned table or table partition<br>OID of the partitioned index when the object is an index partition |

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| Name | Type | Description |
| --- | --- | --- |
| rangenum | integer | Reserved column |
| intervalnum | integer | Reserved column |
| partstrategy | "char" | Partition policy of the partitioned table<br>• **r**: range partition<br>• **v**: numeric partition |
| relfilenode | oid | Physical storage locations of the table partition, index partition, and TOAST table on the table partition |
| reltablespace | oid | OID of the tablespace containing the table partition, index partition, and TOAST table on the table partition |
| relpages | double precision | Statistics: numbers of data pages of the table partition and index partition |
| reltuples | double precision | Statistics: numbers of tuples of the table partition and index partition |
| relallvisible | integer | Statistics: number of visible data pages of the table partition and index partition |
| reltoastrelid | oid | OID of the TOAST table corresponding to the table partition |
| reltoastidxid | oid | OID of the TOAST table index corresponding to the table partition |
| indextblid | oid | OID of the table partition corresponding to the index partition |
| indisusable | boolean | Whether the index partition is available<br>• **t** (true): yes<br>• **f** (false): no |
| reldeltarelid | oid | OID of a Delta table |
| reldeltaidx | oid | OID of the index for a Delta table |
| relcudescrelid | oid | OID of a CU description table |
| relcudescidx | oid | OID of the index for a CU description table |
| relfrozenxid | xid32 | Frozen transaction ID<br>To ensure forward compatibility, this column is reserved. The **relfrozenxid64** column is added to record the information. |
| intspnum | integer | Number of tablespaces that the interval partition belongs to |

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| Name | Type | Description |
| --- | --- | --- |
| partkey | int2vector | Column number of the partition key |
| intervaltablespace | oidvector | Tablespace that the interval partition belongs to. Interval partitions fall in the tablespaces in the round-robin manner. |
| interval | text[] | Interval value of the interval partition |
| boundaries | text[] | Upper boundary of the range partition and interval partition |
| transit | text[] | Transit of the interval partition |
| reloptions | text[] | Storage property of a partition used for collecting online scale-out information. Same as **pg_class.reloptions**, it is expressed in a string in the format of keyword=value. |
| relfrozenxid64 | xid | Frozen transaction ID |
| relminmxid | xid | Frozen multi-transaction ID |

## 15.2.77 PG_PLTEMPLATE

**PG_PLTEMPLATE** records template information for procedural languages.

**Table 15-75** PG_PLTEMPLATE columns

| Name | Type | Description |
| --- | --- | --- |
| tmplname | name | Name of the language for which this template is used |
| tmpltrusted | boolean | The value is **true** if the language is considered trusted. Otherwise, the value is **false**. |
| tmpldbacreate | boolean | The value is **true** if the language is created by the owner of the database. Otherwise, the value is **false**. |
| tmplhandler | text | Name of the call handler function |
| tmplinline | text | Name of the anonymous block handler (**NULL** if no name of the block handler exists) |
| tmplvalidator | text | Name of the verification function (**NULL** if no verification function is available) |
| tmpllibrary | text | Path of the shared library that implements languages |

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| Name | Type | Description |
| --- | --- | --- |
| tmplacl | aclitem[] | Access permissions for template (not yet used) |

## 15.2.78 PG_PROC

**PG_PROC** records information about functions or procedures.

**Table 15-76** PG_PROC columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| proname | name | Function name |
| pronamespace | oid | OID of the namespace that contains the function |
| proowner | oid | Owner of the function |
| prolang | oid | Implementation language or call interface of the function |
| procost | real | Estimated execution cost |
| prorows | real | Estimated number of rows that are influenced |
| provariadic | oid | Data type of parameter element |
| protransform | regproc | Simplified call method for the function |
| proisagg | boolean | Whether the function is an aggregate function<br>● **t** (true): yes<br>● **f** (false): no |
| proiswindow | boolean | Whether the function is a window function<br>● **t** (true): yes<br>● **f** (false): no |
| prosecdef | boolean | Whether the function is a security definer (or a "setuid" function)<br>● **t** (true): yes<br>● **f** (false): no |
| proleakproof | boolean | Whether the function has side effects. If no leakproof treatment is provided for parameters, the function throws errors.<br>● **t** (true): There is no side effect.<br>● **f** (false): There are side effects. |

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| Name | Type | Description |
| --- | --- | --- |
| proisstrict | boolean | The function returns null if any call parameter is null. In that case, the function is actually not called at all. Functions that are not "strict" must be prepared to process null inputs. |
| proretset | boolean | The function returns a set (multiple values of a specified data type). |
| provolatile | "char" | Whether the function's result depends only on its input parameters, or is affected by outside factors.<br>● **i**: for "immutable" functions, which always deliver the same result for the same inputs.<br>● **s**: for "stable" functions, whose results (for fixed inputs) do not change within a scan.<br>● **v**: for "volatile" functions, whose results may change at any time. Use **v** also for functions with side-effects, so that the engine cannot get optimized if volatile functions are called. |
| pronargs | smallint | Number of parameters |
| pronargdefaults | smallint | Number of parameters that have default values |
| prorettype | oid | Data type of return values |
| proargtypes | oidvector | Array that stores the data types of function parameters. This array includes only input parameters (including **INOUT** parameters), and represents the call signature (interface) of the function. |
| proallargtypes | oid[] | Array that contains the data types of function parameters. This array includes all parameter types (including **OUT** and **INOUT** parameters); however, if all the parameters are **IN** parameters, this column is null. Note that array subscripting is 1-based, whereas for historical reasons, **proargtypes** is subscripted from 0. |
| proargmodes | "char"[] | Array with the modes of the function parameters, encoded as follows:<br>● **i** indicates the IN parameter.<br>● **o** indicates the OUT parameter.<br>● **b** indicates the INOUT parameter.<br>● **v** indicates the VARIADIC parameter.<br>If all the parameters are **IN** parameters, this column is null. Note that subscripts correspond to positions of **proallargtypes**, not **proargtypes**. |

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| Name | Type | Description |
| --- | --- | --- |
| proargnames | text[] | Array that stores the names of the function parameters. Parameters without a name are set to empty strings in the array. If none of the parameters have a name, this column is null. Note that subscripts correspond to positions of **proallargtypes**, not **proargtypes**. |
| proargdefaults | pg_node_tree | Expression tree of the default value. This is the list of **pronargdefaults** elements. |
| prosrc | text | A definition that describes a function or stored procedure. In an interpreting language, it is the function source code, a link symbol, a file name, or any body content specified when a function or stored procedure is created, depending on how a language or call is used. |
| probin | text | Additional information about how to call the function. Again, the interpretation is language-specific. |
| proconfig | text[] | Function's local settings for run-time configuration variables. |
| proacl | aclitem[] | Access permission. For details, see **12.14.140 GRANT** and **12.14.154 REVOKE**. |
| prodefaultargpos | int2vector | Position of the input parameter of a function with a default value. |
| fencedmode | boolean | Execution mode of a function, indicating whether the function is executed in fence or not fence mode. If the execution mode is **fence,** the function is executed in the fork process that is reworked.<br>In the C function created by the user, the default value of fencedmode is **true**, indicating the fence mode. For built-in functions in the system, the fencedmode field is set to **false**, indicating the not fence mode. |
| proshippable | boolean | Specifies whether the function can be pushed down to DNs for execution. The default value is **false**.<br>• Functions of the **IMMUTABLE** type can always be pushed down to DNs.<br>• Functions of the **STABLE** or **VOLATILE** type can be pushed down to DNs only if their attribute is **SHIPPABLE**. |

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| Name | Type | Description |
| --- | --- | --- |
| propackage | boolean | Whether the function supports overloading. The default value is **false**.<br>● **t** (true): supported.<br>● **f** (false): not supported. |
| prokind | "char" | Whether the object is a function or a stored procedure<br>● **'f'** indicates that the object is a function.<br>● **'p'** indicates that the object is a stored procedure. |
| proargsrc | text | Describes the parameter input strings of functions or stored procedures that are compatible with Oracle syntax, including parameter comments. The default value is **NULL**. |
| proisprivate | boolean | Whether a function is a private function in the package. The default value is **false**. |
| propackageid | oid | OID of the package to which the function belongs. If the function is not in the package, the value is **0**. |
| proargtypesext | oidvector_extend | Data type array used to store function parameters when there are a large number of function parameters. This array includes only input parameters (including **INOUT** parameters), and represents the call signature (interface) of the function. |
| prodefaultargposext | int2vector_extend | Position of the input parameter with a default value when the function has a large number of parameters. |
| allargtypes | oidvector | All stored procedure parameters (including input parameters, output parameters, and INOUT parameters), regardless of the parameter type. |
| allargtypesext | oidvector_extend | Data type array used to store function parameters when there are a large number of function parameters. All parameters (including input parameters, output parameters, and INOUT parameters) are included. |

## 15.2.79 PG_PUBLICATION

**PG_PUBLICATION** contains all publications created in the current database.

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**Table 15-77** PG_PUBLICATION columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| pubname | name | Publication name |
| pubowner | oid | Publication owner |
| puballtables | boolean | If the value is **true**, this publication automatically includes all tables in the database, including any tables that will be created in the future. |
| pubinsert | boolean | If the value is **true**, copy the INSERT operation on tables in the publication. |
| pubupdate | boolean | If the value is **true**, copy the UPDATE operation on tables in the publication. |
| pubdelete | boolean | If the value is **true**, copy the DELETE operation on tables in the publication. |

## 15.2.80 PG_PUBLICATION_REL

**PG_PUBLICATION_REL** contains mappings between tables and publications in the current database. This is a many-to-many mapping.

**Table 15-78** PG_PUBLICATION_REL columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified). |
| prpubid | oid | - | Reference to a publication |
| prrelid | oid | - | Reference to a table |

## 15.2.81 PG_RANGE

**PG_RANGE** records information about range types. Entries in **15.2.101 PG_TYPE** are excluded.

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**Table 15-79** PG_RANGE columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| rngtypid | oid | 15.2.101 PG_TYPE.oid | OID of the range type |
| rngsubtype | oid | 15.2.101 PG_TYPE.oid | OID of the element type (subtype) of this range type |
| rngcollation | oid | 15.2.47 PG_COLLATION.oid | OID of the collation used for range comparisons (**0** if none) |
| rngsubopc | oid | 15.2.73 PG_OPCLASS.oid | OID of the subtype's operator class used for range comparisons |
| rngcanonical | regproc | 15.2.78 PG_PROC.proname | Name of the function to convert a range value into canonical form (**0** if none) |
| rngsubdiff | regproc | 15.2.78 PG_PROC.proname | Name of the function to return the difference between two element values as **double precision** (**0** if none) |

**rngsubopc** (together with **rngcollation**, if the element type is collatable) determines the sort ordering used by the range type. **rngcanonical** is used when the element type is discrete.

## 15.2.82 PG_REPLICATION_ORIGIN

**PG_REPLICATION_ORIGIN** contains all created replication sources and is shared among all databases in a cluster. Each instance has only one copy of **PG_REPLICATION_ORIGIN**, not one copy per database instance.

**Table 15-80** PG_REPLICATION_ORIGIN columns

| Name | Type | Description |
| --- | --- | --- |
| roident | oid | Unique replication source identifier within a cluster |
| roname | text | External user-defined replication source name |

## 15.2.83 PG_RESOURCE_POOL

**PG_RESOURCE_POOL** provides information about database resource pools.

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**Table 15-81** PG_RESOURCE_POOL columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| respool_name | name | Name of a resource pool |
| mem_percent | integer | Percentage of the memory configuration |
| cpu_affinity | bigint | Value of cores bound to the CPU |
| control_group | name | Name of the Cgroup where the resource pool is located |
| active_statements | integer | Maximum number of concurrent statements in the resource pool |
| max_dop | integer | Maximum scanning concurrency during data redistribution. This column is used for scaling. |
| memory_limit | name | Maximum memory of the resource pool |
| parentid | oid | OID of the parent resource pool |
| io_limits | integer | Upper limit of I/O operations per second. It is counted by ones for column storage and by 10 thousands for row storage. |
| io_priority | name | I/O priority set for jobs that consume many I/O resources. It takes effect when I/O usage reaches 90%. |
| nodegroup | name | Name of the logical cluster to which the resource pool belongs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| is_foreign | boolean | Whether the resource pool can be used for users outside the logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) If it is set to **true**, the resource pool controls the resources of common users who do not belong to the current resource pool. If it is set to **false**, the resources of common users who do not belong to the current resource pool are not controlled. |
| max_worker | integer | Concurrency in a table during data redistribution. This column is used only for scaling. |

## 15.2.84 PG_REWRITE

**PG_REWRITE** records rewrite rules defined for tables and views.

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**Table 15-82** PG_REWRITE columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| rulename | name | Name of a rule |
| ev_class | oid | Name of the table that uses the rule |
| ev_attr | smallint | Column to which this rule applies (always **0** to indicate the entire table) |
| ev_type | "char" | Event type for this rule<br>● 1 = SELECT<br>● 2 = UPDATE<br>● 3 = INSERT<br>● 4 = DELETE |
| ev_enabled | "char" | Controls the mode in which the rule is triggered.<br>● **O**: The rule is triggered in origin and local modes.<br>● **D**: The rule is disabled.<br>● **R**: The rule is triggered in replica mode.<br>● **A**: The rule is always triggered. |
| is_instead | boolean | The value is **true** if the rule is of the **INSTEAD** type. |
| ev_qual | pg_node_tree | Expression tree (in the form of a **nodeToString**() representation) for the rule's qualifying condition |
| ev_action | pg_node_tree | Query tree (in the form of a **nodeToString**() representation) for the rule's action |

## 15.2.85 PG_RLSPOLICY

**PG_RLSPOLICY** records row-level access control policies.

**Table 15-83** PG_RLSPOLICY columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| polname | name | Name of an access control policy |

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| Name | Type | Description |
| --- | --- | --- |
| polrelid | oid | OID of the table object on which the row-level access control policy takes effect |
| polcmd | "char" | SQL operations affected by the row-level access control policy |
| polpermissive | boolean | Attribute of the row-level access control policy. **t** indicates an expression that uses the OR condition, and **f** indicates an expression that uses the AND condition. |
| polroles | oid[] | OID list of users affected by the row-level access control policy. If this parameter is not specified, all users are affected. |
| polqual | pg_node_tree | Expression of the row-level access control policy |

## 15.2.86 PG_SECLABEL

**PG_SECLABEL** records security labels on database objects.

See also **15.2.89 PG_SHSECLABEL**, which provides a similar function for security labels of database objects that are shared across a database cluster.

**Table 15-84** PG_SECLABEL columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| objoid | oid | Any OID column | OID of the object that this security label pertains to |
| classoid | oid | **15.2.46 PG_CLASS**.oid | OID of the system catalog where the object appears |
| objsubid | integer | - | Column number for a security label on a table column |
| provider | text | - | Label provider associated with the label |
| label | text | - | Security label applied to the object |

## 15.2.87 PG_SHDEPEND

**PG_SHDEPEND** records the dependency between database objects and shared objects, such as roles. Based on this information, GaussDB can ensure that those objects are unreferenced before attempting to delete them.

See also **15.2.53 PG_DEPEND**, which provides a similar function for dependencies involving objects within a single database.

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Unlike most system catalogs, **PG_SHDEPEND** is shared across all databases of a cluster. There is only one copy of **PG_SHDEPEND** per database cluster, not one per database.

**Table 15-85** PG_SHDEPEND columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| dbid | oid | 15.2.50 PG_DATABASE.oid | OID of the database where a dependent object is (**0** for a shared object) |
| classid | oid | 15.2.46 PG_CLASS.oid | OID of the system catalog where the dependent object is |
| objid | oid | Any OID column | OID of the dependent object |
| objsubid | integer | - | Column number for a table column (**objid** and **classid** refer to the table itself); **0** for all other object types |
| refclassid | oid | 15.2.46 PG_CLASS.oid | OID of the system catalog where a referenced object is (must be a shared catalog) |
| refobjid | oid | Any OID column | OID of the referenced object |
| deptype | "char" | - | Code segment defining the specific semantics of this dependency relationship. See the following for details. |
| objfile | text | - | Path of a user-defined C function library file |

In all cases, a **PG_SHDEPEND** entry indicates that the referenced object cannot be dropped without also dropping the dependent object. However, there are several subflavors identified by **deptype**:

- SHARED_DEPENDENCY_OWNER (o)

  The referenced object (which must be a role) is the owner of the dependent object.

- SHARED_DEPENDENCY_ACL (a)

  The referenced object (which must be a role) is mentioned in the access control list (ACL) of the dependent object. A **SHARED_DEPENDENCY_ACL** entry is not made for the owner of the object, since the owner will have a **SHARED_DEPENDENCY_OWNER** entry anyway.

- SHARED_DEPENDENCY_PIN (p)

  There is no dependent object. This type of entry is a signal that the system itself depends on the referenced object, and so that object cannot be deleted.

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Entries of this type are created only by **initdb**. The columns for the dependent object contain zeroes.

- SHARED_DEPENDENCY_ DBPRIV(d)

  The referenced object (must be a role) has the ANY permission on the dependent object (the specified OID of the dependent object corresponds to a row in the **GS_DB_PRIVILEGE** system catalog).

## 15.2.88 PG_SHDESCRIPTION

**PG_SHDESCRIPTION** records optional comments for shared database objects. Descriptions can be manipulated with the **COMMENT** command and viewed with psql's **\d** commands.

See also **PG_DESCRIPTION**, which provides a similar function for descriptions involving objects within a single database.

Unlike most system catalogs, **PG_SHDESCRIPTION** is shared across all databases of a cluster. There is only one copy of **PG_SHDESCRIPTION** per cluster, not one per database.

**Table 15-86** PG_SHDESCRIPTION columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| objoid | oid | Any OID column | OID of the object that this description pertains to |
| classoid | oid | 15.2.46 PG_CLASS.oid | OID of the system catalog where the object appears |
| description | text | - | Arbitrary text that serves as the description of the object |

## 15.2.89 PG_SHSECLABEL

**PG_SHSECLABEL** records security labels on shared database objects. Security labels can be manipulated with the **SECURITY LABEL** command.

For an easier way to view security labels, see **15.3.139 PG_SECLABELS**.

See also **15.2.86 PG_SECLABEL**, which provides a similar function for security labels involving objects within a single database.

Unlike most system catalogs, **PG_SHSECLABEL** is shared across all databases of a cluster. There is only one copy of **PG_SHSECLABEL** per cluster, not one per database.

**Table 15-87** PG_SHSECLABEL columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| objoid | oid | Any OID column | OID of the object that this security label pertains to |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| classoid | oid | 15.2.46 PG_CLASS.oid | OID of the system catalog where the object appears |
| provider | text | - | Label provider associated with the label |
| label | text | - | Security label applied to the object |

## 15.2.90 PG_STATISTIC

**PG_STATISTIC** records statistics about tables and index columns in a database. By default, only the system administrator can access the system catalog. Common users can access the system catalog only after being authorized.

**Table 15-88** PG_STATISTIC columns

| Name | Type | Description |
| --- | --- | --- |
| starelid | oid | Table or index that the described column belongs to |
| starelkind | "char" | Type of an object |
| staattnum | smallint | Number of the described column in the table, starting from 1 |
| stainherit | boolean | Whether to collect statistics on objects that have inheritance relationship |
| stanullfrac | real | Percentage of column entries that are null |
| stawidth | integer | Average stored width, in bytes, of non-null entries |
| stadistinct | real | Number of distinct, non-null data values in the column for all DNs<br>• A value greater than 0 is the actual number of distinct values.<br>• A value less than 0 is the negative of a multiplier for the number of rows in the table. (For example, **stadistinct=-0.5** indicates that values in a column appear twice on average.)<br>• The value **0** indicates that the number of distinct values is unknown. |
| stakindN | smallint | Code number stating that the type of statistics is stored in slot N of the **pg_statistic** row<br>Value range: 1 to 5 |

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| Name | Type | Description |
| --- | --- | --- |
| staopN | oid | Operator used to generate the statistics stored in slot N. For example, a histogram slot shows the < operator that defines the sort order of the data.<br>Value range: 1 to 5 |
| stanumbersN | real[] | Numerical statistics of the appropriate type for slot N. The value is **NULL** if the slot does not involve numerical values.<br>Value range: 1 to 5 |
| stavaluesN | anyarray | Column data values of the appropriate type for slot N. The value is **NULL** if the slot type does not store any data values. Each array's element values are actually of the specific column's data type so there is no way to define these columns' type more specifically than anyarray.<br>Value range: 1 to 5 |
| stadndistinct | real | Number of unique non-null data values in the **dn1** column<br>• A value greater than 0 is the actual number of distinct values.<br>• A value less than 0 is the negative of a multiplier for the number of rows in the table. (For example, **stadistinct=-0.5** indicates that values in a column appear twice on average.)<br>• The value **0** indicates that the number of distinct values is unknown. |
| staextinfo | text | Information about extension statistics. This is reserved. |

NOTICE

**PG_STATISTIC** stores sensitive information about statistical objects, such as MCVs. The system administrator and authorized users can access the **PG_STATISTIC** system catalog to query the sensitive information about the statistical objects.

## 15.2.91 PG_STATISTIC_EXT

**PG_STATISTIC_EXT** displays extended statistics of tables in a database, such as statistics of multiple columns. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Statistics of expressions will be supported later. You can specify the extended statistics to collect. This system catalog is accessible only to users with the system administrator permission.

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**Table 15-89** PG_STATISTIC_EXT columns

| Name | Type | Description |
| --- | --- | --- |
| starelid | oid | Table or index that the described column belongs to. |
| starelkind | "char" | Type of an object. **'c'** indicates a table, and **'p'** indicates a partition. |
| stainherit | boolean | Specifies whether to collect statistics for objects that have inheritance relationship.<br>● **t** (true): yes<br>● **f** (false): no |
| stanullfrac | real | Percentage of column entries that are null. |
| stawidth | integer | Average stored width, in bytes, of non-null entries. |
| stadistinct | real | Number of distinct, non-null data values in the column for all DNs.<br>● A value greater than 0 is the actual number of distinct values.<br>● A value less than 0 is the negative of a multiplier for the number of rows in the table. (For example, **stadistinct=-0.5** indicates that values in a column appear twice on average.)<br>● The value **0** indicates that the number of distinct values is unknown. |
| stadndistinct | real | Number of unique non-null data values in the **dn1** column.<br>● A value greater than 0 is the actual number of distinct values.<br>● A value less than 0 is the negative of a multiplier for the number of rows in the table. (For example, **stadistinct=-0.5** indicates that values in a column appear twice on average.)<br>● The value **0** indicates that the number of distinct values is unknown. |
| stakindN | smallint | Code number stating that the type of statistics is stored in slot N of the **pg_statistic** row.<br>Value range: 1 to 5 |
| staopN | oid | Operator used to generate the statistics stored in slot N. For example, a histogram slot shows the < operator that defines the sort order of the data.<br>Value range: 1 to 5 |
| stakey | int2vector | Array of a column ID. |

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| Name | Type | Description |
| --- | --- | --- |
| stanumbersN | real[] | Numerical statistics of the appropriate type for slot N. The value is **NULL** if the slot does not involve numerical values.<br>Value range: 1 to 5 |
| stavaluesN | anyarray | Column data values of the appropriate type for slot N. The value is **NULL** if the slot type does not store any data values. Each array's element values are actually of the specific column's data type so there is no way to define these columns' type more specifically than anyarray.<br>Value range: 1 to 5 |
| staexprs | pg_node_tree | Expression corresponding to the extended statistics information. |

**NOTICE**

**PG_STATISTIC_EXT** stores sensitive information about statistical objects, such as MCVs. The system administrator and authorized users can access the **PG_STATISTIC_EXT** system catalog to query the sensitive information about the statistical objects.

## 15.2.92 PG_SUBSCRIPTION

**PG_SUBSCRIPTION** contains all existing logical replication subscriptions. This system catalog is accessible only to system administrators.

Unlike most system catalogs, **PG_SUBSCRIPTION** is shared across all databases in a cluster. Each cluster has only one copy of **PG_SUBSCRIPTION**, not one copy per database.

**Table 15-90** PG_SUBSCRIPTION columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified). |
| subdbid | oid | OID of the database where the subscription is located |
| subname | name | Subscription name |
| subowner | oid | Subscription owner |

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| Name | Type | Description |
| --- | --- | --- |
| subenabled | boolean | If the value is **true**, the subscription is enabled and should be replicated. |
| subconninfo | text | Information about the connection to the publisher database |
| subslotname | name | Name of the replication slot in the publisher database If this parameter is left empty, the value is **NONE**. |
| subsynccommit | text | Value of **synchronous_commit** of the subscription worker |
| subpublications | text[] | Array containing names of subscribed publications. These are publications referenced from the publisher server. |

## 15.2.93 PG_SYNONYM

**PG_SYNONYM** records the mapping between synonym object names and other database object names.

**Table 15-91 PG_SYNONYM** columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Database object ID |
| synname | name | Synonym name |
| synnamespace | oid | OID of the namespace that contains the synonym |
| synowner | oid | Owner of the synonym, usually the OID of the user who created it |
| synobjschema | name | Schema name specified by the associated object |
| synobjname | name | Name of the associated object |

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## 15.2.94 PG_TABLESPACE

**PG_TABLESPACE** records tablespace information.

**Table 15-92** PG_TABLESPACE columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| spcname | name | Tablespace name |
| spcowner | oid | Owner of the tablespace, usually the user who created it |
| spcacl | aclitem[] | Access permissions. For details, see **12.14.140 GRANT** and **12.14.154 REVOKE**. |
| spcoptions | text[] | Options of the tablespace |
| spcmaxsize | text | Maximum size of the available disk space, in bytes |
| relative | boolean | Whether the storage path specified by the tablespace is a relative path<br>• **t (true)**: yes.<br>• **f (false)**: no. |

## 15.2.95 PG_TRIGGER

**PG_TRIGGER** records trigger information.

**Table 15-93** PG_TRIGGER columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| tgrelid | oid | OID of the table where the trigger is located |
| tgname | name | Trigger name |
| tgfoid | oid | Trigger OID |
| tgtype | smallint | Trigger type |

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| Name | Type | Description |
| --- | --- | --- |
| tgenabled | "char" | **O**: The trigger is triggered in origin or local mode.<br>**D**: The trigger is disabled.<br>**R**: The trigger is triggered in replica mode.<br>**A**: The trigger is always triggered. |
| tgisinternal | boolean | Internal trigger ID. If the value is **true**, it indicates an internal trigger. |
| tgconstrrelid | oid | Table referenced by the integrity constraint |
| tgconstrindid | oid | Index of the integrity constraint |
| tgconstraint | oid | OID of the constraint trigger in **PG_CONSTRAINT** |
| tgdeferrable | boolean | Whether the constraint trigger is of the DEFERRABLE type<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| tginitdeferred | boolean | Whether the trigger is of the INITIALLY DEFERRED type<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| tgnargs | smallint | Number of input parameters of the trigger function |
| tgattr | int2vector | Column ID specified by the trigger. If no column is specified, an empty array is used. |
| tgargs | bytea | Parameter transferred to the trigger |
| tgqual | pg_node_tree | WHEN condition of the trigger (**NULL** if the WHEN condition does not exist) |
| tgowner | oid | Trigger owner |

## 15.2.96 PG_TS_CONFIG

**PG_TS_CONFIG** contains entries representing text search configurations. A configuration specifies a particular text search parser and a list of dictionaries to use for each of the parser's output token types.

The parser is shown in the **PG_TS_CONFIG** entry, but the token-to-dictionary mapping is defined by subsidiary entries in **15.2.97 PG_TS_CONFIG_MAP**.

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**Table 15-94** PG_TS_CONFIG columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| cfgname | name | - | Text search configuration name |
| cfgnamespace | oid | 15.2.70 PG_NAMESPACE.oid | OID of the namespace that contains the configuration |
| cfgowner | oid | 15.2.42 PG_AUTHID.oid | Owner of the configuration |
| cfgparser | oid | 15.2.99 PG_TS_PARSER.oid | OID of the text search parser for this configuration |
| cfoptions | text[] | - | Configuration options |

## 15.2.97 PG_TS_CONFIG_MAP

**PG_TS_CONFIG_MAP** contains entries showing which text search dictionaries should be consulted, and in what order, for each output token type of each text search configuration's parser.

**Table 15-95** PG_TS_CONFIG_MAP columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| mapcfg | oid | 15.2.96 PG_TS_CONFIG.oid | OID of the 15.2.96 PG_TS_CONFIG entry owning this map entry |
| maptokentype | integer | - | Token type generated by the configuration's parser |
| mapseqno | integer | - | Sequence number of a token type when the values of **mapcfg** or **maptokentype** are the same. |
| mapdict | oid | 15.2.98 PG_TS_DICT.oid | OID of the text search dictionary to consult |

## 15.2.98 PG_TS_DICT

**PG_TS_DICT** contains entries that define text search dictionaries. A dictionary depends on a text search template, which specifies all the implementation functions needed; the dictionary itself provides values for the user-settable parameters supported by the template.

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This division of labor allows dictionaries to be created by unprivileged users. The parameters are specified by a text string **dictinitoption**, whose format and meaning vary depending on the template.

**Table 15-96** PG_TS_DICT columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| dictname | name | - | Text search dictionary name |
| dictnamespace | oid | 15.2.70 PG_NAMESPACE.oid | OID of the namespace that contains the dictionary |
| dictowner | oid | 15.2.42 PG_AUTHID.oid | Owner of the dictionary |
| dicttemplate | oid | 15.2.100 PG_TS_TEMPLATE.oid | OID of the text search template for the dictionary |
| dictinitoption | text | - | Initialization option string for the template |

## 15.2.99 PG_TS_PARSER

**PG_TS_PARSER** contains entries defining text search parsers. A parser is responsible for splitting input text into lexemes and assigning a token type to each lexeme. Since a parser must be implemented by C-language-level functions, creation of new parsers is restricted to database superusers.

**Table 15-97** PG_TS_PARSER columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| prsname | name | - | Text search parser name |
| prsnamespace | oid | 15.2.70 PG_NAMESPACE.oid | OID of the namespace that contains the parser |
| prsstart | regproc | 15.2.78 PG_PROC.proname | Name of the parser's startup function |
| prstoken | regproc | 15.2.78 PG_PROC.proname | Name of the parser's next-token function |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| prsend | regproc | 15.2.78 PG_PROC.proname | Name of the parser's shutdown function |
| prsheadline | regproc | 15.2.78 PG_PROC.proname | Name of the parser's headline function |
| prslextype | regproc | 15.2.78 PG_PROC.proname | Name of the parser's lextype function |

## 15.2.100 PG_TS_TEMPLATE

**PG_TS_TEMPLATE** contains entries defining text search templates. A template provides a framework for text search dictionaries. Since a template must be implemented by C-language-level functions, templates can be created only by database administrators.

**Table 15-98** PG_TS_TEMPLATE columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| tmplname | name | - | Text search template name |
| tmplnamespace | oid | 15.2.70 PG_NAMESPACE.oid | OID of the namespace that contains the template |
| tmplinit | regproc | 15.2.78 PG_PROC.proname | Name of the template's initialization function |
| tmpllexize | regproc | 15.2.78 PG_PROC.proname | Name of the template's lexize function |

## 15.2.101 PG_TYPE

**PG_TYPE** stores information about data types.

**Table 15-99** PG_TYPE columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| typname | name | Data type name |

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| Name | Type | Description |
| --- | --- | --- |
| typnamespace | oid | OID of the namespace that contains the type |
| typowner | oid | Owner of the type |
| typlen | smallint | Number of bytes in the internal representation of the type for a fixed-size type. It is a negative number for a variable-length type.<br>• The value **-1** indicates a "varlena" type (one that has a length word).<br>• The value **-2** indicates a null-terminated C string. |
| typbyval | boolean | Specifies whether to pass a value (**true**) or a reference (**false**) when a value of this type is passed internally. **typbyval** is **false** if the type of **typlen** is not **1**, **2**, **4**, or **8**, because values of this type are always passed by reference of this column. **typbyval** can be **false** even if the **typlen** is passed by a parameter of this column. |
| typtype | "char" | • **b**: base type.<br>• **c**: composite type (for example, a table's row type)<br>• **d**: domain<br>• **p**: pseudo<br>• **r**: range<br>• **e**: enumeration<br>• **o**: set type<br>For details, see **typrelid** and **typbasetype**. |
| typcategory | "char" | **typcategory** is an arbitrary classification of data types that is used by the parser to determine which implicit casts should be preferred. |
| typispreferred | boolean | The value is **true** if conversion is performed when data meets conversion rules specified by **typcategory**. Otherwise, the conversion is not performed. |
| typisdefined | boolean | Whether a type has been defined. It is **true** if the type is defined, and **false** if this is a placeholder entry for a not-yet-defined type. When it is **false**, nothing except the type name, namespace, and OID can be relied on. |
| typdelim | "char" | Character that separates two values of this type when parsing an array input. Note that the delimiter is associated with the array element data type, not the array data type. |

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| Name | Type | Description |
| --- | --- | --- |
| typrelid | oid | If this is a composite type (see **typtype**), then this column points to the **PG_CLASS** entry that defines the corresponding table. For a free-standing composite type, the **PG_CLASS** entry does not represent a table, but it is required for the type's **PG_ATTRIBUTE** entries to link to. It is **0** for non-composite type. |
| typelem | oid | If **typelem** is not **0**, it identifies another row in **PG_TYPE**. The current type can be described as an array yielding values of type **typelem**. A "true" array type has a variable length (**typlen** = **-1**), but some fixed-length types (**typlen** > **0**) also have non-zero **typelem**, for example **name** and **point**. If a fixed-length type has a **typelem**, its internal representation must be a number of values of the **typelem** data type with no other data. Variable-length array types have a header defined by the array subroutines. |
| typarray | oid | If the value is not **0**, the corresponding type record is available in **PG_TYPE**. |
| typinput | regproc | Input conversion function (text format) |
| typoutput | regproc | Output conversion function (text format) |
| typreceive | regproc | Input conversion function (binary format); **0** for non-input conversion function |
| typsend | regproc | Output conversion function (binary format); **0** for non-output conversion function |
| typmodin | regproc | Type modifier input function; **0** if the type does not support modifiers |
| typmodout | regproc | Type modifier output function; **0** if the type does not support modifiers |
| typanalyze | regproc | Custom **ANALYZE** function; **0** if the standard function is used |

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| Name | Type | Description |
| --- | --- | --- |
| typalign | "char" | Alignment required when storing a value of this type. It applies to storage on disks as well as most representations of the value. When multiple values are stored consecutively, such as in the representation of a complete row on disk, padding is inserted before a data of this type so that it begins on the specified boundary. The alignment reference is the beginning of the first datum in the sequence. Possible values are:<br>• **c**: char alignment, that is, no alignment needed<br>• **s**: short alignment (2 bytes on most machines)<br>• **i**: integer alignment (4 bytes on most machines)<br>• **d**: double alignment (8 bytes on many machines, but by no means all)<br>**NOTICE**<br>For types used in system tables, the size and alignment defined in **PG_TYPE** must agree with the way that the compiler lays out the column in a structure representing a table row. |
| typstorage | "char" | **typstorage** tells for varlena types (those with **typlen = -1**) if the type is prepared for toasting and what the default strategy for attributes of this type should be. Possible values are:<br>• **p**: Values are always stored plain.<br>• **e**: Value can be stored in a secondary relationship (if the relation has one, see **pg_class.reltoastrelid**).<br>• **m**: Values can be stored compressed inline.<br>• **x**: Values can be stored compressed inline or stored in secondary storage.<br>**NOTICE**<br>**m** domains can also be moved out to secondary storage, but only as a last resort (**e** and **x** domains are moved first). |
| typnotnull | boolean | Whether the type has a NOTNULL constraint. Currently, it is used for domains only. |
| typbasetype | oid | If this is a domain (see **typtype**), then **typbasetype** identifies the type that this one is based on. The value is **0** if this type is not a derived type. |
| typtypmod | integer | Records the **typtypmod** to be applied to domains' base types by domains (the value is **–1** if the base type does not use **typmod**). This is **–1** if this type is not a domain. |

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| Name | Type | Description |
| --- | --- | --- |
| typndims | integer | Number of array dimensions for a domain that is an array (**typbasetype** is an array type; the domain's **typelem** matches the base type's **typelem**). This is **0** for types other than domains over array types. |
| typcollation | oid | Sorting rule of a specified type. For details about the values, see the **15.2.47 PG_COLLATION** system catalog. (**0** if sequencing is not supported) |
| typdefaultbin | pg_node_tree | **nodeToString()** representation of a default expression for the type if the value is non-null. Currently, this column is only used for domains. |
| typdefault | text | The value is **NULL** if a type has no associated default value. If **typdefaultbin** is not set to **NULL**, **typdefault** must contain a default expression represented by **typdefaultbin**. If **typdefaultbin** is **NULL** and **typdefault** is not, then **typdefault** is the external representation of the type's default value, which can be fed to the type's input converter to produce a constant. |
| typacl | aclitem[] | Access permission |

## 15.2.102 PG_USER_MAPPING

**PG_USER_MAPPING** records mappings from local users to remote.

This system catalog is accessible only to system administrators. Common users can query the **15.3.183 PG_USER_MAPPINGS** view.

**Table 15-100** PG_USER_MAPPING columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| oid | oid | - | Row identifier (hidden attribute, which must be specified) |
| umuser | oid | **15.2.42 PG_AUTHID**.oid | OID of the local role being mapped (**0** if the user mapping is public) |
| umserver | oid | **15.2.60 PG_FOREIGN_SERVER**.oid | OID of the foreign server that contains the mapping |
| umoptions | text[] | - | User mapping specific options, expressed in a string in the format of keyword=value |

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## 15.2.103 PG_USER_STATUS

**PG_USER_STATUS** provides the states of users who access the database. This system catalog is accessible only to users with the system administrator permission.

**Table 15-101** PG_USER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| roloid | oid | ID of a role |
| failcount | integer | Number of failed attempts |
| locktime | timestamp with time zone | Time at which the role is locked |
| rolstatus | smallint | Role state<br>• **0**: normal<br>• **1**: The role is locked for a specific period of time because the failed login attempts exceed the threshold.<br>• **2**: The role is locked by the administrator. |
| permspace | bigint | Size of the permanent table storage space used by a role |
| tempspace | bigint | Size of the temporary table storage space used by a role |
| password expired | smallint | Whether a password is valid.<br>• **0**: The password is valid.<br>• **1**: The password is invalid. |

## 15.2.104 PG_WORKLOAD_GROUP

**PG_WORKLOAD_GROUP** provides workload group information in the database.

**Table 15-102** PG_WORKLOAD_GROUP columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| workload_gpname | name | Workload group name |
| respool_oid | oid | ID bound to the resource pool |

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| Name | Type | Description |
| --- | --- | --- |
| act_statements | integer | Maximum number of active statements in the workload group |

## 15.2.105 PGXC_CLASS

**PGXC_CLASS** records replicated or distributed information for each table.

**Table 15-103** PGXC_CLASS columns

| Name | Type | Description |
| --- | --- | --- |
| pcrelid | oid | OID of the table |
| pclocatortype | "char" | Locator type<br>• **H**: Hash<br>• **G**: Range<br>• **L**: List<br>• **M**: Modulo<br>• **N**: Round Robin<br>• **R**: Replication |
| pchashalgorithm | smallint | Distributed tuple using the hash algorithm |
| pchashbuckets | smallint | Value of a harsh container |
| pgroup | name | Name of the node |
| redistributed | "char" | Indicates that a table has been redistributed. |
| redis_order | integer | Redistribution sequence. Tables whose values are **0** will not be redistributed in this round of redistribution. |
| pcattnum | int2vector | Column number used as a distributed key |
| nodeoids | oidvector_extend | List of distributed table node OIDs |
| options | text | Extension status information. This is a reserved column in the system. |

## 15.2.106 PGXC_GROUP

**PGXC_GROUP** records information about storage node groups.

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**Table 15-104** PGXC_GROUP columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |
| group_name | name | Name of a node group |
| in_redistribution | "char" | Whether redistribution is required. The value must be one of the following:<br>• **n**: The node group is not redistributed.<br>• **y**: The source node group is in redistribution.<br>• **t**: The destination node group is in redistribution. |
| group_members | oidvector_extend | Node OID list of the node group |
| group_buckets | text | Distributed data bucket group |
| is_installation | boolean | Whether to install a sub-cluster<br>• **t** (true): yes<br>• **f** (false): no |
| group_acl | aclitem[] | Access permission |
| group_kind | "char" | Node group type. The value can be **i**, **n**, **v**, or **e**.<br>• **i**: installation node group<br>• **n**: node group in a common, non-logical cluster<br>• **v**: node group in a logical cluster (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)<br>• **e**: elastic cluster |
| group_parent | oid | For a child node group, this field indicates the OID of the parent node group. For a parent node group, this field is left blank. |

## 15.2.107 PGXC_NODE

**PGXC_NODE** records information about cluster nodes.

**Table 15-105** PGXC_NODE columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | Row identifier (hidden attribute, which must be specified) |

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| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| node_type | "char" | Node type<br>• **C**: CN<br>• **D**: DN<br>• **S**: standby DN. |
| node_port | integer | Port ID of the node |
| node_host | name | Host name or IP address of a node. (If a virtual IP address is configured, its value is a virtual IP address.) |
| node_port1 | integer | Port number of a replication node |
| node_host1 | name | Host name or IP address of a replication node. (If a virtual IP address is configured, its value is a virtual IP address.) |
| hostis_primary | boolean | Whether a switchover occurs between the primary and standby servers on the current node<br>• **t** (true): yes<br>• **f** (false): no |
| nodeis_primary | boolean | Whether the current node is preferred to execute non-query operations in the **replication** table<br>• **t** (true): yes<br>• **f** (false): no |
| nodeis_preferred | boolean | Whether the current node is preferred to execute queries in the **replication** table<br>• **t** (true): yes<br>• **f** (false): no |
| node_id | integer | Node identifier. The value is obtain by calculating the value of **node_name** using the hash function. |
| sctp_port | integer | Port used by the TCP proxy communication library or SCTP communication library of the primary node to listen on the data channel. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) |
| control_port | integer | Port used by the TCP proxy communications library of the primary node to listen on the control channel |

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| Name | Type | Description |
| --- | --- | --- |
| sctp_port1 | integer | Port used by the TCP proxy communication library or SCTP communication library (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) of the standby node to listen on the data channel |
| control_port1 | integer | Port used by the TCP proxy communications library of the standby node to listen on the control channel |
| nodeis_central | boolean | Whether the current node is a central control node. It is used only for CNs and is invalid for DNs.<br>• **t** (true): yes<br>• **f** (false): no |
| nodeis_active | boolean | Indicates whether the current node is normal. It is used to mark whether the CN is removed and is invalid for DNs.<br>• **t** (true): yes<br>• **f** (false): no |

## 15.2.108 PGXC_REDISTB

**PGXC_REDISTB** is created during scale-out for each database to record the redistribution status of user tables. It will be deleted after scale-out. Only users with the **connect** permission can view the information.

**Table 15-106**

| Name | Type | Description |
| --- | --- | --- |
| relname | name | Name of a user table. |
| nspname | name | Name of the tablespace that contains the table. |
| pcrelid | oid | OID of a table. |
| pclocatortype | character | Locator type.<br>H: hash<br>M: Modulo<br>N: Round Robin<br>R: Replicate |
| pchashalgorithm | smallint | Distributed tuple using the hash algorithm. |

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| Name | Type | Description |
| --- | --- | --- |
| pchashbuckets | smallint | Value of a harsh container. |
| pgroup | name | Node group to which a table belongs. |
| redistributed | character | Catalog status.<br>**i**: Table is being redistributed.<br>**y**: Table redistribution is complete.<br>**n**: Table has not been redistributed.<br>**d**: The redistribution is complete, but the temporary table has not been deleted. |
| redis_order | interger | Table redistribution sequence. The default value is **1024**. The value **0** indicates that the table is not redistributed. A smaller value indicates that the table is redistributed first. |
| pcattnum | int2vector | Column number used as a distribution key. |
| nodeoids | oidvector_extend | Node ID of the node group where the table is located. |
| internal_mask | integer | Whether reloption contains internal information. Values are as follows:<br>**0X0**: The internal mask is disabled.<br>**0X8000**: The internal mask is enabled.<br>**0X01**: The insert operation is not allowed in this table.<br>**0X02**: The delete operation is not allowed in this table.<br>**0X04**: The alter operation is not allowed in this table.<br>**0X08**: The select operation is not allowed in this table.<br>**0X0100**: The update operation is not allowed in this table. |
| table_size | bigint | Size of a table, in bytes. |

## 15.2.109 PGXC_SLICE

**PGXC_SLICE** is a system catalog created for recording range distribution and list distribution details. Currently, range interval cannot be used to automatically scale out shards. It is reserved in the system catalog.

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**Table 15-107** PGXC_SLICE columns

| Name | Type | Description |
| --- | --- | --- |
| relname | name | Table name or shard name, which is distinguished by **type**. |
| type | "char" | When the value is **t**, relname indicates the table name. When the value is **s**, relname indicates the shard name. |
| strategy | "char" | **r**: range distribution table<br>**l**: list distribution table<br>This value will be extended for subsequent interval shards. |
| relid | oid | OID of the distribution table to which the tuple belongs. |
| referenceoid | oid | OID of the referenced distribution table, which is used for slice reference table creation syntax. |
| sindex | integer | Position of the current boundary in a shard when the table is a list distribution table. |
| interval | text[] | Reserved column |
| transitboundary | text[] | Reserved column |
| transitno | integer | Reserved column |
| nodeoid | oid | When **relname** is set to a shard name, **nodeoid** indicates the OID of the DN where the shard data is stored. |
| boundaries | text[] | When **relname** is set to a shard name, this parameter indicates the boundary value of the shard. |
| specified | boolean | Check whether the DN corresponding to the current segment is explicitly specified in the DDL. |
| sliceorder | integer | User-defined shard sequence. |

## 15.2.110 PLAN_TABLE_DATA

**PLAN_TABLE_DATA** stores plan information collected by **EXPLAIN PLAN**. Different from the **PLAN_TABLE** view, the system catalog **PLAN_TABLE_DATA** stores **EXPLAIN PLAN** information collected by all sessions and users.

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**Table 15-108** PLAN_TABLE_DATA columns

| Name | Type | Description |
| --- | --- | --- |
| session_id | text | Session that inserts the data. Its value consists of a service thread start timestamp and a service thread ID. Values are constrained by **NOT NULL**. |
| user_id | oid | User who inserts the data. Values are constrained by **NOT NULL**. |
| statement_id | character varying(30) | Query tag specified by a user |
| plan_id | bigint | Query plan ID. The ID is automatically generated in the plan generation phase and is used by kernel engineers for debugging. |
| id | integer | Node ID in a plan |
| operation | character varying(30) | Operation description |
| options | character varying(255) | Operation action |
| object_name | name | Name of an operated object. It is defined by users. |
| object_type | character varying(30) | Object type |
| object_owner | name | Schema to which an object belongs. It is defined by users. |
| projection | character varying(4000) | Returned column information |
| cost | double precision | Execution cost estimated by the optimizer for an operator |
| cardinality | double precision | Number of rows estimated by the optimizer for an operator |

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NOTE

- **PLAN_TABLE_DATA** records data of all users and sessions on the current node. Only administrators can access all the data. Common users can view their own data in the **15.3.214 PLAN_TABLE** view.
- Data of inactive (exited) sessions is cleaned from **PLAN_TABLE_DATA** by **gs_clean** after being stored in this system catalog for a certain period of time (5 minutes by default). You can also manually run **gs_clean -C** to delete inactive session data from the table. For details, see **"Server Tools > gs_clean"** in **Tool Reference**.
- Data is automatically inserted into **PLAN_TABLE_DATA** after **EXPLAIN PLAN** is executed. Therefore, do not manually insert data into or update data in **PLAN_TABLE_DATA**. Otherwise, data in **PLAN_TABLE_DATA** may be disordered. When you need to delete data from a table, it is recommended that you use the **15.3.214 PLAN_TABLE** view or see "Server Tools > gs_clean" in the *Tool Reference*.
- Information in the **statement_id**, **object_name**, **object_owner**, and **projection** columns is stored in letter cases specified by users and information in other columns is stored in uppercase.

# 15.2.111 STATEMENT_HISTORY

**STATEMENT_HISTORY** displays information about execution statements on the current node. To query this system catalog, you must have the sysadmin permission. The result can be queried only in the system database but cannot be queried in the user database.

The constraints on the query of this system catalog are as follows:

- Data must be queried in the Postgres database. No data exists in other databases.
- This system catalog is controlled by **track_stmt_stat_level**. The default value is **OFF,L0**, where the first part controls full SQL statements, and the second part controls slow SQL statements. For details about the record level of each field, see the following table.
- For slow SQL statements, if the value of **track_stmt_stat_level** is not **OFF** and the SQL execution time exceeds the value of **log_min_duration_statement**, the SQL statement is recorded as a slow SQL statement.

**Table 15-109** STATEMENT_HISTORY columns

| Name | Type | Description | Record Level |
| --- | --- | --- | --- |
| db_name | name | Database name. | L0 |
| schema_name | name | Schema name. | L0 |
| origin_node | integer | Node name. | L0 |
| user_name | name | Username. | L0 |
| application_name | text | Name of the application that sends a request. | L0 |

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| Name | Type | Description | Record Level |
| --- | --- | --- | --- |
| client_addr | text | IP address of the client that sends a request. | L0 |
| client_port | integer | Port number of the client that sends a request. | L0 |
| unique_query_id | bigint | ID of the normalized SQL statement. | L0 |
| debug_query_id | bigint | ID of the unique SQL statement. | L0 |
| query | text | Normalized SQL (available only on CNs). | L0 |
| start_time | timestamp with time zone | Time when a statement starts. | L0 |
| finish_time | timestamp with time zone | Time when a statement ends. | L0 |
| slow_sql_threshold | bigint | Standard for slow SQL statement execution. | L0 |
| transaction_id | bigint | Transaction ID. | L0 |
| thread_id | bigint | ID of an execution thread. | L0 |
| session_id | bigint | Session ID of a user. | L0 |
| n_soft_parse | bigint | Number of soft parsing times. The value of **n_soft_parse** plus **n_hard_parse** may be greater than that of **n_calls** because **n_calls** does not count the subquery. | L0 |
| n_hard_parse | bigint | Number of hard parsing times. The value of **n_soft_parse** plus **n_hard_parse** may be greater than that of **n_calls** because **n_calls** does not count the subquery. | L0 |
| query_plan | text | Statement execution plan. | L1 |
| n_returned_rows | bigint | Number of rows in the result set returned by the SELECT statement. | L0 |
| n_tuples_fetched | bigint | Number of rows randomly scanned. | L0 |

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| Name | Type | Description | Record Level |
| --- | --- | --- | --- |
| n_tuples_returned | bigint | Number of rows sequentially scanned. | L0 |
| n_tuples_inserted | bigint | Number of rows inserted. | L0 |
| n_tuples_updated | bigint | Number of rows updated. | L0 |
| n_tuples_deleted | bigint | Number of rows deleted. | L0 |
| n_blocks_fetched | bigint | Number of buffer block access times. | L0 |
| n_blocks_hit | bigint | Number of buffer block hits. | L0 |
| db_time | bigint | Valid DB time, which is accumulated if multiple threads are involved (unit: μs). | L0 |
| cpu_time | bigint | CPU time (unit: μs). | L0 |
| execution_time | bigint | Execution time in the executor (unit: μs). | L0 |
| parse_time | bigint | SQL parsing time (unit: μs). | L0 |
| plan_time | bigint | SQL plan generation time (unit: μs). | L0 |
| rewrite_time | bigint | SQL rewriting time (unit: μs). | L0 |
| pl_execution_time | bigint | Execution time of PL/pgSQL (unit: μs). | L0 |
| pl_compilation_time | bigint | Compilation time of PL/pgSQL (unit: μs). | L0 |
| data_io_time | bigint | I/O time (unit: μs). | L0 |
| net_send_info | text | Network status of messages sent through a physical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, CNs communicate with each other, CNs communicate with customer service ends, and CNs communicate with DNs through physical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system. Example: {"time":xxx, "n_calls":xxx, "size":xxx}. | L0 |

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| Name | Type | Description | Record Level |
| --- | --- | --- | --- |
| net_recv_info | text | Network status of messages received through a physical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, CNs communicate with each other, CNs communicate with customer service ends, and CNs communicate with DNs through physical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system. Example: {"time":xxx, "n_calls":xxx, "size":xxx}. | L0 |
| net_stream_send_info | text | Network status of messages sent through a logical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, DNs of different shards communicate with each other through logical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. | L0 |
| net_stream_recv_info | text | Network status of messages received through a logical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, DNs of different shards communicate with each other through logical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. | L0 |
| lock_count | bigint | Number of locks. | L0 |
| lock_time | bigint | Time required for locking. | L1 |
| lock_wait_count | bigint | Number of lock waits. | L0 |
| lock_wait_time | bigint | Time required for lock waiting. | L1 |

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| Name | Type | Description | Record Level |
| --- | --- | --- | --- |
| lock_max_count | bigint | Maximum number of locks. | L0 |
| lwlock_count | bigint | Number of lightweight locks (reserved). | L0 |
| lwlock_wait_count | bigint | Number of lightweight lock waits. | L0 |
| lwlock_time | bigint | Time required for lightweight locking (reserved). | L1 |
| lwlock_wait_time | bigint | Time required for lightweight lock waiting. | L1 |
| details | bytea | List of statement lock events, which are recorded in chronological order. The number of records is affected by the **track_stmt_details_size** parameter. This column is binary and needs to be read using the parsing function **pg_catalog.statement_detail_decode**. For details, see **Table 12-63**.<br>Events include:<br>Start locking.<br>Complete locking.<br>Start lock waiting.<br>Complete lock waiting.<br>Start unlocking.<br>Complete unlocking.<br>Start lightweight lock waiting.<br>Complete lightweight lock waiting. | L2 |
| is_slow_sql | boolean | Specifies whether the SQL statement is a slow SQL statement.<br>• **t** (true): yes<br>• **f** (false): no | L0 |
| trace_id | text | Driver-specific trace ID, which is associated with an application request. | L0 |

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| Name | Type | Description | Record Level |
| --- | --- | --- | --- |
| advise | text | Risks which may cause slow SQL statements. (Multiple risks may exist at the same time.)<br>• **Cast Function Cause Index Miss.**: Index matching may fail due to implicit conversion.<br>• **Limit too much rows.**: The SQL statement execution may slow down due to a large **limit** value.<br>• **Proleakproof of function is false.**: The **proleakproof** of the function is set to **false**. In this case, the function does not use statistics when generating a plan due to data leakage risks. As a result, the accuracy of the generated plan is affected and the SQL statement execution may slow down. | L0 |

## 15.2.112 STREAMING_STREAM

**STREAMING_STREAM** records the metadata of all STREAM objects.

**Table 15-110** STREAMING_STREAM column

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | STREAM object ID. |
| queries | bytea | Bitmap mapping of the CONTVIEW corresponding to the STREAM. |

## 15.2.113 STREAMING_CONT_QUERY

**STREAMING_CONT_QUERY** records the metadata of all CONTVIEW objects.

**Table 15-111** STREAMING_CONT_QUERY columns

| Name | Type | Description |
| --- | --- | --- |
| id | integer | Unique identifier of the CONTVIEW object. |

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| Name | Type | Description |
| --- | --- | --- |
| type | "char" | CONTVIEW type.<br>● **'c'** indicates that the CONTVIEW is based on the column-store model.<br>● **'r'** indicates that the CONTVIEW is based on the row-store model.<br>● **'p'** indicates that the CONTVIEW is based on the partitioned column-store model. |
| relid | oid | CONTVIEW object ID. |
| defrelid | oid | ID of the continuous computing rule view corresponding to CONTVIEW. |
| active | boolean | Whether the CONTVIEW is in the continuous computing state.<br>● **t** (true): yes<br>● **f** (false): no |
| streamrelid | oid | ID of STREAM corresponding to CONTVIEW. |
| matrelid | oid | ID of the materialized table corresponding to CONTVIEW. |
| lookupidxid | oid | ID of GROUP LOOK UP INDEX corresponding to CONTVIEW. This column is for internal use and is available only in row-store tables. |
| step_factor | smallint | CONTVIEW step mode. The main values are **0** (no overlapping window) and **1** (sliding window, with one step). |
| ttl | integer | Value of **ttl_interval** set by CONTVIEW. |
| ttl_attno | smallint | Number of a time column corresponding to the TTL function set by CONTVIEW. |
| dictrelid | oid | ID of the dictionary table corresponding to CONTVIEW. |
| grpnum | smallint | Number of dimension columns in the CONTVIEW continuous computing rule. This column is for internal use. |
| grpidx | int2vector | Index of the dimension column in TARGET LIST in the CONTVIEW continuous computing rule. This column is for internal use. |

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## 15.2.114 STREAMING_REAPER_STATUS

**STREAMING_REAPER_STATUS** records the status information about the reaper thread of the streaming engine. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

**Table 15-112** STREAMING_REAPER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| id | integer | Unique identifier of the CONTVIEW object. |
| contquery_name | name | Name of the CONTVIEW object. |
| gather_interval | text | Value of **gather_interval** (time parameter for automatically aggregating historical data before a specific time) set by the CONTVIEW object. |
| gather_completion_time | text | Time when the latest GATHER (historical data aggregation) of the CONTVIEW object is completed. |

# 15.3 System Views

## 15.3.1 ADM_COL_COMMENTS

**ADM_COL_COMMENTS** displays information about table column comments in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-113** ADM_COL_COMMENTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | character varying(64) | Column name |
| comments | text | Comments |

## 15.3.2 ADM_CONS_COLUMNS

**ADM_CONS_COLUMNS** displays information about constraint columns in database tables. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in the **PG_CATALOG** and **SYS** schemas.

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**Table 15-114** ADM_CONS_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Constraint creator |
| column_name | character varying(64) | Name of a constraint-related column |
| constraint_name | character varying(64) | Constraint name |
| position | smallint | Position of the column in the table |
| table_name | character varying(64) | Name of a constraint-related table |

## 15.3.3 ADM_CONSTRAINTS

**ADM_CONSTRAINTS** displays information about table constraints in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-115** ADM_CONSTRAINTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Constraint creator |
| constraint_name | character varying(64) | Constraint name |
| constraint_type | text | Constraint type<br>• **c**: check constraint<br>• **f**: foreign key constraint<br>• **p**: primary key constraint<br>• **u**: unique constraint |
| table_name | character varying(64) | Name of a constraint-related table |
| index_owner | character varying(64) | Owner of a constraint-related index (only for the unique constraint and primary key constraint) |
| index_name | character varying(64) | Name of the constraint-related index (only for the unique constraint and primary key constraint) |

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## 15.3.4 ADM_DATA_FILES

**ADM_DATA_FILES** displays the description of database files. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-116** ADM_DATA_FILES columns

| Name | Type | Description |
| --- | --- | --- |
| tablespace_name | name | Name of the tablespace to which a file belongs |
| bytes | double precision | Length of the file in bytes |

## 15.3.5 ADM_HIST_SNAPSHOT

**ADM_HIST_SNAPSHOT** records the index information and start time of WDR snapshots stored in the current system. By default, only the system administrator can access this view. Common users can access the view only after being authorized.

**Table 15-117** ADM_HIST_SNAPSHOT columns

| Name | Type | Description |
| --- | --- | --- |
| SNAP_ID | bigint | WDR snapshot ID |
| BEGIN_INTERVAL_TIME | timestamp | Start time of a WDR snapshot |

## 15.3.6 ADM_HIST_SQL_PLAN

ADM_HIST_SQL_PLAN displays plan information collected by the current user by running the **EXPLAIN PLAN** statement.

**Table 15-118** ADM_HIST_SQL_PLAN columns

| Name | Type | Description |
| --- | --- | --- |
| SQL_ID | character varying(30) | Session that inserts the data. Its value consists of a service thread start timestamp and a service thread ID. Values are constrained by **NOT NULL**. |
| PLAN_HASH_VALUE | bigint | Query ID |
| OPERATION | character varying(30) | Operation description |

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| Name | Type | Description |
| --- | --- | --- |
| OPTIONS | character varying(255) | Operation action |
| OBJECT_NAME | name | Name of an operated object. It is defined by users. |

## 15.3.7 ADM_HIST_SQLSTAT

ADM_HIST_SQLSTAT displays information about statements executed on the current node.

**Table 15-119** ADM_HIST_SQLSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| INSTANCE_NUMBER | integer | Instance ID of a snapshot. |
| SQL_ID | bigint | Query ID |
| PLAN_HASH_VALUE | bigint | ID of the normalized SQL statement. |
| MODULE | text | Name of the module that is executing when the SQL statement is first parsed. |
| ELAPSED_TIME_DELTA | bigint | Valid DB time, which is accumulated if multiple threads are involved (unit: μs) |
| CPU_TIME_DELTA | bigint | CPU time (unit: μs) |
| EXECUTIONS_DELTA | integer | Increment in the number of executions that have occurred on this object since it was brought into the cache. |
| IOWAIT_DELTA | bigint | I/O time (unit: μs) |
| APWAIT_DELTA | integer | Delta value of the application wait time. |
| ROWS_PROCESSED_DELTA | bigint | Number of rows in the result set returned by the **SELECT** statement |
| SNAP_ID | integer | Unique snapshot ID. |

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## 15.3.8 ADM_INDEXES

**ADM_INDEXES** displays all indexes in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-120** ADM_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| table_name | character varying(64) | Name of the table corresponding to the index |
| uniqueness | text | Whether the index is a unique index |
| partitioned | character(3) | Whether the index has the property of partitioned tables |
| generated | character varying(1) | Whether the index name is generated by the system |

## 15.3.9 ADM_IND_COLUMNS

**ADM_IND_COLUMNS** displays column information about all indexes in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-121** ADM_IND_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| index_owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| table_owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | name | Column name |
| column_position | smallint | Position of the column in the index |

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## 15.3.10 ADM_IND_EXPRESSIONS

**ADM_IND_EXPRESSIONS** displays information about expression indexes in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-122** ADM_IND_EXPRESSIONS columns

| Name | Type | Description |
| --- | --- | --- |
| table_owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| index_owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| column_expression | text | Function-based index expression of a specified column |
| column_position | smallint | Position of the column in the index |

## 15.3.11 ADM_IND_PARTITIONS

**ADM_IND_PARTITIONS** displays information about all index partitions in the database. Each index partition of a partitioned table in the database, if present, has a row of records in **ADM_IND_PARTITIONS**. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-123** ADM_IND_PARTITIONS columns

| Name | Type | Description |
| --- | --- | --- |
| index_owner | character varying(64) | Name of the owner of the partitioned table index to which an index partition belongs |
| index_name | character varying(64) | Index name of the partitioned table index to which the index partition belongs |
| partition_name | character varying(64) | Name of the index partition |
| def_tablespace_name | name | Tablespace name of the index partition |

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| Name | Type | Description |
| --- | --- | --- |
| high_value | text | Upper limit of the partition corresponding to the index partition |
| index_partition_usable | boolean | Whether the index partition is available<br>• **t** (true): yes<br>• **f** (false): no |
| schema | character varying(64) | Schema of the partitioned table index to which the index partition belongs |

## 15.3.12 ADM_OBJECTS

**ADM_OBJECTS** displays all database objects in the database. Only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-124** ADM_OBJECTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | name | Object owner |
| object_name | name | Object name |
| object_id | oid | OID of the object |
| object_type | name | Object class. For example, table, schema, and index. |
| namespace | oid | Namespace containing the object |
| created | timestamp with time zone | Creation time of the object |
| last_ddl_time | timestamp with time zone | Last time when the object was modified |

NOTICE

For details on the value ranges of **created** and **last_ddl_time**, see **15.2.71 PG_OBJECT**.

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## 15.3.13 ADM_PART_INDEXES

**ADM_PART_INDEXES** displays information about all partitioned table indexes in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-125** ADM_PART_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| def_tablespace_name | name | Tablespace name of the partitioned table index |
| index_owner | character varying(64) | Name of the owner of a partitioned table index |
| index_name | character varying(64) | Name of the partitioned table index |
| partition_count | bigint | Number of index partitions of the partitioned table index |
| partitioning_key_count | integer | Number of partition keys of the partitioned table |
| partitioning_type | text | Partition policy of the partitioned table<br>**NOTE**<br>Only range partitioning is supported. |
| schema | character varying(64) | Name of the schema to which the partitioned table index belongs |
| table_name | character varying(64) | Name of the partitioned table to which the partitioned table index belongs |

## 15.3.14 ADM_PART_TABLES

**ADM_PART_TABLES** displays information about all partitioned tables in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-126** ADM_PART_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| table_owner | character varying(64) | Owner name of a partitioned table |

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| Name | Type | Description |
| --- | --- | --- |
| table_name | character varying(64) | Name of the partitioned table |
| partitioning_type | text | Partition policy of the partitioned table<br>**NOTE**<br>Only range partitioning is supported. |
| partition_count | bigint | Number of partitions in the partitioned table |
| partitioning_key_count | integer | Number of partition keys of the partitioned table |
| def_tablespace_name | name | Tablespace name of the partitioned table |
| schema | character varying(64) | Schema of the partitioned table |

## 15.3.15 ADM_PROCEDURES

**ADM_PROCEDURES** displays information about all stored procedures and functions in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-127** ADM_PROCEDURES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a stored procedure or function |
| object_name | character varying(64) | Name of the stored procedure or function |
| argument_number | smallint | Number of input parameters in the stored procedure |

## 15.3.16 ADM_SEQUENCES

**ADM_SEQUENCES** displays information about all sequences in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in the **PG_CATALOG** and **SYS** schemas.

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**Table 15-128** ADM_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| sequence_owner | character varying(64) | Owner of a sequence |
| sequence_name | character varying(64) | Name of a sequence |
| min_value | int16 | Minimum value of a sequence |
| max_value | int16 | Maximum value of a sequence |
| increment_by | int16 | Increment of a sequence |
| last_number | int16 | Value of the previous sequence |
| cache_size | int16 | Size of the sequence disk cache |
| cycle_flag | character(1) | Whether a sequence is a cycle sequence. The value can be **Y** or **N**.<br>• **Y**: It is a cycle sequence.<br>• **N**: It is not a cycle sequence. |

## 15.3.17 ADM_SCHEDULER_JOBS

**ADM_SCHEDULER_JOBS** displays information about all DBE_SCHEDULER scheduled tasks in the database.

**Table 15-129** ADM_SCHEDULER_JOBS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | name | Owner of a scheduled task. |
| job_name | text | Name of a scheduled task. |
| job_style | text | Action mode of a scheduled task. |
| job_creator | name | Creator of a scheduled task. |
| program_name | text | Name of the program referenced by a scheduled task. |
| job_action | text | Program content of a scheduled task. |

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| Name | Type | Description |
| --- | --- | --- |
| number_of_arguments | text | Number of parameters of a scheduled task. |
| schedule_name | text | Name of the schedule referenced by a scheduled task. |
| start_date | timestamp without time zone | Start time of a scheduled task. |
| repeat_interval | text | Period of a scheduled task. |
| end_date | timestamp without time zone | End time of a scheduled task. |
| job_class | text | Name of the scheduled task class to which a scheduled task belongs. |
| enabled | boolean | Status of a scheduled task. |
| auto_drop | text | Status of the automatic deletion function of a scheduled task. |
| state | "char" | Status of a scheduled task. |
| failure_count | smallint | Number of scheduled task failures. |
| last_start_date | timestamp without time zone | Last time when a scheduled task was started. |
| next_run_date | timestamp without time zone | Next execution time of a scheduled task. |
| destination | text | Target name of a scheduled task. |
| credential_name | text | Certificate name of a scheduled task. |
| comments | text | Comments of a scheduled task. |

## 15.3.18 ADM_SOURCE

**ADM_SOURCE** displays all stored procedures or functions in the database, and it provides columns defined by the stored procedures or functions. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

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**Table 15-130** ADM_SOURCE columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a stored procedure or function |
| name | character varying(64) | Name of the stored procedure or function |
| text | text | Definition of the stored procedure or function |

## 15.3.19 ADM_SYNONYMS

**ADM_SYNONYMS** displays all synonyms in the database. This view is accessible only to system administrators. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-131** ADM_SYNONYMS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | text | Owner of a synonym |
| schema_name | text | Name of the schema to which the synonym belongs |
| synonym_name | text | Synonym name |
| table_owner | text | Owner of the associated object. Although the column is called **table_owner**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |
| table_name | text | Name of the associated object. Although the column is called **table_name**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |

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| Name | Type | Description |
| --- | --- | --- |
| table_schema_name | text | Schema name of the associated object. Although the column is called **table_schema_name**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |

## 15.3.20 ADM_TABLES

**ADM_TABLES** displays all tables in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-132** ADM_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| tablespace_name | character varying(64) | Tablespace name of the table |
| dropped | character varying | Whether the current record is deleted<br>• **YES**: The record is deleted.<br>• **NO**: The record is not deleted. |
| num_rows | numeric | Estimated number of rows in the table |
| status | character varying(8) | Whether the current record is valid |
| temporary | character(1) | Whether the table is a temporary table<br>• **Y**: The table is a temporary table.<br>• **N**: The table is not a temporary table. |

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## 15.3.21 ADM_TABLESPACES

**ADM_TABLESPACES** displays information about available tablespaces. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-133** ADM_TABLESPACES columns

| Name | Type | Description |
| --- | --- | --- |
| tablespace_name | character varying(64) | Tablespace name |

## 15.3.22 ADM_TAB_COLUMNS

**ADM_TAB_COLUMNS** displays columns in tables. Each column in a table of the database has a row in **ADM_TAB_COLUMNS**. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-134** ADM_TAB_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | character varying(64) | Column name |
| data_type | character varying(128) | Data type of the column |
| data_length | integer | Length of the column, in bytes |
| data_precision | integer | Precision of the data type. This parameter is valid for the numeric data type and **NULL** for other types. |
| data_scale | integer | Number of decimal places. This parameter is valid for the numeric data type and **0** for other data types. |
| nullable | bpchar | Whether the column can be empty (**n** for the primary key constraint and non-null constraint) |

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| Name | Type | Description |
| --- | --- | --- |
| column_id | integer | Sequence number of the column when the table is created |
| avg_col_len | numeric | Average length of a column, in bytes |
| char_length | numeric | Column length (in the unit of bytes) which is valid only for varchar, nvarchar2, bpchar, and char types. |
| comments | text | Specifies the comment content. |

## 15.3.23 ADM_TAB_COMMENTS

**ADM_TAB_COMMENTS** displays comments about all tables and views in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-135** ADM_TAB_COMMENTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a table or view |
| table_name | character varying(64) | Name of the table or view |
| comments | text | Comments |

## 15.3.24 ADM_TAB_PARTITIONS

**ADM_TAB_PARTITIONS** stores information about all partitions in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-136** ADM_TAB_PARTITIONS columns

| Name | Type | Description |
| --- | --- | --- |
| table_owner | character varying(64) | Role name |
| table_name | character varying(64) | Relational table name |

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| Name | Type | Description |
| --- | --- | --- |
| partition_name | character varying(64) | Partition name |
| high_value | text | Upper boundary of the range partition and interval partition |
| tablespace_name | name | Tablespace name of the partitioned table |
| schema | character varying(64) | Name of a namespace |

## 15.3.25 ADM_TRIGGERS

**ADM_TRIGGERS** displays information about triggers in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-137** ADM_TRIGGERS columns

| Name | Type | Description |
| --- | --- | --- |
| trigger_name | character varying(64) | Trigger name |
| table_owner | character varying(64) | Role name |
| table_name | character varying(64) | Relational table name |
| status | character varying(64) | • **O**: The trigger is initiated in origin or local mode.<br>• **D**: The trigger is disabled.<br>• **R**: The trigger is initiated in replica mode.<br>• **A**: The trigger is always initiated. |

## 15.3.26 ADM_TYPE_ATTRS

**ADM_TYPE_ATTRS** displays the attributes of the current database object type.

**Table 15-138** ADM_TYPE_ATTRS columns

| Name | Type | Description |
| --- | --- | --- |
| OWNER | oid | Owner of the type |
| TYPE_NAME | name | Data type name |
| ATTR_NAME | name | Column name |

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| Name | Type | Description |
| --- | --- | --- |
| ATTR_TYPE_MOD | integer | Type-specific data supplied at the table creation time (for example, the maximum length of a **varchar** column). This column is used as the third parameter when passing to type-specific input functions and length coercion functions. The value will generally be **–1** for types that do not need ATTTYPMOD. |
| ATTR_TYPE_OWNER | oid | Owner of an attribute of this type |
| ATTR_TYPE_NAME | name | Data type attribute name |
| LENGTH | smallint | Number of bytes in the internal representation of the type for a fixed-size type. It is a negative number for a variable-length type.<br>● The value **–1** indicates a "varlena" type (one that has a length word).<br>● The value **–2** indicates a null-terminated C string. |
| PRECISION | integer | Precision of the numeric type |
| SCALE | integer | Range of the numeric type |
| CHARACTER_SET_NAME | character(1) | Character set name of an attribute (**c** or **n**) |
| ATTR_NO | smalllint | Attribute number |
| INHERITED | character(1) | Specifies whether the attribute is inherited from the super type (**Y** or **N**). |

## 15.3.27 ADM_USERS

**ADM_USERS** displays all usernames in the database. This view is accessible only to system administrators. This view exists in both PG_CATALOG and SYS schema.

**Table 15-139** ADM_USERS columns

| Name | Type | Description |
| --- | --- | --- |
| username | character varying(64) | Name of a user |

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## 15.3.28 ADM_VIEWS

**ADM_VIEWS** displays views in the database. By default, only the system administrator can access this view. Common users can access the view only after being authorized. This view exists in both PG_CATALOG and SYS schema.

**Table 15-140** ADM_VIEWS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a view |
| view_name | character varying(64) | View name |

## 15.3.29 COMM_CLIENT_INFO

COMM_CLIENT_INFO stores information about active client connections of a single node (Query the display of the view on DNs and CNs connect information on DNs). By default, only the users with system administrator permission can access this view.

**Table 15-141** COMM_CLIENT_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Name of the current DN, for example, dn_6001_6002_6003. |
| app | text | Query a view on a DN. The app displays the client connected to the current DN, such as the coordinator (CN), GTM, or DN. |
| tid | bigint | Thread ID of the current thread |
| lwtid | integer | Lightweight thread ID of the current thread |
| query_id | bigint | Query ID. It is equivalent to **debug_query_id**. |
| socket | integer | **socket fd** is displayed if the connection is a physical connection. |
| remote_ip | text | Peer node IP address |
| remote_port | text | Peer node port |
| logic_id | integer | Displayed if the connection is a logical connection |

## 15.3.30 DB_ALL_TABLES

**DB_ALL_TABLES** displays tables or views accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

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**Table 15-142** DB_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | name | Owner of a table or view |
| table_name | name | Name of the table or view |
| tablespace_name | name | Tablespace where the table or view is located |

## 15.3.31 DB_CONSTRAINTS

**DB_CONSTRAINTS** displays information about constraints accessible to the current user. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-143** DB_CONSTRAINTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Constraint creator |
| constraint_name | character varying(64) | Constraint name |
| constraint_type | text | Constraint type<br>• **c**: check constraint<br>• **f**: foreign key constraint<br>• **p**: primary key constraint<br>• **u**: unique constraint |
| table_name | character varying(64) | Name of a constraint-related table |
| index_owner | character varying(64) | Owner of a constraint-related index (only for the unique constraint and primary key constraint) |
| index_name | character varying(64) | Name of the constraint-related index (only for the unique constraint and primary key constraint) |

## 15.3.32 DB_CONS_COLUMNS

**DB_CONS_COLUMNS** displays information about constraint columns accessible to the current user. This view exists in the **PG_CATALOG** and **SYS** schemas.

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**Table 15-144** DB_CONS_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Constraint creator |
| constraint_name | character varying(64) | Constraint name |
| table_name | character varying(64) | Name of a constraint-related table |
| column_name | character varying(64) | Name of a constraint-related column |
| position | smallint | Position of the column in the table |

## 15.3.33 DB_DEPENDENCIES

**DB_DEPENDENCIES** displays dependencies between functions and advanced packages accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

NOTICE

In GaussDB, this table is empty without any record due to information constraints.

**Table 15-145** DB_DEPENDENCIES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(30) | Object owner |
| name | character varying(30) | Object name |
| type | character varying(17) | Object class |
| referenced_owner | character varying(30) | Owner of a referenced object |
| referenced_name | character varying(64) | Name of the referenced object |
| referenced_type | character varying(17) | Type of the referenced object |
| referenced_link_name | character varying(128) | Name of the link to the referenced object |
| schemaid | numeric | ID of the current schema |

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| Name | Type | Description |
| --- | --- | --- |
| dependency_type | character varying(4) | Dependency type (**REF** indicates soft reference and **HARD** indicates direct description). |

## 15.3.34 DB_IND_COLUMNS

**DB_IND_COLUMNS** displays all index columns accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-146** DB_IND_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| index_owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| table_owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | name | Column name |
| column_position | smallint | Position of the column in the index |

## 15.3.35 DB_IND_EXPRESSIONS

**DB_IND_EXPRESSIONS** displays information about expression indexes accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-147** DB_IND_EXPRESSIONS columns

| Name | Type | Description |
| --- | --- | --- |
| index_owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| table_owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_expression | text | Function-based index expression of a specified column |

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| Name | Type | Description |
| --- | --- | --- |
| column_position | smallint | Position of the column in the index |

## 15.3.36 DB_INDEXES

**DB_INDEXES** displays information about indexes accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-148** DB_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| table_name | character varying(64) | Name of the table corresponding to the index |
| uniqueness | text | Whether the index is a unique index |
| partitioned | character(3) | Whether the index has the property of partitioned tables |
| generated | character varying(1) | Whether the index name is generated by the system |

## 15.3.37 DB_OBJECTS

**DB_OBJECTS** displays all database objects accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-149** DB_OBJECTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | name | Object owner |
| object_name | name | Object name |
| object_id | oid | OID of the object |
| object_type | name | Object class |
| namespace | oid | ID of the namespace where the object resides |

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| Name | Type | Description |
| --- | --- | --- |
| created | timestamp with time zone | Creation time of the object |
| last_ddl_time | timestamp with time zone | Last time when the object was modified |

NOTICE

For details on the value ranges of **created** and **last_ddl_time**, see 15.2.71 PG_OBJECT.

## 15.3.38 DB_PROCEDURES

**DB_PROCEDURES** displays information about all stored procedures or functions accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-150** DB_PROCEDURES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | name | Object owner |
| object_name | name | Object name |

## 15.3.39 DB_SEQUENCES

**DB_SEQUENCES** displays all sequences accessible to the current user. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-151** DB_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| sequence_owner | name | Owner of a sequence |
| sequence_name | name | Name of the sequence |
| min_value | int16 | Minimum value of the sequence |
| max_value | int16 | Maximum value of the sequence |
| last_number | int16 | Value of the previous sequence |
| cache_size | int16 | Size of the sequence disk cache |

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| Name | Type | Description |
| --- | --- | --- |
| increment_by | int16 | Value by which the sequence is incremented |
| cycle_flag | character(1) | Whether a sequence is a cycle sequence. The value can be **Y** or **N**.<br>• **Y**: It is a cycle sequence.<br>• **N**: It is not a cycle sequence. |

## 15.3.40 DB_SOURCE

**DB_SOURCE** displays information about stored procedures or functions accessible to the current user, and provides columns defined by the stored procedures and functions. This view exists in both PG_CATALOG and SYS schema.

**Table 15-152** DB_SOURCE columns

| Name | Type | Description |
| --- | --- | --- |
| owner | name | Object owner |
| name | name | Object name |
| type | name | Object class |
| text | text | Definition of the object |

## 15.3.41 DB_SYNONYMS

**DB_SYNONYMS** displays all synonyms accessible to the current user.

**Table 15-153** DB_SYNONYMS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | text | Owner of a synonym |
| schema_name | text | Name of the schema to which the synonym belongs |
| synonym_name | text | Synonym name |
| table_owner | text | Owner of the associated object Although the column is called **table_owner**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |

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| Name | Type | Description |
| --- | --- | --- |
| table_name | text | Name of the associated object Although the column is called **table_name**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |
| table_schema_name | text | Schema name of the associated object Although the column is called **table_schema_name**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |

## 15.3.42 DB_TAB_COLUMNS

**DB_TAB_COLUMNS** displays description information about columns of tables accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-154** DB_TAB_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | character varying(64) | Column name |
| data_type | character varying(128) | Data type of the column |
| data_length | integer | Length of the column, in bytes |
| data_precision | integer | Precision of the data type. This parameter is valid for the numeric data type and **NULL** for other types. |
| data_scale | integer | Number of decimal places. This parameter is valid for the numeric data type and **0** for other data types. |
| nullable | bpchar | Whether the column can be empty (**n** for the primary key constraint and non-null constraint) |

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| Name | Type | Description |
| --- | --- | --- |
| column_id | integer | Column ID generated when the object is created or column is added |
| char_length | numeric | Length of the column, in characters. This parameter is valid only for the varchar, nvarchar2, bpchar, and char types. |
| avg_col_len | numeric | Average length of a column, in bytes |
| comments | text | Specifies the comment content. |

## 15.3.43 DB_TAB_COMMENTS

**DB_TAB_COMMENTS** displays comments about all tables and views accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-155** DB_TAB_COMMENTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a table or view |
| table_name | character varying(64) | Name of the table or the view |
| comments | text | Comments |

## 15.3.44 DB_COL_COMMENTS

**DB_COL_COMMENTS** displays comment information about table columns accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-156** DB_COL_COMMENTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | character varying(64) | Column name |
| comments | text | Comments |

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## 15.3.45 DB_TABLES

**DB_TABLES** displays all tables accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-157** DB_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| tablespace_name | character varying(64) | Tablespace name of the table |
| num_rows | numeric | Estimated number of rows in the table |
| status | character varying(8) | Whether the current record is valid |
| temporary | character(1) | Whether the table is a temporary table<br>• **Y**: The table is a temporary table.<br>• **N**: The table is not a temporary table. |
| dropped | character varying | Whether the current record is deleted<br>• **YES**: The record is deleted.<br>• **NO**: The record is not deleted. |

## 15.3.46 DB_TRIGGERS

**DB_TRIGGERS** displays information about triggers accessible to the current user. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-158** DB_TRIGGERS columns

| Name | Type | Description |
| --- | --- | --- |
| trigger_name | character varying(64) | Trigger name |
| table_owner | character varying(64) | Role name |
| table_name | character varying(64) | Relational table name |

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| Name | Type | Description |
| --- | --- | --- |
| status | character varying(64) | • **O**: The trigger is enabled in origin or local mode.<br>• **D**: The trigger is disabled.<br>• **R**: The trigger is enabled in replica mode.<br>• **A**: The trigger is always enabled. |

## 15.3.47 DB_USERS

**DB_USERS** displays all users of the database visible to the current user. However, it does not describe the users. By default, only the system administrator can access this view. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-159** DB_USERS columns

| Name | Type | Description |
| --- | --- | --- |
| user_id | oid | OID of a user |
| username | name | Name of a user |

## 15.3.48 DB_VIEWS

**DB_VIEWS** displays the description about all views accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-160** DB_VIEWS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | name | Owner of a view |
| view_name | name | View name |
| text | text | Text in the view |
| text_length | integer | Text length of the view |

## 15.3.49 DV_SESSIONS

**DV_SESSIONS** displays all session information about the current session. By default, only the system administrator can access this view. Common users can access the view only after being authorized.

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**Table 15-161** DV_SESSIONS columns

| Name | Type | Description |
| --- | --- | --- |
| sid | bigint | OID of the active background thread of the current session |
| serial# | integer | Sequence number of the active background thread, which is **0** in GaussDB |
| user# | oid | OID of the user that has logged in to the background thread (**0** if the background thread is a global auxiliary thread) |
| username | name | Username of the user that has logged in to the background thread. (null if the background thread is a global auxiliary thread)<br>The **application_name** can be identified by associating with **pg_stat_get_activity()**.<br>Example:<br>select s.*,a.application_name from DV_SESSIONS as s left join pg_stat_get_activity(NULL) as a on s.sid=a.sessionid; |

## 15.3.50 DV_SESSION_LONGOPS

**DV_SESSION_LONGOPS** displays the progress of ongoing operations. The view can be accessed only after being authorized.

**Table 15-162** DV_SESSION_LONGOPS columns

| Name | Type | Description |
| --- | --- | --- |
| sid | bigint | OID of the running background process |
| serial# | integer | Sequence number of the running background process, which is **0** in GaussDB |
| sofar | integer | Completed workload, which is empty in GaussDB |
| totalwork | integer | Total workload, which is empty in GaussDB |

## 15.3.51 GET_GLOBAL_PREPARED_XACTS

**GET_GLOBAL_PREPARED_XACTS** records prepared transactions on all nodes globally.

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**Table 15-163** GET_GLOBAL_PREPARED_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| transaction | xid | XID of a prepared transaction |
| gid | text | GID of the prepared transaction |
| prepared | timestamp with time zone | Prepared time of the prepared transaction |
| owner | name | Owner of the prepared transaction |
| database | name | Database to which the prepared transaction belongs |
| node_name | text | Name of the node where the prepared transaction resides |

## 15.3.52 GLOBAL_BAD_BLOCK_INFO

**GLOBAL_BAD_BLOCK_INFO** is executed on the CN to collect statistics on damaged data pages of all instances. The basic information about damaged pages is displayed in the query result. The execution result on the DN is empty. Based on the information, you can use the page detection and repair function in **12.5.40 Data Damage Detection and Repair Functions** to perform further repair operations. By default, only initial users, users with the **sysadmin** permission, users with the O&M administrator permission in the O&M mode, and monitoring users can view the information. Other users can view the information only after being granted with permissions.

**Table 15-164** GLOBAL_BAD_BLOCK_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Information about the node where the current damaged page is located |
| spc_node | oid | ID of the tablespace corresponding to the current damaged page |
| db_node | oid | ID of the database corresponding to the current damaged page |
| rel_node | oid | Relfilenode of the relation corresponding to the current damaged page |
| bucket_node | integer | Bucket node of the current damaged page. It is set to **–1** for a non-segment-page table and to a value other than 0 for a segment-page table. This column is used to specify whether a table is a segment-page table during repair. |
| block_num | oid | Page number of the current damaged page |

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| Name | Type | Description |
| --- | --- | --- |
| fork_num | integer | File forknum of the current damaged page |
| file_path | text | Relative path of the current damaged page. The logical path instead of the actual file is displayed for a segment-page table. |
| check_time | timestamp with time zone | Time when an error is detected on the current damaged page |
| repair_time | timestamp with time zone | Time when the current damaged page is repaired |

## 15.3.53 GLOBAL_CLEAR_BAD_BLOCK_INFO

**GLOBAL_CLEAR_BAD_BLOCK_INFO** is executed on the CN to clear information about repaired pages in all instances. The execution result on DNs is empty. By default, only initial users, users with the **sysadmin** permission, users with the O&M administrator permission in the O&M mode, and monitoring users can view the information. Other users can view the information only after being granted with permissions.

**Table 15-165** GLOBAL_BAD_BLOCK_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node information corresponding to the current repaired page clearance result |
| result | boolean | Execution result of clearing repaired pages of the current instance |

## 15.3.54 GLOBAL_COMM_CLIENT_INFO

**GLOBAL_COMM_CLIENT_INFO** queries information about active client connections of global nodes in a cluster. By default, only the system administrator has the permission to access this system view.

**Table 15-166** GLOBAL_COMM_CLIENT_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name. |
| app | text | app |
| tid | bigint | Thread ID of the current thread. |

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| Name | Type | Description |
| --- | --- | --- |
| lwtid | integer | Lightweight thread ID of the current thread. |
| query_id | bigint | Query ID. It is equivalent to **debug_query_id**. |
| socket | integer | Displayed if the connection is a physical connection. |
| remote_ip | text | Peer node IP address. |
| remote_port | text | Peer node port. |
| logic_id | integer | Displayed if the connection is a logical connection. |

## 15.3.55 GLOBAL_STAT_HOTKEYS_INFO

**GLOBAL_STAT_HOTKEYS_INFO** queries the statistics of hotspot keys in the entire cluster. The query results are sorted by **count** in descending order.

**Table 15-167** GLOBAL_STAT_HOTKEYS_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| database_name | text | Name of the database where the hotspot key is located. |
| schema_name | text | Name of the schema where the hotspot key is located. |
| table_name | text | Name of the table where the hotspot key is located. |
| key_value | text | Value of a hotspot key. |
| hash_value | bigint | Hash value of the hotspot key in the database. If the table is a list or range distribution table, the value of this field is **0**. |
| count | numeric | Frequency of accessing the hotspot key. |

## 15.3.56 GLOBAL_WAL_SENDER_STATUS

**GLOBAL_WAL_SENDER_STATUS** displays the redo log transfer and replay status of the primary DN in the current cluster. This view can be viewed only by the users with monitor admin and sysadmin permission.

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**Table 15-168** GLOBAL_WAL_SENDER_STATUS column

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Name of the primary node |
| source_ip | text | IP address of the primary node |
| source_port | integer | Port of the primary node |
| dest_ip | text | IP address of the standby node |
| dest_port | integer | Port of the standby node |
| sender_pid | integer | PID of the sending thread |
| local_role | text | Type of the primary node |
| peer_role | text | Type of the standby node |
| peer_state | text | Status of the standby node |
| state | text | WAL sender status |
| sender_sent_location | text | Sending position of the primary node |
| sender_write_location | text | Writing position of the primary node |
| sender_flush_location | text | Flushing position of the primary node |
| sender_replay_location | text | Redo position of the primary node |
| receiver_received_location | text | Receiving position of the standby node |
| receiver_write_location | text | Writing position of the standby node |
| receiver_flush_location | text | Flushing location of the standby node |
| receiver_replay_location | text | Redo location of the standby node |

## 15.3.57 GS_ALL_CONTROL_GROUP_INFO

**GS_ALL_CONTROL_GROUP_INFO** displays all Cgroup information in a database.

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**Table 15-169** GS_ALL_CONTROL_GROUP_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| name | text | Name of a Cgroup |
| type | text | Type of the Cgroup<br>• **GROUP_NONE**: no group.<br>• **GROUP_TOP**: top group.<br>• **GROUP_CLASS**: class group of the resource, which does not control any thread.<br>• **GROUP_BAKWD**: backend thread control group.<br>• **GROUP_DEFWD**: default control group, which controls only the query threads at this level.<br>• **GROUP_TSWD**: time-sharing control group of each user, which controls the query thread at the bottom layer. |
| gid | bigint | Cgroup ID |
| classgid | bigint | ID of the **Class** Cgroup to which a **Workload** Cgroup belongs |
| class | text | **Class** Cgroup |
| workload | text | Workload Cgroup |
| shares | bigint | CPU quota allocated to the Cgroup |
| limits | bigint | Limit of CPUs allocated to the Cgroup |
| wdlevel | bigint | **Workload** Cgroup level |
| cpucores | text | Usage of CPU cores in the Cgroup |

## 15.3.58 GS_AUDITING

**GS_AUDITING** displays all audit information about database-related operations. Only the users with system administrator or security policy administrator permission can access this view.

**Table 15-170** GS_AUDITING columns

| Name | Type | Description |
| --- | --- | --- |
| polname | name | Policy name, which must be unique. |
| pol_type | text | Audit policy type. The value can be **access** or **privilege**.<br>• **access**: DML operations are audited.<br>• **privilege**: DDL operations are audited. |

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| Name | Type | Description |
| --- | --- | --- |
| polenabled | boolean | Specifies whether to enable the policy.<br>• **t (true)**: enabled.<br>• **f (false)**: disabled. |
| access_type | name | DML database operation type. For example, SELECT, INSERT, and DELETE. |
| label_name | name | Specifies the resource label name. This parameter corresponds to the **polname** column in the **GS_AUDITING_POLICY** system catalog. |
| priv_object | text | Describes the path of the database asset. |
| filter_name | text | Logical character string of a filter criterion. |

## 15.3.59 GS_AUDITING_ACCESS

**GS_AUDITING_ACCESS** displays all audit information about database DML-related operations. Only the users with system administrator or security policy administrator permission can access this view.

**Table 15-171** GS_AUDITING_ACCESS columns

| Name | Type | Description |
| --- | --- | --- |
| polname | name | Policy name, which must be unique. |
| pol_type | text | Audit policy type. The value **access** indicates that DML operations are audited. |
| polenabled | boolean | Specifies whether to enable the policy.<br>• **t** (true): enabled<br>• **f** (false): disabled |
| access_type | name | DML database operation type. For example, SELECT, INSERT, and DELETE. |
| label_name | name | Specifies the resource label name. This parameter corresponds to the **polname** column in the **GS_AUDITING_POLICY** system catalog. |
| access_object | text | Describes the path of the database asset. |
| filter_name | text | Logical character string of a filter criterion. |

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## 15.3.60 GS_AUDITING_PRIVILEGE

**GS_AUDITING_PRIVILEGE** displays all audit information about database DDL-related operations. Only the users with system administrator or security policy administrator permission can access this view.

| Name | Type | Description |
| --- | --- | --- |
| polname | name | Policy name, which must be unique. |
| pol_type | text | Audit policy type. The value **privilege** indicates that DDL operations are audited. |
| polenabled | boolean | Specifies whether to enable the policy.<br>• **t (true)**: enabled.<br>• **f (false)**: disabled. |
| access_type | name | DDL database operation type. For example, CREATE, ALTER, and DROP. |
| label_name | name | Specifies the resource label name. This parameter corresponds to the **polname** column in the **GS_AUDITING_POLICY** system catalog. |
| priv_object | text | Full domain name of a database object. |
| filter_name | text | Logical character string of a filter criterion. |

## 15.3.61 GS_CLUSTER_RESOURCE_INFO

**GS_CLUSTER_RESOURCE_INFO** displays all DNs resource summaries. This view can be queried only when **enable_dynamic_workload** is set to **on** and the view cannot be executed on DNs. Only the user with sysadmin permission can query this view.

**Table 15-172** GS_CLUSTER_RESOURCE_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| min_mem_util | integer | Minimum memory usage of a DN |
| max_mem_util | integer | Maximum memory usage of the DN |
| min_cpu_util | integer | Minimum CPU usage of the DN |
| max_cpu_util | integer | Maximum CPU usage of the DN |
| min_io_util | integer | Minimum I/O usage of the DN |
| max_io_util | integer | Maximum I/O usage of the DN |
| used_mem_rate | integer | Maximum physical memory usage |

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## 15.3.62 GS_DB_PRIVILEGES

**GS_DB_PRIVILEGES** displays the granting of ANY permissions. Each record corresponds to a piece of authorization information.

**Table 15-173** GS_DB_PRIVILEGES columns

| Name | Type | Description |
| --- | --- | --- |
| rolename | name | Username |
| privilege_type | text | ANY permission of a user. For details about the value, see **Table 12-124**. |
| admin_option | text | Whether the ANY permission recorded in the **privilege_type** column can be re-granted<br>• **yes**<br>• **no** |

## 15.3.63 GS_GET_CONTROL_GROUP_INFO

**GS_GET_CONTROL_GROUP_INFO** displays information about all Cgroups. Only the user with sysadmin permission can query this view.

**Table 15-174** GS_GET_CONTROL_GROUP_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| group_name | text | Name of a Cgroup. |
| group_type | text | Type of the Cgroup.<br>• **GROUP_NONE**: no group.<br>• **GROUP_TOP**: top group.<br>• **GROUP_CLASS**: class group of the resource, which does not control any thread.<br>• **GROUP_BAKWD**: backend thread control group.<br>• **GROUP_DEFWD**: default control group, which controls only the query threads at this level.<br>• **GROUP_TSWD**: time-sharing control group of each user, which controls the query thread at the bottom layer. |

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| Name | Type | Description |
| --- | --- | --- |
| gid | bigint | Cgroup ID. |
| classgid | bigint | ID of the **Class** Cgroup to which a **Workload** Cgroup belongs. |
| class | text | **Class** Cgroup. |
| group_workload | text | Workload Cgroup. |
| shares | bigint | CPU quota allocated to the Cgroup. |
| limits | bigint | Limit of CPUs allocated to the Cgroup. |
| wdlevel | bigint | Workload Cgroup level. |
| cpucores | text | Usage of CPU cores in the Cgroup. |
| nodegroup | text | Node group name. |
| group_kind | text | Node group type. The value must be one of the following:<br>• **i**: installation node group<br>• **n**: node group in a common, non-logical cluster<br>• **v**: node group in a logical cluster (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)<br>• **e**: elastic cluster |

## 15.3.64 GS_GSC_MEMORY_DETAIL

**GS_GSC_MEMORY_DETAIL** displays the global SysCache memory usage of the current process on the current node. The data is displayed only when Global SysCache is enabled.

Note that the query is separated by the database memory context. Therefore, some memory statistics are missing. The memory context corresponding to the missing memory statistics is **GlobalSysDBCache**.

The current feature is a lab feature. Contact Huawei technical support before using it.

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**Table 15-175** GS_GSC_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| db_id | text | Database ID. |
| totalsize | numeric | Total size of the shared memory, in bytes. |
| freesize | numeric | Remaining size of the shared memory, in bytes. |
| usedsize | numeric | Used size of the shared memory, in bytes. |

## 15.3.65 GS_LABELS

**GS_LABELS** displays all configured resource labels. Only the users with system administrator or security policy administrator permission can access this view.

| Name | Type | Description |
| --- | --- | --- |
| labelname | name | Resource label name |
| labeltype | name | Resource label type This parameter corresponds to the **labeltype** column in the **15.2.25 GS_POLICY_LABEL** system catalog. |
| fqdntype | name | Database resource type. For example, table, schema, and index. |
| schemaname | name | Name of the schema to which the database resource belongs |
| fqdnname | name | Database resource name |
| columnname | name | Name of the database resource column. If the marked database resource is not a column, this parameter is left blank. |

## 15.3.66 GS_LSC_MEMORY_DETAIL

**GS_LSC_MEMORY_DETAIL** displays the memory usage of the local system cache of all threads based on the MemoryContext node. The data is displayed only when Global SysCache is enabled.

The current feature is a lab feature. Contact Huawei technical support before using it.

**Table 15-176** GS_LSC_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| threadid | text | Thread start time + thread ID (string: *timestamp.sessionid*) |

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| Name | Type | Description |
| --- | --- | --- |
| tid | bigint | Thread ID |
| thrdtype | text | Thread type. It can be any thread type in the system, such as postgresql and wlmmonitor. |
| contextname | text | Name of the memory context |
| level | smallint | Hierarchy of the memory context |
| parent | text | Name of the parent memory context |
| totalsize | bigint | Total size of the memory context, in bytes |
| freesize | bigint | Total size of released memory in the memory context, in bytes |
| usedsize | bigint | Total size of used memory in the memory context, in bytes |

## 15.3.67 GS_MASKING

**GS_MASKING** displays all configured dynamic masking policies. Only the users with system administrator or security policy administrator permission can access this view.

| Name | Type | Description |
| --- | --- | --- |
| polname | name | Name of the masking policy |
| polenabled | boolean | Specifies whether to enable the masking policy. |
| maskaction | name | Masking function |
| labelname | name | Name of the label to which the masking function applies. |
| masking_object | text | Masking database resource object |
| filter_name | text | Logical expression of a filter criterion |

## 15.3.68 GS_MATVIEWS

**GS_MATVIEWS** provides information about each materialized view in the database.

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**Table 15-177** GS_MATVIEWS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| schemaname | name | 15.2.70 PG_NAMESPACE.nspname | Name of the schema of a materialized view. |
| matviewname | name | 15.2.46 PG_CLASS.relname | Name of a materialized view. |
| matviewowner | name | 15.2.42 PG_AUTHID.Erolname | Owner of a materialized view. |
| tablespace | name | 15.2.94 PG_TABLESPACE.spcname | Tablespace name of a materialized view. If the default tablespace of the database is used, the value is null. |
| hasindexes | boolean | - | This column is true if a materialized view has (or has recently had) any indexes. |
| definition | text | - | Definition of a materialized view (a reconstructed SELECT query). |

## 15.3.69 GS_MATVIEWS

**GS_MATVIEWS** stores metadata of all materialized views.

**Table 15-178** GS_MATVIEWS columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Schema to which the materialized view belongs |
| matviewname | name | Name of a materialized view |
| matviewowner | name | Owner of the materialized view |
| tablespace | name | Tablespace to which the materialized view belongs |
| hasindexes | boolean | Whether an index exists in the materialized view<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| definition | text | Action statement of the materialized view |

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## 15.3.70 GS_SESSION_CPU_STATISTICS

**GS_SESSION_CPU_STATISTICS** shows load management information about CPU usage of ongoing complex jobs executed by the current user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the user with sysadmin permission can query this view.

**Table 15-179** GS_SESSION_CPU_STATISTICS columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the backend is connected to |
| usename | name | Name of the user logged in to the backend |
| pid | bigint | Process ID of the backend |
| start_time | timestamp with time zone | Time when the statement starts to run |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs, in ms |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs, in ms |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs, in ms |
| query | text | Statement being executed |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| top_cpu_dn | text | Top N CPU usage |

## 15.3.71 GS_SESSION_MEMORY_STATISTICS

**GS_SESSION_MEMORY_STATISTICS** displays load management information about memory usage of ongoing complex jobs executed by the current user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the user with sysadmin permission can query this view.

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**Table 15-180** GS_SESSION_MEMORY_STATISTICS columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the backend is connected to |
| usename | name | Name of the user logged in to the backend |
| pid | bigint | Process ID of the backend |
| start_time | timestamp with time zone | Time when the statement starts to run |
| min_peak_memory | integer | Minimum memory peak of the statement across all DNs, in MB |
| max_peak_memory | integer | Maximum memory peak of the statement across all DNs, in MB |
| spill_info | text | Statement spill information on all DNs:<br>**None**: No data is spilled to disks on all DNs.<br>**All**: Data is spilled to disks on all DNs.<br>**[*a*:*b*]**: The statement has been spilled to disks on *a* of *b* DNs. |
| query | text | Statement being executed |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| top_mem_dn | text | Top N memory usage |

## 15.3.72 GS_SQL_COUNT

**GS_SQL_COUNT** displays statistics about five types of running statements (**SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO**) on the current node of the database.

- When a common user queries the **GS_SQL_COUNT** view, statistics about the current node of the user are displayed. When an administrator queries the **GS_SQL_COUNT** view, statistics about the current node of all users are displayed.
- When the cluster or node is restarted, the statistics are cleared and will be measured again.
- The system counts when a node receives a query, including a query inside the cluster. For example, when a CN receives a query and distributes multiple queries to DNs, the queries are counted accordingly on the DNs.

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**Table 15-181** GS_SQL_COUNT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| user_name | name | Username |
| select_count | bigint | Statistical result of the **SELECT** statement |
| update_count | bigint | Statistical result of the **UPDATE** statement |
| insert_count | bigint | Statistical result of the **INSERT** statement |
| delete_count | bigint | Statistical result of the **DELETE** statement |
| mergeinto_count | bigint | Statistical result of the **MERGE INTO** statement |
| ddl_count | bigint | Number of DDL statements |
| dml_count | bigint | Number of DML statements |
| dcl_count | bigint | Number of DCL statements |
| total_select_elapse | bigint | Total response time of **SELECT** statements (unit: μs) |
| avg_select_elapse | bigint | Average response time of **SELECT** statements (unit: μs) |
| max_select_elapse | bigint | Maximum response time of **SELECT** statements (unit: μs) |
| min_select_elapse | bigint | Minimum response time of **SELECT** statements (unit: μs) |
| total_update_elapse | bigint | Total response time of **UPDATE** statements (unit: μs) |
| avg_update_elapse | bigint | Average response time of **UPDATE** statements (unit: μs) |
| max_update_elapse | bigint | Maximum response time of **UPDATE** statements (unit: μs) |
| min_update_elapse | bigint | Minimum response time of **UPDATE** statements (unit: μs) |
| total_insert_elapse | bigint | Total response time of **INSERT** statements (unit: μs) |
| avg_insert_elapse | bigint | Average response time of **INSERT** statements (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| max_insert_elapse | bigint | Maximum response time of **INSERT** statements (unit: μs) |
| min_insert_elapse | bigint | Minimum response time of **INSERT** statements (unit: μs) |
| total_delete_elapse | bigint | Total response time of **DELETE** statements (unit: μs) |
| avg_delete_elapse | bigint | Average response time of **DELETE** statements (unit: μs) |
| max_delete_elapse | bigint | Maximum response time of **DELETE** statements (unit: μs) |
| min_delete_elapse | bigint | Minimum response time of **DELETE** statements (unit: μs) |

## 15.3.73 GS_STAT_DB_CU

**GS_STAT_DB_CU** queries CU hits in a database and in each node in a cluster. You can clear it using **gs_stat_reset()**. This view can be viewed only by the users with monitor admin and sysadmin permission.

**Table 15-182** GS_STAT_DB_CU columns

| Name | Type | Description |
| --- | --- | --- |
| node_name1 | text | Node name |
| db_name | text | Database name |
| mem_hit | bigint | Number of memory hits |
| hdd_sync_read | bigint | Number of synchronous hard disk reads |
| hdd_asyn_read | bigint | Number of asynchronous hard disk reads |

## 15.3.74 GS_STAT_SESSION_CU

**GS_STAT_SESSION_CU** queries the CU hit rate of running sessions on each node in a cluster. This data about a session is cleared when you exit this session After the cluster is restarted, the statistics are also cleared. This view can be viewed only by the users with monitor admin and sysadmin permission.

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**Table 15-183** GS_STAT_SESSION_CU columns

| Name | Type | Description |
| --- | --- | --- |
| node_name1 | text | Node name |
| mem_hit | integer | Number of memory hits |
| hdd_sync_read | integer | Number of synchronous hard disk reads |
| hdd_asyn_read | integer | Number of asynchronous hard disk reads |

## 15.3.75 GS_TOTAL_NODEGROUP_MEMORY_DETAIL

**GS_TOTAL_NODEGROUP_MEMORY_DETAIL** returns the memory usage (in MB) of the current logical cluster of the database. If **enable_memory_limit** is set to **off**, this function cannot be used. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 15-184** GS_TOTAL_NODEGROUP_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| ngname | text | Name of the logical cluster (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| memorytype | text | Memory type. The value must be one of the following:<br>• **ng_total_memory**: total memory of the logical cluster<br>• **ng_used_memory**: memory usage of the logical cluster<br>• **ng_estimate_memory**: estimated memory usage of the logical cluster<br>• **ng_foreignrp_memsize**: total memory of the external resource pool of the logical cluster<br>• **ng_foreignrp_usedsize**: memory usage of the external resource pool of the logical cluster<br>• **ng_foreignrp_peaksize**: peak memory usage of the external resource pool of the logical cluster<br>• **ng_foreignrp_mempct**: percentage of the external resource pool of the logical cluster to the total memory of the logical cluster<br>• **ng_foreignrp_estmsize**: estimated memory usage of the external resource pool of the logical cluster |

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| Name | Type | Description |
| --- | --- | --- |
| memorymbytes | integer | Size of allocated memory-typed memory |

## 15.3.76 GS_WLM_CGROUP_INFO

**GS_WLM_CGROUP_INFO** displays information about a Cgroup for a job that is being executed.

**Table 15-185** GS_WLM_CGROUP_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| cgroup_name | text | Cgroup name |
| priority | integer | Priority of the job |
| usage_percent | integer | Percentage of resources used by the Cgroup |
| shares | bigint | CPU quota allocated to the Cgroup |
| cpuacct | bigint | Allocated CPU quota |
| cpuset | text | Allocated CPU cores |
| relpath | text | Relative path of the Cgroup |
| valid | text | Whether the Cgroup is valid |
| node_group | text | Name of the logical cluster (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

## 15.3.77 GS_WLM_EC_OPERATOR_STATISTICS

**GS_WLM_EC_OPERATOR_STATISTICS** displays operators of the Extension Connector jobs that are being executed by the current user. Only the user with sysadmin permission can query this view. The current feature is a lab feature. Contact Huawei technical support before using it.

**Table 15-186** GS_WLM_EC_OPERATOR_STATISTICS columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for Extension Connector statement execution |
| plan_node_id | integer | Plan node ID of the execution plan of an Extension Connector operator |

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| Name | Type | Description |
| --- | --- | --- |
| start_time | timestamp with time zone | Time when the Extension Connector operator starts to process the first data record |
| ec_status | text | Status of the Extension Connector job<br>• **EC_STATUS_INIT**: initialized.<br>• **EC_STATUS_CONNECTED**: connected.<br>• **EC_STATUS_EXECUTED**: executed.<br>• **EC_STATUS_FETCHING**: fetching.<br>• **EC_STATUS_END**: ended. |
| ec_execute_datanode | text | Name of the DN executing the Extension Connector job |
| ec_dsn | text | DSN used by the Extension Connector job |
| ec_username | text | Username used by the Extension Connector job to access the remote cluster (null if the remote cluster type is SPARK) |
| ec_query | text | Statement sent by the Extension Connector job to a remote cluster |
| ec_libodbc_type | text | Type of the unixODBC driver used by the Extension Connector job<br>• Type 1: corresponds to **libodbc.so.1**.<br>• Type 2: corresponds to **libodbc.so.2**. |
| ec_fetch_count | bigint | Number of data records processed by the Extension Connector job |

## 15.3.78 GS_WLM_EC_OPERATOR_HISTORY

**GS_WLM_EC_OPERATOR_HISTORY** displays records of operators in Extension Connector jobs that have been executed by the current user on the current CN. The records in this view are cleared every 3 minutes. Only the user with sysadmin permission can query this view. The current feature is a lab feature. Contact Huawei technical support before using it.

- If the GUC parameter **enable_resource_record** is **on**, the records in the view are dumped to the **15.2.30 GS_WLM_EC_OPERATOR_INFO** system catalog and then deleted from the view every 3 minutes.
- If **enable_resource_record** is set to **off**, the records are retained in the view for 3 minutes and then deleted. Columns in the view are the same as those in **15.2.30 GS_WLM_EC_OPERATOR_INFO**.

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## 15.3.79 GS_WLM_OPERATOR_HISTORY

**GS_WLM_OPERATOR_HISTORY** displays records of operators in jobs that have been executed by the current user on the current CN. Only the user with sysadmin permission can query this view.

Data in the kernel is cleared every 3 minutes. If the GUC parameter **enable_resource_record** is set to **on**, the records in the view are dumped to the **15.2.32 GS_WLM_OPERATOR_INFO** system catalog every 3 minutes and deleted from the view. If **enable_resource_record** is set to **off**, the records are retained in the view for 3 minutes and then deleted. The recorded data is the same as that described in **Table 15-29**.

## 15.3.80 GS_WLM_OPERATOR_STATISTICS

**GS_WLM_OPERATOR_STATISTICS** displays operators of the jobs that are being executed by the current user. Only the user with sysadmin permission can query this view.

**Table 15-187** GS_WLM_OPERATOR_STATISTICS columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for statement execution |
| pid | bigint | Backend thread ID |
| plan_node_id | integer | Plan node ID of the execution plan |
| plan_node_name | text | Name of the operator corresponding to the plan node ID |
| start_time | timestamp with time zone | Time when an operator starts to process the first data record |
| duration | bigint | Total execution time of the operator, in ms |
| status | text | Execution status of the current operator, which can be **finished** or **running**. |
| query_dop | integer | DOP of the operator |
| estimated_rows | bigint | Number of rows estimated by the optimizer |
| tuple_processed | bigint | Number of elements returned by the operator |
| min_peak_memory | integer | Minimum peak memory used by the operator on all DNs, in MB |
| max_peak_memory | integer | Maximum peak memory used by the operator on all DNs, in MB |

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| Name | Type | Description |
| --- | --- | --- |
| average_peak_memory | integer | Average peak memory used by the operator on all DNs, in MB |
| memory_skew_percent | integer | Memory usage skew of the operator among DNs |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_cpu_time | bigint | Minimum execution time of the operator on all DNs, in ms |
| max_cpu_time | bigint | Maximum execution time of the operator on all DNs, in ms |
| total_cpu_time | bigint | Total execution time of the operator on all DNs, in ms |
| cpu_skew_percent | integer | Skew of the execution time among DNs |
| warning | text | The following warnings are displayed:<br>• Sort/SetOp/HashAgg/HashJoin spill<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |

## 15.3.81 GS_WLM_REBUILD_USER_RESOURCE_POOL

**GS_WLM_REBUILD_USER_RESOURCE_POOL** is used to rebuild a user's resource pool information in memory on the current connection node. This view is only used as a remedy when resource pool information is missing or misplaced. Only the user with sysadmin permission can query this view.

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**Table 15-188** Fields in **GS_WLM_REBUILD_USER_RESOURCE_POOL**

| Name | Type | Description |
| --- | --- | --- |
| gs_wlm_rebuild_user_resource_pool | boolean | Rebuilds information about the user resource pool in the memory. **t** indicates success, and **f** indicates failure. |

## 15.3.82 GS_WLM_RESOURCE_POOL

**GS_WLM_RESOURCE_POOL** records statistics on a resource pool.

**Table 15-189** GS_WLM_RESOURCE_POOL columns

| Name | Type | Description |
| --- | --- | --- |
| rpoid | oid | OID of a resource pool |
| respool | name | Name of the resource pool |
| control_group | name | Cgroup associated with the resource pool |
| parentid | oid | OID of the parent resource pool |
| ref_count | integer | Number of jobs associated with the resource pool |
| active_points | integer | Number of used points in the resource pool |
| running_count | integer | Number of jobs running in the resource pool |
| waiting_count | integer | Number of jobs queuing in the resource pool |
| io_limits | integer | IOPS upper limit of the resource pool |
| io_priority | integer | I/O priority of the resource pool |

## 15.3.83 GS_WLM_SESSION_HISTORY

**GS_WLM_SESSION_HISTORY** displays load management information about a completed job executed by the current user on the current CN. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the user with the **sysadmin** or **monitor admin** permission can query this view.

The data in GaussDB is deleted every 3 minutes. If the GUC parameter **enable_resource_record** is set to **on**, the records in the view are dumped to the **15.2.33 GS_WLM_SESSION_QUERY_INFO_ALL** system catalog every 3 minutes and deleted from the view. If **enable_resource_record** is set to **off**, the records are retained in the view for 3 minutes and then deleted.

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**Table 15-190** GS_WLM_SESSION_HISTORY columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the backend is connected to |
| dbname | text | Name of the database that the backend is connected to |
| schemaname | text | Schema name |
| nodename | text | Name of the CN where the statement is executed |
| username | text | Username used for connecting to the backend |
| application_name | text | Name of the application that is connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is **null**, either the client is connected via a Unix socket on the server machine or this is an internal process such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will only be non-null for IP connections, and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with this backend (**-1** if a Unix socket is used) |
| query_band | text | Job type, which is specified by the GUC parameter **query_band**. The default value is a null string. |
| block_time | bigint | Duration (in ms) that a statement is blocked before being executed, including the statement parsing and optimization duration |
| start_time | timestamp with time zone | Time when the statement starts to run |
| finish_time | timestamp with time zone | Time when the statement execution ends |
| duration | bigint | Execution time of the statement, in ms |
| estimate_total_time | bigint | Estimated execution time of the statement, in ms |

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| Name | Type | Description |
| --- | --- | --- |
| status | text | Final statement execution status, which can be **finished** (normal) or **aborted** (abnormal). |
| abort_info | text | Exception information displayed if the final statement execution status is **aborted** |
| resource_pool | text | Resource pool used by the user |
| control_group | text | Cgroup used by the statement |
| estimate_memory | integer | Estimated memory size of the statement. |
| min_peak_memory | integer | Minimum memory peak of the statement across all DNs, in MB |
| max_peak_memory | integer | Maximum memory peak of the statement across all DNs, in MB |
| average_peak_memory | integer | Average memory usage during statement execution, in MB |
| memory_skew_percent | integer | Memory usage skew of the statement among each DN |
| spill_info | text | Statement spill information on all DNs.<br>● None: No data is spilled to disks.<br>● All: Data is spilled to disks on all DNs.<br>● **[***a*:*b***]**: The statement has been spilled to disks on *a* of *b* DNs. |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs, in MB (default value: 0) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs, in MB (default value: 0) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs, in MB (default value: 0) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_dn_time | bigint | Minimum execution time of the statement across all DNs, in ms |
| max_dn_time | bigint | Maximum execution time of the statement across all DNs, in ms |
| average_dn_time | bigint | Average execution time of the statement across all DNs, in ms |
| dntime_skew_percent | integer | Execution time skew of the statement among each DN |

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| Name | Type | Description |
| --- | --- | --- |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs, in ms |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs, in ms |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs, in ms |
| cpu_skew_percent | integer | CPU time skew of the statement among DNs |
| min_peak_iops | integer | Minimum IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| max_peak_iops | integer | Maximum IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| average_peak_iops | integer | Average IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| iops_skew_percent | integer | I/O skew across DNs |
| warning | text | Warning. The following warnings and warnings related to **10.3.6.1 Optimizing SQL Self-Diagnosis** are displayed:<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |
| queryid | bigint | Internal query ID used for statement execution |
| query | text | Statement executed |
| query_plan | text | Execution plan of the statement |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

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| Name | Type | Description |
| --- | --- | --- |
| cpu_top1_node_name | text | Name of the node with the highest CPU usage |
| cpu_top2_node_name | text | Name of the node with the second highest CPU usage |
| cpu_top3_node_name | text | Name of the node with the third highest CPU usage |
| cpu_top4_node_name | text | Name of the node with the fourth highest CPU usage |
| cpu_top5_node_name | text | Name of the node with the fifth highest CPU usage |
| mem_top1_node_name | text | Name of the node with the highest memory usage |
| mem_top2_node_name | text | Name of the node with the second highest CPU usage |
| mem_top3_node_name | text | Name of the node with the third highest CPU usage |
| mem_top4_node_name | text | Name of the node with the fourth highest CPU usage |
| mem_top5_node_name | text | Name of the node with the fifth highest CPU usage |
| cpu_top1_value | bigint | CPU usage |
| cpu_top2_value | bigint | CPU usage |
| cpu_top3_value | bigint | CPU usage |
| cpu_top4_value | bigint | CPU usage |
| cpu_top5_value | bigint | CPU usage |
| mem_top1_value | bigint | Memory usage |
| mem_top2_value | bigint | Memory usage |
| mem_top3_value | bigint | Memory usage |
| mem_top4_value | bigint | Memory usage |
| mem_top5_value | bigint | Memory usage |
| top_mem_dn | text | Top N memory usage |

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| Name | Type | Description |
| --- | --- | --- |
| top_cpu_dn | text | Top N CPU usage |

## 15.3.84 GS_WLM_SESSION_INFO

**GS_WLM_SESSION_INFO** displays load management information about a completed job executed by the current CN. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the user with sysadmin permission can query this view.

Data is dumped from the kernel to this system catalog. If **enable_resource_record** is set to **on**, the system imports the query information from the kernel to **GS_WLM_SESSION_QUERY_INFO_ALL** every 3 minutes. This operation occupies storage space and affects performance. You can query the **GS_WLM_SESSION_INFO** to view the top SQL statements that have been dumped. For details about the columns, see **Table 15-190**.

## 15.3.85 GS_WLM_SESSION_INFO_ALL

**GS_WLM_SESSION_INFO_ALL** displays load management information for completed jobs executed on all CNs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the user with the **sysadmin** or **monitor admin** permission can query this view.

**Table 15-191** GS_WLM_SESSION_INFO_ALL columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the backend is connected to |
| dbname | text | Name of the database that the backend is connected to |
| schemaname | text | Schema name |
| nodename | text | Name of the CN where the statement is executed |
| username | text | Username used for connecting to the backend |
| application_name | text | Name of the application connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is **NULL**, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as **AUTOVACUUM**. |

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| Name | Type | Description |
| --- | --- | --- |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with this backend (**-1** if a Unix socket is used) |
| query_band | text | Job type, which is specified by the GUC parameter **query_band**. The default value is a null string. |
| block_time | bigint | Duration that the statement is blocked before being executed, including the statement parsing and optimization duration (unit: ms) |
| start_time | timestamp with time zone | Time when the statement starts to be executed |
| finish_time | timestamp with time zone | Time when the statement execution ends |
| duration | bigint | Execution time of the statement (unit: ms) |
| estimate_total_time | bigint | Estimated execution time of the statement (unit: ms) |
| status | text | Final statement execution status, which can be **finished** (normal) or **aborted** (abnormal) |
| abort_info | text | Exception information displayed if the final statement execution status is **aborted** |
| resource_pool | text | Resource pool used by the user |
| control_group | text | Cgroup used by the statement |
| estimate_memory | integer | Estimated memory size of the statement |
| min_peak_memory | integer | Minimum peak memory of the statement across all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory of the statement across all DNs (unit: MB) |
| average_peak_memory | integer | Average memory usage during statement execution (unit: MB) |
| memory_skew_percent | integer | Memory usage skew of the statement among DNs |

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| Name | Type | Description |
| --- | --- | --- |
| spill_info | text | Statement spill information on all DNs.<br>• **None**: No data is spilled to disks on all DNs.<br>• **All**: Data is spilled to disks on all DNs.<br>• **[*a*:*b*]**: The statement has been spilled to disks on *a* of *b* DNs. |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_dn_time | bigint | Minimum execution time of the statement across all DNs (unit: ms) |
| max_dn_time | bigint | Maximum execution time of the statement across all DNs (unit: ms) |
| average_dn_time | bigint | Average execution time of the statement across all DNs (unit: ms) |
| dntime_skew_percent | integer | Execution time skew of the statement among DNs |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs (unit: ms) |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs (unit: ms) |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs (unit: ms) |
| cpu_skew_percent | integer | CPU time skew of the statement among DNs |
| min_peak_iops | integer | Minimum peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| max_peak_iops | integer | Maximum peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |

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| Name | Type | Description |
| --- | --- | --- |
| average_peak_iops | integer | Average peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| iops_skew_percent | integer | I/O skew of the statement among DNs |
| warning | text | Warning. The following warnings and warnings related to **10.3.6.1 Optimizing SQL Self-Diagnosis** are displayed:<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |
| queryid | bigint | Internal query ID used for statement execution |
| query | text | Statement executed |
| query_plan | text | Execution plan of the statement |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| cpu_top1_node_name | text | Name of the node with the 1st CPU usage |
| cpu_top2_node_name | text | Name of the node with the 2nd CPU usage |
| cpu_top3_node_name | text | Name of the node with the 3rd CPU usage |
| cpu_top4_node_name | text | Name of the node with the 4th CPU usage |
| cpu_top5_node_name | text | Name of the node with the 5th CPU usage |
| mem_top1_node_name | text | Name of the node with the 1st memory usage |
| mem_top2_node_name | text | Name of the node with the 2nd memory usage |
| mem_top3_node_name | text | Name of the node with the 3rd memory usage |

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| Name | Type | Description |
| --- | --- | --- |
| mem_top4_node_name | text | Name of the node with the 4th memory usage |
| mem_top5_node_name | text | Name of the node with the 5th memory usage |
| cpu_top1_value | bigint | CPU usage |
| cpu_top2_value | bigint | CPU usage |
| cpu_top3_value | bigint | CPU usage |
| cpu_top4_value | bigint | CPU usage |
| cpu_top5_value | bigint | CPU usage |
| mem_top1_value | bigint | Memory usage |
| mem_top2_value | bigint | Memory usage |
| mem_top3_value | bigint | Memory usage |
| mem_top4_value | bigint | Memory usage |
| mem_top5_value | bigint | Memory usage |
| top_mem_dn | text | Top *N* memory usage |
| top_cpu_dn | text | Top *N* CPU usage |
| n_returned_rows | bigint | Number of rows in the result set returned by the **SELECT** statement |
| n_tuples_fetched | bigint | Number of rows randomly scanned |
| n_tuples_returned | bigint | Number of rows sequentially scanned |
| n_tuples_inserted | bigint | Number of rows inserted |
| n_tuples_updated | bigint | Number of rows updated |
| n_tuples_deleted | bigint | Number of rows deleted |
| n_blocks_fetched | bigint | Number of buffer block access times |
| n_blocks_hit | bigint | Number of buffer block hits |

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| Name | Type | Description |
| --- | --- | --- |
| db_time | bigint | Valid DB time, which is accumulated if multiple threads are involved (unit: μs) |
| cpu_time | bigint | CPU time (unit: μs) |
| execution_time | bigint | Execution time in the executor (unit: μs) |
| parse_time | bigint | SQL parsing time (unit: μs) |
| plan_time | bigint | SQL plan generation time (unit: μs) |
| rewrite_time | bigint | SQL rewriting time (unit: μs) |
| pl_execution_time | bigint | Execution time of PL/pgSQL (unit: μs) |
| pl_compilation_time | bigint | Compilation time of PL/pgSQL (unit: μs) |
| net_send_time | bigint | Network time (unit: μs) |
| data_io_time | bigint | I/O time (unit: μs) |
| is_slow_query | bigint | Whether the record is a slow SQL record. |

## 15.3.86 GS_WLM_USER_INFO

**GS_WLM_USER_INFO** displays user statistics. Only the user with sysadmin permission can query this view.

**Table 15-192** GS_WLM_USER_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| userid | oid | OID of a user |
| username | name | Username |
| sysadmin | boolean | Whether the user is the administrator<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| rpoid | oid | OID of the associated resource pool |
| respool | name | Name of the associated resource pool |
| parentid | oid | OID of the user group |
| totalspace | bigint | Available space limit of the user |

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| Name | Type | Description |
| --- | --- | --- |
| spacelimit | bigint | User table space limit |
| childcount | interger | Number of child users |
| childlist | text | Child user list |

## 15.3.87 GS_WLM_USER_SESSION_INFO

**GS_WLM_USER_SESSION_INFO** displays load management information about all completed jobs executed by the current user on all CNs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The data in this view is obtained from **15.2.33 GS_WLM_SESSION_QUERY_INFO_ALL**. For details on columns in the view, see **Table 15-190**. This view can be queried by users with the **sysadmin** permission only in Postgres.

## 15.3.88 GS_WLM_SESSION_STATISTICS

**GS_WLM_SESSION_STATISTICS** displays load management information about jobs being executed by the current user on the current CN. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the user with sysadmin permission can query this view.

**Table 15-193** GS_WLM_SESSION_STATISTICS columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the backend is connected to |
| dbname | name | Name of the database that the backend is connected to |
| schemaname | text | Schema name |
| nodename | text | Name of the CN where the statement is executed. |
| username | name | Username used for connecting to the backend |
| application_name | text | Name of the application that is connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is **NULL**, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as **AUTOVACUUM**. |

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| Name | Type | Description |
| --- | --- | --- |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with this backend (**-1** if a Unix socket is used) |
| query_band | text | Job type, which is specified by the GUC parameter **query_band**. The default value is a null string. |
| pid | bigint | Backend thread ID |
| sessionid | bigint | Session ID |
| global_sessionid | text | Global session ID |
| block_time | bigint | Block time before the statement is run, in ms |
| start_time | timestamp with time zone | Time when the statement starts to run |
| duration | bigint | Duration that a statement has been executed, in ms |
| estimate_total_time | bigint | Estimated execution time of the statement, in ms |
| estimate_left_time | bigint | Estimated remaining execution time of the statement, in ms |
| enqueue | text | Resource status in workload management. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| resource_pool | name | Resource pool used by the user |
| control_group | text | Cgroup used by the statement |
| estimate_memory | integer | Estimated memory used by the statement, in MB. This parameter takes effect only if **enable_dynamic_workload** is set to **on**. |
| min_peak_memory | integer | Minimum memory peak of the statement across all DNs, in MB |
| max_peak_memory | integer | Maximum memory peak of the statement across all DNs, in MB |
| average_peak_memory | integer | Average memory usage during statement execution, in MB |

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| Name | Type | Description |
| --- | --- | --- |
| memory_skew_percent | integer | Memory usage skew of the statement among each DNs |
| spill_info | text | Statement spill information on all DNs:<br>• **None**: No data is spilled to disks on all DNs.<br>• **All**: Data is spilled to disks on all DNs.<br>• **[*a*:*b*]**: The statement has been spilled to disks on *a* of *b* DN. |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs, in MB (default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_dn_time | bigint | Minimum execution time of the statement across all DNs, in ms |
| max_dn_time | bigint | Maximum execution time of the statement across all DNs, in ms |
| average_dn_time | bigint | Average execution time of the statement across all DNs, in ms |
| dntime_skew_percent | integer | Execution time skew of the statement among each DN |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs, in ms |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs, in ms |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs, in ms |
| cpu_skew_percent | integer | CPU time skew of the statement among each DNs |
| min_peak_iops | integer | Minimum IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| max_peak_iops | integer | Maximum IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |

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| Name | Type | Description |
| --- | --- | --- |
| average_peak_iops | integer | Average IOPS peak of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| iops_skew_percent | integer | I/O skew across DN |
| warning | text | Warning. The following warnings and warnings related to **10.3.6.1 Optimizing SQL Self-Diagnosis** are displayed:<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |
| queryid | bigint | Internal query ID used for statement execution |
| query | text | Statement being executed |
| query_plan | text | Execution plan of the statement |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| top_cpu_dn | text | Top N CPU usage |
| top_mem_dn | text | Top *N* memory usage |

## 15.3.89 GS_WLM_WORKLOAD_RECORDS

**GS_WLM_WORKLOAD_RECORDS** displays the status of job executed by the current user on each CN. Only the user with sysadmin permission can query this view.

**Table 15-194** GS_WLM_WORKLOAD_RECORDS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Name of the CN where a job is executed |
| thread_id | bigint | Process ID of the backend |
| processid | integer | PID of the backend thread |

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| Name | Type | Description |
| --- | --- | --- |
| time_stamp | bigint | Time when the statement starts to be run |
| username | name | Name of the user logged in to the backend |
| memory | integer | Memory required by the statement |
| active_points | integer | Number of resource points consumed by the statement in a resource pool |
| max_points | integer | Maximum number of resource points that can be consumed by the statement in a resource pool |
| priority | integer | Priority of the job The value must be within the **integer** range. A larger value indicates a higher priority. |
| resource_pool | text | Resource pool to which the job belongs |
| status | text | Job execution status. The value must be one of the following:<br>● pending<br>● running<br>● finished<br>● aborted<br>● unknown |
| control_group | text | Cgroups used by the job |
| enqueue | text | Queue that the job is in. The value must be one of the following:<br>● **GLOBAL**: global queue<br>● **RESPOOL**: resource pool queue<br>● **Active**: not in a queue |
| query | text | Statement being executed |
| node_group | text | Logical cluster name (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

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# 15.3.90 GV_SESSION

**GV_SESSION** view describes the information related to the current user's queries. The columns save the information about the last query.

**Table 15-195** GV_SESSION columns

| Name | Type | Description |
| --- | --- | --- |
| SID | bigint | Session ID |
| SERIAL# | integer | Sequence number of the active backend thread, which is **0** in GaussDB. |
| SCHEMANAME | name | Name of the user logged in to the backend. |
| USER# | oid | OID of the user that has logged in to the backend thread. (**0** if the backend thread is a global auxiliary thread) |
| USERNAME | name | Username of the user that has logged in to the backend thread. (null if the backend thread is a global auxiliary thread) |
| MACHINE | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| SQL_ID | bigint | ID of a query. |
| CLIENT_INFO | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| EVENT | text | Queuing status of a statement. Possible values are:<br>● **waiting in queue**: The statement is in the queue.<br>● null: The statement is running. |
| SQL_EXEC_START | timestamp with time zone | Time when the currently active query was started, or if **state** is not **active**, when the last query was started. |
| PROGRAM | text | Name of the application connected to the backend. |

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| Name | Type | Description |
| --- | --- | --- |
| STATUS | text | Overall status of this backend. Possible values are:<br>• **active**: The backend is executing a query.<br>• **idle**: The backend is waiting for a new client command.<br>• **idle in transaction**: The backend is in a transaction, but there is no statement being executed in the transaction.<br>• **idle in transaction (aborted)**: The backend is in a transaction, but there are statements failed in the transaction.<br>• **fastpath function call**: The backend is executing a fast-path function.<br>• **disabled**: This state is reported if **track_activities** is disabled in this backend. |

## 15.3.91 MPP_TABLES

**MPP_TABLES** displays information about tables in **PGXC_CLASS**.

**Table 15-196** MPP_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that contains a table |
| tablename | name | Table name |
| tableowner | name | Table owner |
| tablespace | name | Tablespace containing the table |
| pgroup | name | Name of the node |
| nodeoids | oidvector_extend | List of distributed table node OIDs |

## 15.3.92 MY_COL_COMMENTS

**MY_COL_COMMENTS** displays column comments of the table accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

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**Table 15-197** MY_COL_COMMENTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | character varying(64) | Column name |
| comments | text | Comments |

## 15.3.93 MY_CONS_COLUMNS

**MY_CONS_COLUMNS** displays information about primary key constraint columns in tables accessible to the current user. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-198** MY_CONS_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Constraint creator |
| table_name | character varying(64) | Name of a constraint-related table |
| column_name | character varying(64) | Name of a constraint-related column |
| constraint_name | character varying(64) | Constraint name |
| position | smallint | Position of the column in the table |

## 15.3.94 MY_CONSTRAINTS

**MY_CONSTRAINTS** displays table constraint information accessible to the current user. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-199** MY_CONSTRAINTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varyiny(64) | Constraint creator |
| constraint_name | vcharacter varying(64) | Constraint name |

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| Name | Type | Description |
| --- | --- | --- |
| constraint_type | text | Constraint type<br>• **c**: check constraint<br>• **f**: foreign key constraint<br>• **p**: primary key constraint<br>• **u**: unique constraint |
| table_name | character varying(64) | Name of a constraint-related table |
| index_owner | character varying(64) | Owner of a constraint-related index (only for the unique constraint and primary key constraint) |
| index_name | character varying(64) | Name of the constraint-related index (only for the unique constraint and primary key constraint) |

## 15.3.95 MY_INDEXES

**MY_INDEXES** displays index information in the current schema. This view exists in both PG_CATALOG and SYS schema.

**Table 15-200** MY_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| table_name | character varying(64) | Name of the table corresponding to the index |
| uniqueness | text | Whether the index is unique |
| partitioned | character(3) | Whether the index has the property of partitioned tables |
| generated | character varying(1) | Whether the index name is generated by the system |

## 15.3.96 MY_IND_COLUMNS

**MY_IND_COLUMNS** displays column information about all indexes accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

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**Table 15-201** MY_IND_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| index_owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| table_owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | name | Column name |
| column_position | smallint | Position of the column in the index |

## 15.3.97 MY_IND_EXPRESSIONS

**MY_IND_EXPRESSIONS** displays information about function-based expression indexes accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-202** MY_IND_EXPRESSIONS columns

| Name | Type | Description |
| --- | --- | --- |
| table_owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| index_owner | character varying(64) | Index owner |
| index_name | character varying(64) | Index name |
| column_expression | text | Function-based index expression of a specified column |
| column_position | smallint | Position of the column in the index |

## 15.3.98 MY_IND_PARTITIONS

**MY_IND_PARTITIONS** displays information about index partitions accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

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**Table 15-203** MY_IND_PARTITIONS columns

| Name | Type | Description |
| --- | --- | --- |
| index_owner | character varying(64) | Name of the owner of the partitioned table index to which an index partition belongs |
| index_name | character varying(64) | Index name of the partitioned table index to which the index partition belongs |
| partition_name | character varying(64) | Name of the index partition |
| def_tablespace_name | name | Tablespace name of the index partition |
| high_value | text | Upper limit of the partition corresponding to the index partition |
| index_partition_usable | boolean | Whether the index partition is available<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| schema | character varying(64) | Schema of the partitioned table index to which the index partition belongs |

## 15.3.99 MY_JOBS

**MY_JOBS** displays all jobs owned by the user. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-204** MY_JOBS columns

| Name | Type | Description |
| --- | --- | --- |
| job | bigint | Job ID |
| log_user | name | Username of the job creator |
| priv_user | name | Username of the job executor |
| dbname | name | Name of the database in which the job is created |
| start_date | timestamp without time zone | Job start time |
| start_suc | text | Start time of the successful job execution |

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| Name | Type | Description |
| --- | --- | --- |
| last_date | timestamp without time zone | Start time of the last job execution |
| last_suc | text | Start time of the last successful job execution |
| this_date | timestamp without time zone | Start time of the ongoing job execution |
| this_suc | text | Start time of the ongoing successful job execution |
| next_date | timestamp without time zone | Schedule time of the next job execution |
| next_suc | text | Schedule time of the next successful job execution |
| broken | text | **y** if the job status is broken and **n** if otherwise |
| status | "char" | Status of the current job. The value can be **r**, **s**, **f**, or **d**. The default value is **r**.<br>Status of job step:<br>● r=running<br>● s=successfully finished<br>● f= job failed<br>● d=aborted |
| interval | text | Time expression used to calculate the next time the job will be executed. If this parameter is set to **null**, the job will be executed once only. |
| failures | smallint | Number of times the job has started and failed. If a job fails to be executed for 16 consecutive times, no more attempt will be made on it. |
| what | text | Executable job |

## 15.3.100 MY_OBJECTS

**MY_OBJECTS** displays all database objects accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

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**Table 15-205** MY_OBJECTS columns

| Name | Type | Description |
| --- | --- | --- |
| object_name | name | Object name |
| object_id | oid | OID of the object |
| object_type | name | Type of the object (**TABLE**, **INDEX**, **SEQUENCE**, or **VIEW**) |
| namespace | oid | Namespace that the object belongs to |
| created | timestamp with time zone | Creation time of the object |
| last_ddl_time | timestamp with time zone | Last modification time of the object |

**NOTICE**

For details on the value ranges of **created** and **last_ddl_time**, see **15.2.71 PG_OBJECT**.

## 15.3.101 MY_PART_INDEXES

**MY_PART_INDEXES** displays information about partitioned table indexes accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-206** MY_PART_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| def_tablespace_name | name | Tablespace name of the partitioned table index |
| index_owner | character varying(64) | Name of the owner of a partitioned table index |
| index_name | character varying(64) | Name of the partitioned table index |
| partition_count | bigint | Number of index partitions of the partitioned table index |
| partitioning_key_count | integer | Number of partition keys of the partitioned table |

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| Name | Type | Description |
| --- | --- | --- |
| partitioning_type | text | Partition policy of the partitioned table<br>**NOTE**<br>Only range partitioning is supported. |
| schema | character varying(64) | Schema of the partitioned table index |
| table_name | character varying(64) | Name of the partitioned table to which the partitioned table index belongs |

## 15.3.102 MY_PART_TABLES

**MY_PART_TABLES** displays information about partitioned tables accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-207** MY_PART_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| table_owner | character varying(64) | Owner name of a partitioned table |
| table_name | character varying(64) | Name of the partitioned table |
| partitioning_type | text | Partition policy of the partitioned table<br>**NOTE**<br>Only range partitioning is supported. |
| partition_count | bigint | Number of partitions in the partitioned table |
| partitioning_key_count | integer | Number of partition keys of the partitioned table |
| def_tablespace_name | name | Tablespace name of the partitioned table |
| schema | character varying(64) | Schema of the partitioned table |

## 15.3.103 MY_PROCEDURES

**MY_PROCEDURES** displays information about all stored procedures and functions in the current schema. This view exists in both PG_CATALOG and SYS schema.

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**Table 15-208** MY_PROCEDURES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a stored procedure or function |
| object_name | character varying(64) | Name of the stored procedure or function |
| argument_number | smallint | Number of input parameters in the stored procedure |

## 15.3.104 MY_SEQUENCES

**MY_SEQUENCES** displays information about sequences in the current schema. This view exists in the **PG_CATALOG** and **SYS** schemas.

**Table 15-209** MY_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| sequence_owner | name | Owner of a sequence |
| sequence_name | name | Name of a sequence |
| min_value | int16 | Minimum value of a sequence |
| max_value | int16 | Maximum value of a sequence |
| increment_by | int16 | Value by which a sequence is incremented |
| cycle_flag | character(1) | Whether a sequence is a cycle sequence. The value can be **Y** or **N**.<br>• **Y**: It is a cycle sequence.<br>• **N**: It is not a cycle sequence. |
| last_number | int16 | Value of the previous sequence |
| cache_size | int16 | Size of the sequence disk cache |

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## 15.3.105 MY_SOURCE

**MY_SOURCE** displays information about stored procedures or functions in this schema, and provides columns defined by the stored procedures or the functions. This view exists in both PG_CATALOG and SYS schema.

**Table 15-210** MY_SOURCE columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a stored procedure or function |
| name | character varying(64) | Name of the stored procedure or function |
| text | text | Definition of the stored procedure or function |

## 15.3.106 MY_SYNONYMS

**MY_SYNONYMS** displays synonyms accessible to the current user.

**Table 15-211** MY_SYNONYMS columns

| Name | Type | Description |
| --- | --- | --- |
| schema_name | text | Name of the schema to which the synonym belongs |
| synonym_name | text | Synonym name |
| table_owner | text | Owner of the associated object. Although the column is called **table_owner**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |
| table_name | text | Name of the associated object. Although the column is called **table_name**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |

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| Name | Type | Description |
| --- | --- | --- |
| table_schema_name | text | Schema name of the associated object. Although the column is called **table_schema_name**, the associated object is not necessarily a table. It can be any common database object, such as a view, stored procedure, or synonym. |

## 15.3.107 MY_TAB_COLUMNS

**MY_TAB_COLUMNS** displays information about table columns accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-212** MY_TAB_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| column_name | character varying(64) | Column name |
| data_type | character varying(128) | Data type of the column |
| data_length | integer | Length of the column, in bytes |
| data_precision | integer | Precision of the data type. This parameter is valid for the numeric data type and **NULL** for other types. |
| data_scale | integer | Number of decimal places. This parameter is valid for the numeric data type and **0** for other data types. |
| nullable | bpchar | Whether the column can be empty (**n** for the primary key constraint and non-null constraint) |
| column_id | integer | Sequence number of the column when the table is created |
| avg_col_len | numeric | Average length of a column, in bytes |

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| Name | Type | Description |
| --- | --- | --- |
| char_length | numeric | Length of the column, in characters. This parameter is valid only for the varchar, nvarchar2, bpchar, and char types. |
| comments | text | Specifies the comment content. |

## 15.3.108 MY_TAB_COMMENTS

**MY_TAB_COMMENTS** displays comments about all tables and views accessible to the current user. This view exists in both PG_CATALOG and SYS schema.

**Table 15-213** MY_TAB_COMMENTS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a table or view |
| table_name | character varying(64) | Name of the table or view |
| comments | text | Comments |

## 15.3.109 MY_TAB_PARTITIONS

**MY_TAB_PARTITIONS** displays all table partitions accessible to the current user. Each table partition of a partitioned table accessible to the current user has a piece of record in **USER_TAB_PARTITIONS**. This view exists in both PG_CATALOG and SYS schema.

**Table 15-214** MY_TAB_PARTITIONS columns

| Name | Type | Description |
| --- | --- | --- |
| table_owner | character varying(64) | Owner name of a partitioned table |
| table_name | character varying(64) | Name of the partitioned table |
| partition_name | character varying(64) | Name of a table partition |
| high_value | text | Upper boundary of the table partition |
| tablespace_name | name | Name of the tablespace of the table partition |

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| Name | Type | Description |
| --- | --- | --- |
| schema | character varying(64) | Schema of the partitioned table |

## 15.3.110 MY_TABLES

**MY_TABLES** displays table information in the current schema. This view exists in both PG_CATALOG and SYS schema.

**Table 15-215** MY_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Table owner |
| table_name | character varying(64) | Table name |
| tablespace_name | character varying(64) | Tablespace name of the table |
| dropped | character varying | Whether the current record is deleted<br>• **yes**: The record is deleted.<br>• **no**: The record is not deleted. |
| num_rows | numeric | Estimated number of rows in the table |
| status | character varying(8) | Whether the current record is valid<br>• **valid**: indicates that this record is valid. |
| temporary | character(1) | Whether the table is a temporary table<br>• **y**: The table is a temporary table.<br>• **n**: The table is not a temporary table. |

## 15.3.111 MY_TRIGGERS

**MY_TRIGGERS** displays information about triggers accessible to the current user. This view exists in the **PG_CATALOG** and **SYS** schemas.

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**Table 15-216** MY_TRIGGERS columns

| Name | Type | Description |
| --- | --- | --- |
| trigger_name | character varying(64) | Trigger name |
| table_name | character varying(64) | Relational table name |
| table_owner | character varying(64) | Role name |
| status | character varying(64) | **O**: The trigger is initiated in origin or local mode.<br>**D**: The trigger is disabled.<br>**R**: The trigger is initiated in replica mode.<br>**A**: The trigger is always initiated. |

## 15.3.112 MY_VIEWS

**MY_VIEWS** displays information about all views in the current schema. This view exists in both PG_CATALOG and SYS schema.

**Table 15-217** MY_VIEWS columns

| Name | Type | Description |
| --- | --- | --- |
| owner | character varying(64) | Owner of a view |
| view_name | character varying(64) | View name |

## 15.3.113 PG_AVAILABLE_EXTENSIONS

**PG_AVAILABLE_EXTENSIONS** displays extended information about certain database features.

**Table 15-218** PG_AVAILABLE_EXTENSIONS columns

| Name | Type | Description |
| --- | --- | --- |
| name | name | Extension name |
| default_version | text | Name of the default version (**NULL** if none is specified) |
| installed_version | text | Currently installed version of the extension (**NULL** if no version is installed) |
| comment | text | Comment string from the extension's control file |

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## 15.3.114 PG_AVAILABLE_EXTENSION_VERSIONS

**PG_AVAILABLE_EXTENSION_VERSIONS** displays extension versions of certain database features.

**Table 15-219** PG_AVAILABLE_EXTENSION_VERSIONS columns

| Name | Type | Description |
| --- | --- | --- |
| name | name | Extension name |
| version | text | Version name |
| installed | boolean | Whether this extension version is installed Otherwise, the value is **false**. |
| superuser | boolean | Whether only system administrators are allowed to install the extension Otherwise, the value is **false**. |
| relocatable | boolean | Whether the extension can be relocated to another schema Otherwise, the value is **false**. |
| schema | name | Name of the schema that the extension must be installed into (**NULL** if the extension is partially or fully relocatable) |
| requires | name[] | Names of prerequisite extensions (**NULL** if none) |
| comment | text | Comment string from the extension's control file |

## 15.3.115 PG_COMM_DELAY

**PG_COMM_DELAY** displays the communication library delay status for a single DN.

**Table 15-220** PG_COMM_DELAY columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| remote_name | text | Name of the peer node |
| remote_host | text | IP address of the peer node |
| stream_num | integer | Number of logical stream connections used by the current physical connection |

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| Name | Type | Description |
| --- | --- | --- |
| min_delay | integer | Minimum delay of the current physical connection within 1 minute, in microsecond<br>**NOTE**<br>A negative result is invalid. Wait until the delay status is updated and query again. |
| average | integer | Average delay of the current physical connection within 1 minute, in microsecond |
| max_delay | integer | Maximum delay of the current physical connection within 1 minute, in microsecond |

## 15.3.116 PG_COMM_RECV_STREAM

**PG_COMM_RECV_STREAM** displays the receiving stream status of all the communication libraries for a single DN.

**Table 15-221** PG_COMM_RECV_STREAM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| local_tid | bigint | ID of the thread using this stream |
| remote_name | text | Name of the peer node |
| remote_tid | bigint | Peer thread ID |
| idx | integer | Peer DN ID in the local DN |
| sid | integer | Stream ID in the physical connection |
| tcp_sock | integer | TCP socket used in the stream |
| state | text | Status of the stream<br>• **UNKNOWN**: The logical connection status is unknown.<br>• **READY**: The logical connection is ready.<br>• **RUN**: The logical connection sends packets normally.<br>• **HOLD**: The logical connection is waiting to send packets.<br>• **CLOSED**: The logical connection is closed.<br>• **TO_CLOSED**: The logical connection will be closed. |
| query_id | bigint | **debug_query_id** corresponding to the stream |

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| Name | Type | Description |
| --- | --- | --- |
| pn_id | integer | **plan_node_id** of the query executed by the stream |
| send_smp | integer | **smpid** of the sender of the query executed by the stream |
| recv_smp | integer | **smpid** of the receiver of the query executed by the stream |
| recv_bytes | bigint | Total data volume received from the stream, in byte |
| time | bigint | Current lifecycle service duration of the stream, in ms |
| speed | bigint | Average receiving rate of the stream, in byte/s |
| quota | bigint | Current communication quota value of the stream, in byte |
| buff_usize | bigint | Current size of the data cache of the stream, in byte |

## 15.3.117 PG_COMM_SEND_STREAM

**PG_COMM_SEND_STREAM** displays the sending stream status of all the communication libraries for a single DN.

**Table 15-222** PG_COMM_SEND_STREAM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| local_tid | bigint | ID of the thread using this stream |
| remote_name | text | Name of the peer node |
| remote_tid | bigint | Peer thread ID |
| idx | integer | Peer DN ID in the local DN |
| sid | integer | Stream ID in the physical connection |
| tcp_sock | integer | TCP socket used in the stream |

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| Name | Type | Description |
| --- | --- | --- |
| state | text | Status of the stream<br>• **UNKNOWN**: The logical connection status is unknown.<br>• **READY**: The logical connection is ready.<br>• **RUN**: The logical connection sends packets normally.<br>• **HOLD**: The logical connection is waiting to send packets.<br>• **CLOSED**: The logical connection is closed.<br>• **TO_CLOSED**: The logical connection will be closed. |
| query_id | bigint | **debug_query_id** corresponding to the stream |
| pn_id | integer | **plan_node_id** of the query executed by the stream |
| send_smp | integer | **smpid** of the sender of the query executed by the stream |
| recv_smp | integer | **smpid** of the receiver of the query executed by the stream |
| send_bytes | bigint | Total data volume sent by the stream, in byte |
| time | bigint | Current lifecycle service duration of the stream, in ms |
| speed | bigint | Average sending rate of the stream, in byte/s |
| quota | bigint | Current communication quota value of the stream, in byte |
| wait_quota | bigint | Extra time generated when the stream waits the quota value, in ms |

## 15.3.118 PG_COMM_STATUS

**PG_COMM_STATUS** displays the communication library status for a single DN.

**Table 15-223** PG_COMM_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| rxpck_rate | integer | Receiving rate of the communication library on the node, in byte/s |

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| Name | Type | Description |
| --- | --- | --- |
| txpck_rate | integer | Sending rate of the communication library on the node, in byte/s |
| rxkbyte_rate | bigint | Receiving rate of the communication library on the node, in kbyte/s |
| txkbyte_rate | bigint | Sending rate of the communication library on the node, in kbyte/s |
| buffer | bigint | Size of the buffer of the Cmailbox |
| memkbyte_libcomm | bigint | Communication memory size of the **libcomm** process, in bytes |
| memkbyte_libpq | bigint | Communication memory size of the **libpq** process, in bytes |
| used_pm | integer | Real-time usage of the **postmaster** thread |
| used_sflow | integer | Real-time usage of the **gs_sender_flow_controller** thread |
| used_rflow | integer | Real-time usage of the **gs_receiver_flow_controller** thread |
| used_rloop | integer | Highest real-time usage among multiple **gs_receivers_loop** threads |
| stream | integer | Total number of used logical connections. |

## 15.3.119 PG_CONTROL_GROUP_CONFIG

**PG_CONTROL_GROUP_CONFIG** stores Cgroup configuration information in the system. Only the user with sysadmin permission can query this view.

**Table 15-224** PG_CONTROL_GROUP_CONFIG columns

| Name | Type | Description |
| --- | --- | --- |
| pg_control_group_config | text | Configuration information of the Cgroup |

## 15.3.120 PG_CURSORS

**PG_CURSORS** displays cursors that are currently available.

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**Table 15-225** PG_CURSORS columns

| Name | Type | Description |
| --- | --- | --- |
| name | text | Cursor name |
| statement | text | Query statement when the cursor is declared to change |
| is_holdable | boolean | **True** if the cursor is holdable (it can be accessed after the transaction that declared the cursor has committed); **false** otherwise |
| is_binary | boolean | Whether the cursor was declared BINARY. If it was, the value is **true**. |
| is_scrollable | boolean | Whether the cursor is scrollable (it allows rows to be retrieved in a nonsequential manner). If it is, the value is **true**. |
| creation_time | timestamp with time zone | Timestamp at which the cursor is declared |

## 15.3.121 PG_EXT_STATS

**PG_EXT_STATS** allows for access to extension statistics stored in the **15.2.91 PG_STATISTIC_EXT** system catalog. The extension statistics means multiple columns of statistics. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 15-226** PG_EXT_STATS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| schemaname | name | **15.2.70 PG_NAMESPACE**.nspname | Name of the schema that contains a table |
| tablename | name | **relname** in **15.2.46 PG_CLASS** | Table name |
| attname | int2vector | **15.2.91 PG_STATISTIC_EXT**.stakey | Columns to be combined for collecting statistics |
| inherited | boolean | - | Includes inherited sub-columns if the value is **true**; otherwise, it indicates the column in a specified table. |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| null_frac | real | - | Percentage of column combinations that are null to all records |
| avg_width | integer | - | Average width of column combinations, in byte |
| n_distinct | real | - | • Estimated number of distinct values in a column combination if the value is greater than 0<br>• Negative of the number of distinct values divided by the number of rows if the value is less than 0<br>1. The negated form is used when **ANALYZE** believes that the number of distinct values is likely to increase as the table grows.<br>2. The positive form is used when the column seems to have a fixed number of possible values. For example, **–1** indicates that the number of distinct values is the same as the number of rows for a column combination.<br>• The number of distinct values is unknown if the value is **0**. |
| n_dndistinct | real | - | Number of unique not-null data values in the **dn1** column combination<br>• Exact number of distinct values if the value is greater than **0**.<br>• Negative of the number of distinct values divided by the number of rows if the value is less than **0**. For example, if a value in a column combination appears twice in average, **n_dndistinct** equals **–0.5**.<br>• The number of distinct values is unknown if the value is **0**. |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| most_common_vals | anyarray | - | List of the most common values in a column combination. If this combination does not have the most common values, **most_common_vals** will be **NULL**. None of the most common values in **most_common_vals** is **NULL**. |
| most_common_freqs | real[] | - | List of the frequencies of the most common values, that is, the number of occurrences of each value divided by the total number of rows (**NULL** if **most_common_vals** is **NULL**) |
| most_common_vals_null | anyarray | - | List of the most common values in a column combination. If this combination does not have the most common values, **most_common_vals_null** will be **NULL**. At least one of the common values in **most_common_vals_null** is **NULL**. |
| most_common_freqs_null | real[] | - | List of the frequencies of the most common values, that is, the number of occurrences of each value divided by the total number of rows (**NULL** if **most_common_vals_null** is **NULL**) |
| histogram_bounds | anyarray | - | Boundary value list of the histogram |

## 15.3.122 PG_GET_INVALID_BACKENDS

The **PG_GET_INVALID_BACKENDS** view displays information about current DN standby server backend threads connected to the CN. Only system administrator and monitor administrator can access this view.

**Table 15-227** PG_GET_INVALID_BACKENDS columns

| Name | Type | Description |
| --- | --- | --- |
| pid | bigint | Thread ID |

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| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node information connected to the backend thread |
| dbname | name | Name of the connected database |
| backend_start | timestamp with time zone | Backend thread startup time |
| query | text | Query statement executed by the backend thread |

## 15.3.123 PG_GET_SENDERS_CATCHUP_TIME

**PG_GET_SENDERS_CATCHUP_TIME** displays catchup information of the currently active primary/standby instance sender thread on the DN.

**Table 15-228** PG_GET_SENDERS_CATCHUP_TIME columns

| Name | Type | Description |
| --- | --- | --- |
| pid | bigint | Current sender thread ID |
| lwpid | integer | Current sender lwpid |
| local_role | text | Local role |
| peer_role | text | Peer role |
| state | text | Current sender's replication status |
| type | text | Current sender type |
| catchup_start | timestamp with time zone | Startup time of a catchup task |
| catchup_end | timestamp with time zone | End time of the catchup task |

## 15.3.124 PG_GROUP

**PG_GROUP** displays the database role authentication and the relationship between roles.

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**Table 15-229** PG_GROUP columns

| Name | Type | Description |
| --- | --- | --- |
| groname | name | Group name |
| grosysid | oid | Group ID |
| grolist | oid[] | An array, including all the role IDs in this group |

## 15.3.125 PG_INDEXES

**PG_INDEXES** provides access to useful information about each index in the database.

**Table 15-230** PG_INDEXES columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| schemaname | name | 15.2.70 PG_NAMESPACE.nspname | Name of the schema that contains tables and indexes |
| tablename | name | 15.2.46 PG_CLASS.relname | Name of the table for which the index serves |
| indexname | name | 15.2.46 PG_CLASS.relname | Index name |
| tablespace | name | 15.2.94 PG_TABLESPACE.nspname | Name of the tablespace that contains the index |
| indexdef | text | - | Index definition (a reconstructed **CREATE INDEX** command) |

## 15.3.126 PG_LOCKS

**PG_LOCKS** displays information about locks held by open transactions.

**Table 15-231** PG_LOCKS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| locktype | text | - | Type of the locked object: **relation**, **extend**, **page**, **tuple**, **transactionid**, **virtualxid**, **object**, **userlock**, or **advisory** |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| database | oid | OID in **15.2.50 PG_DATABASE** | OID of the database in which the locked target exists<br>• The OID is **0** if the target is a shared object.<br>• The OID is **NULL** if the locked target is a transaction. |
| relation | oid | OID in **15.2.46 PG_CLASS** | OID of the relationship targeted by the lock (**NULL** if the object is not a relation or part of a relation) |
| page | integer | - | Page number targeted by the lock within the relation (**NULL** if the object is not a relation page or row page) |
| tuple | smallint | - | Row number targeted by the lock within the page (**NULL** if the object is not a row) |
| bucket | integer | - | Hash bucket ID |
| virtualxid | text | - | Virtual ID of the transaction targeted by the lock (**NULL** if the object is not a virtual transaction) |
| transactionid | xid | - | ID of the transaction targeted by the lock (**NULL** if the object is not a transaction) |
| classid | oid | OID in **15.2.46 PG_CLASS** | OID of the system catalog that contains the object (**NULL** if the object is not a general database object) |
| objid | oid | - | OID of the lock target within its system table (**NULL** if the target is not a general database object) |
| objsubid | smallint | - | Column number for a column in the table (**0** if the target is of other object type and **NULL** if the target is not a general database object) |
| virtualtransaction | text | - | Virtual ID of the transaction holding or awaiting this lock |
| pid | bigint | - | Logical ID of the server thread holding or awaiting this lock (**NULL** if the lock is held by a prepared transaction) |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| sessionid | bigint | - | ID of the session that holds or waits for the lock |
| mode | text | - | Lock mode held or desired by this thread |
| granted | boolean | - | • The value is **TRUE** if the lock is a held lock.<br>• The value is **FALSE** if the lock is an awaited lock. |
| fastpath | boolean | - | The value is **TRUE** if the lock is obtained through **fast-path**, and is **FALSE** if the lock is obtained through the main lock table. |
| locktag | text | - | Information about the lock that the session waits for. It can be parsed using the **locktag_decode()** function. |
| global_sessionid | text | - | Global session ID |

## 15.3.127 PG_NODE_ENV

**PG_NODE_ENV** displays environment variables of the current node. Only the user with system administrator or monitor admin permission can access this system view.

**Table 15-232** PG_NODE_ENV columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name |
| host | text | Host name of the node |
| process | integer | Number of the node process |
| port | integer | Port ID of the node |
| installpath | text | Installation directory of the node |
| datapath | text | Data directory of the node |
| log_directory | text | Log directory of the node |

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## 15.3.128 PG_OS_THREADS

**PG_OS_THREADS** provides status information about all the threads under the current node.

**Table 15-233** PG_OS_THREADS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name |
| pid | bigint | PID of the thread running under the current node process |
| lwpid | integer | Lightweight thread ID corresponding to the PID |
| thread_name | text | Thread name corresponding to the PID |
| creation_time | timestamp with time zone | Thread creation time corresponding to the PID |

## 15.3.129 PG_POOLER_STATUS

**PG_POOLER_STATUS** queries the cache connection status in the pooler.

**Table 15-234** PG_POOLER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| database | text | Database name |
| user_name | text | Username |
| tid | bigint | In non-thread pool logic, this parameter indicates the ID of the thread connected to the CN. In thread pool logic, this parameter indicates the ID of the session connected to the CN. |
| node_oid | bigint | OID of the node connected |
| node_name | name | Name of the node connected |
| in_use | boolean | Whether the connection is currently used.<br>• **t** (true): The connection is in use.<br>• **f** (false): The connection is not in use. |
| node_port | integer | Port number of the connected instance node |
| fdsock | bigint | Peer socket |
| remote_pid | bigint | Peer thread ID |

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| Name | Type | Description |
| --- | --- | --- |
| session_params | text | GUC session parameter delivered by the connection |
| used_count | bigint | Number of reuse times of a connection. |
| idx | bigint | Logical connection ID of the connected instance node. |
| streamid | bigint | Stream ID corresponding to each logical connection. |

**PG_POOLER_STATUS** can only perform the query on the CN and display connection cache information about the pooler module.

## 15.3.130 PG_PREPARED_STATEMENTS

**PG_PREPARED_STATEMENTS** displays all prepared statements that are available in the current session.

**Table 15-235** PG_PREPARED_STATEMENTS columns

| Name | Type | Description |
| --- | --- | --- |
| name | text | Identifier of the prepared statement |
| statement | text | Query string for creating this prepared statement. For prepared statements created through SQL, this is the PREPARE statement submitted by the client. For prepared statements created through the frontend/backend protocol, this is the text of the prepared statement itself. |
| prepare_time | timestamp with time zone | Timestamp when the prepared statement is created |
| parameter_types | regtype[] | Expected parameter types for the prepared statement in the form of an array of **regtype**. The OID corresponding to an element of this array can be obtained by converting the **regtype** value to **oid**. |
| from_sql | boolean | • **True** if the prepared statement was created through the PREPARE statement<br>• **False** if the statement was prepared through the frontend/backend protocol |

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## 15.3.131 PG_PREPARED_XACTS

**PG_PREPARED_XACTS** displays information about transactions that are currently prepared for two-phase commit.

**Table 15-236** PG_PREPARED_XACTS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| transaction | xid | - | Numeric transaction identifier of the prepared transaction |
| gid | text | - | Global transaction identifier that was assigned to the transaction |
| prepared | timestamp with time zone | - | Time at which the transaction is prepared for commit |
| owner | name | 15.2.42 PG_AUTHID.rolname | Name of the user that executes the transaction |
| database | name | 15.2.50 PG_DATABASE.datname | Name of the database in which the transaction is executed |

## 15.3.132 PG_PUBLICATION_TABLES

**PG_PUBLICATION_TABLES** displays the mapping information between a publication and its published tables. Unlike the underlying system catalog **PG_PUBLICATION_REL**, this view expands publications defined as **FOR ALL TABLES** so that for such publications, there is one row for each eligible table.

**Table 15-237** PG_PUBLICATION_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| pubname | name | Publication name |
| schemaname | name | Name of the schema that contains a table |
| tablename | name | Table name |

## 15.3.133 PG_REPLICATION_ORIGIN_STATUS

**PG_REPLICATION_ORIGIN_STATUS** displays the replication status of the replication source.

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**Table 15-238** PG_REPLICATION_ORIGIN_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| local_id | oid | Replication source ID |
| external_id | text | Name of the replication source |
| remote_lsn | text | Remote LSN of the replication source |
| local_lsn | text | Local LSN of the replication source |

## 15.3.134 PG_REPLICATION_SLOTS

**PG_REPLICATION_SLOTS** contains replication slot information.

**Table 15-239** PG_REPLICATION_SLOTS columns

| Name | Type | Description |
| --- | --- | --- |
| slot_name | text | Replication slot name |
| plugin | text | Name of the output plug-in corresponding to the logical replication slot. |
| slot_type | text | Replication slot type.<br>• **physical**: physical replication slot.<br>• **logical**: logical replication slot. |
| datoid | oid | OID of the database where the replication slot resides. |
| database | name | Name of the database where the replication slot resides. |
| active | boolean | Determines whether the replication slot is activated.<br>• **t** (true): yes<br>• **f** (false): no |
| xmin | xid | XID of the earliest transaction that the database must reserve for the replication slot. |
| catalog_xmin | xid | XID of the earliest system catalog-involved transaction that the database must reserve for the logical replication slot. |
| restart_lsn | text | Physical location of the earliest Xlog required by the replication slot. |

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| Name | Type | Description |
| --- | --- | --- |
| dummy_standby | boolean | Determines whether the peer end connected to the replication slot is a secondary node.<br>• **t** (true): yes<br>• **f** (false): no |
| confirmed_flush | text | Dedicated logical replication slot. The client confirms the location of the received log. |

## 15.3.135 PG_RLSPOLICIES

**PG_RLSPOLICIES** contains row-level access control policies. The initial user and users with the sysadmin attribute can view all policy information. Other users can view only the policy information in their own tables.

**Table 15-240** PG_RLSPOLICIES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema of the table object to which a row-level access control policy is applied |
| tablename | name | Name of the table object to which the row-level access control policy is applied |
| policyname | name | Name of the row-level access control policy |
| policypermissive | text | Attribute of the row-level access control policy |
| policyroles | name[] | List of users affected by the row-level access control policy. If this parameter is not specified, all users are affected. |
| policycmd | text | SQL operations affected by the row-level access control policy |
| policyqual | text | Expression of the row-level access control policy |

## 15.3.136 PG_ROLES

**PG_ROLES** provides information about database roles. Initialization users and users with the sysadmin or createrole attribute can view information about all roles. Other users can view only their own information.

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**Table 15-241** PG_ROLES columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| rolname | name | N/A | Role name |
| rolsuper | boolean | N/A | Whether the role is the initial system administrator with the highest permission<br>• **t** (true): yes<br>• **f** (false): no |
| rolinherit | boolean | N/A | Whether the role inherits the permissions for this type of roles<br>• **t** (true): yes<br>• **f** (false): no |
| rolcreaterole | boolean | N/A | Whether the role can create other roles<br>• **t** (true): yes<br>• **f** (false): no |
| rolcreatedb | boolean | N/A | Whether the role can create databases<br>• **t** (true): yes<br>• **f** (false): no |
| rolcatupdate | boolean | N/A | Whether the role can update system tables directly. Only the initial system administrator whose **usesysid** is **10** has this permission. It is unavailable for other users.<br>• **t** (true): yes<br>• **f** (false): no |
| rolcanlogin | boolean | N/A | Whether the role can log in to the database<br>• **t** (true): yes<br>• **f** (false): no |
| rolreplication | boolean | N/A | Whether the role can be replicated<br>• **t** (true): yes<br>• **f** (false): no |
| rolauditadmin | boolean | N/A | Whether the role is an audit system administrator<br>• **t** (true): yes<br>• **f** (false): no |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| rolsystemadmin | boolean | N/A | Whether the role is a system administrator<br>• **t** (true): yes<br>• **f** (false): no |
| rolconnlimit | integer | N/A | Sets the maximum number of concurrent connections that this role can initiate if this role can log in. The value **–1** indicates no limit. |
| rolpassword | text | N/A | Not the password (always reads as ********) |
| rolvalidbegin | timestamp with time zone | N/A | Start time of the account validity period (**null** if no start time) |
| rolvaliduntil | timestamp with time zone | N/A | Password expiry time (**null** if no expiration) |
| rolrespool | name | N/A | Resource pool that a user can use |
| rolparentid | oid | rolparentid in 15.2.42 PG_AUTHID | OID of a group user to which the user belongs |
| roltabspace | text | N/A | Storage space of the user permanent table |
| rolconfig | text[] | N/A | Session defaults for runtime configuration variables |
| oid | oid | OID in 15.2.42 PG_AUTHID | Role ID |
| roluseft | boolean | **roluseft** in 15.2.42 PG_AUTHID | Whether the role can perform operations on foreign tables<br>• **t** (true): yes<br>• **f** (false): no |
| rolkind | "char" | N/A | Role type |
| nodegroup | name | N/A | Name of the logical cluster associated with the role. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) If no logical cluster is associated, this column is left empty. |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| roltempspace | text | N/A | Storage space of the user temporary table, in KB |
| rolspillspace | text | N/A | Operator disk spill space of the user, in KB |
| rolmonitoradmin | boolean | N/A | Whether the role is a monitor administrator<br>• **t** (true): yes<br>• **f** (false): no |
| roloperatoradmin | boolean | N/A | Whether the role is an O&M administrator<br>• **t** (true): yes<br>• **f** (false): no |
| rolpolicyadmin | boolean | N/A | Whether the role is a security policy administrator<br>• **t** (true): yes<br>• **f** (false): no |

## 15.3.137 PG_RULES

**PG_RULES** provides access to query useful information about rewrite rules.

**Table 15-242** PG_RULES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema containing the table |
| tablename | name | Name of the table to which the rule applies |
| rulename | name | Rule name |
| definition | text | Rule definition (a reconstructed creation command) |

## 15.3.138 PG_RUNNING_XACTS

**PG_RUNNING_XACTS** displays running transaction information on the current node.

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**Table 15-243** PG_RUNNING_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| handle | integer | Handle corresponding to the transaction in GTM |
| gxid | xid | Transaction ID |
| state | tinyint | Transaction status (**3**: prepared; **0**: starting) |
| node | text | Node name |
| xmin | xid | Minimum transaction ID on the node |
| vacuum | boolean | Whether the current transaction is lazy vacuum<br>• **t** (true): yes<br>• **f** (false): no |
| timeline | bigint | Number of database restarts |
| prepare_xid | xid | Transaction ID in the **prepared** state (**0** if the state is not **prepared**) |
| pid | bigint | Thread ID corresponding to the transaction |
| next_xid | xid | Transaction ID sent from a CN to a DN |

## 15.3.139 PG_SECLABELS

**PG_SECLABELS** provides information about security labels.

**Table 15-244** PG_SECLABELS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| objoid | oid | Any OID column | OID of the object that this security label pertains to |
| classoid | oid | 15.2.46 PG_CLASS.oid | OID of the system catalog where the object appears |
| objsubid | integer | - | Column number for the security label on a table column (**objoid** and **classoid** refer to the table itself). The value is **0** for all other object types. |
| objtype | text | - | Type of object to which this label applies, as text |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| objnamespace | oid | 15.2.70 PG_NAMESPACE.oid | OID of the namespace for this object, if applicable; otherwise **NULL** |
| objname | text | - | Text-typed name of the object to which this label applies |
| provider | text | 15.2.86 PG_SECLABEL.provider | Label provider associated with the label |
| label | text | 15.2.86 PG_SECLABEL.label | Security label applied to the object |

## 15.3.140 PG_SESSION_IOSTAT

**PG_SESSION_IOSTAT** shows I/O load management information about the task currently executed by the user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only users with the **sysadmin** or **monitor admin** permission can query this view.

IOPS is counted by ones for column-storage and by 10 thousands for row storage.

**Table 15-245** PG_SESSION_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| query_id | bigint | Job ID |
| mincurriops | integer | Minimum I/O of the current job on each DN |
| maxcurriops | integer | Maximum I/O of the current job on each DN |
| minpeakiops | integer | Minimum peak I/O of the current job on each DN |
| maxpeakiops | integer | Maximum peak I/O of the current job on each DN |
| io_limits | integer | **io_limits** set for the job |
| io_priority | text | **io_priority** set for the job |
| query | text | Job |
| node_group | text | Logical cluster of the user running the job (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| curr_io_limits | integer | Real-time **io_limits** value when **io_priority** is used to control I/Os |

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# 15.3.141 PG_SESSION_WLMSTAT

**PG_SESSION_WLMSTAT** displays corresponding load management information about the task currently executed by the user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the sysadmin user can query this view.

**Table 15-246** PG_SESSION_WLMSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the backend is connected to |
| datname | name | Name of the database that the backend is connected to |
| threadid | bigint | Process ID of the backend |
| sessionid | bigint | Session ID |
| processid | integer | PID of the backend thread |
| usesysid | oid | OID of the user logged in to the backend |
| appname | text | Name of the application that is connected to the backend |
| usename | name | Name of the user logged in to the backend |
| priority | bigint | Priority of Cgroup where the statement is located |
| attribute | text | Attributes of the statement:<br>• **Ordinary**: default attribute of a statement before it is parsed by the database<br>• **Simple**: simple statements<br>• **Complicated**: complicated statements<br>• **Internal**: internal statement of the database<br>• Unknown: unknown |
| block_time | bigint | Pending duration of the statement by now, in seconds |
| elapsed_time | bigint | Actual execution duration of the statement by now, in seconds |
| total_cpu_time | bigint | Total CPU usage duration of the statement on the DN in the last period, in seconds |
| cpu_skew_percent | integer | CPU usage skew percentage of the statement on the DN in the last period |
| statement_mem | integer | **statement_mem** used for executing the statement (reserved column) |

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| Name | Type | Description |
| --- | --- | --- |
| active_points | integer | Number of concurrently active points occupied by the statement in the resource pool |
| dop_value | integer | DOP value obtained by the statement from the resource pool |
| control_group | text | Cgroup currently used by the statement |
| status | text | Status of the statement, including:<br>• **pending**: waiting to be executed<br>• **running**: being executed<br>• **finished**: finished normally (If **enqueue** is set to **StoredProc** or **Transaction**, this state indicates that only a part of jobs in the statement has been executed. This state persists until the finish of this statement.)<br>• **aborted**: terminated unexpectedly<br>• **active**: normal status except for those above<br>• **unknown**: unknown status |
| enqueue | text | Queuing status of the statement, including:<br>• **Global**: queuing in the global queue<br>• **Respool**: queuing in the resource pool queue<br>• **CentralQueue**: queuing on the CCN<br>• **Transaction**: being in a transaction block<br>• **StoredProc**: being in a stored procedure<br>• **None**: not in the queue<br>• **Forced None**: The transaction block statement or stored procedure statement is being forcibly executed because the statement waiting time exceeds the specified value. |
| resource_pool | name | Current resource pool where the statements are located |
| query | text | Latest query at the backend. If **state** is **active**, this column shows the executing query. In all other states, it shows the last query that was executed. |
| is_plana | boolean | Whether a statement occupies the resources of other logical clusters in logical cluster mode. The default value is **f** (does not occupy). |
| node_group | text | Logical cluster of the user running the statement (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

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# 15.3.142 PG_SETTINGS

**PG_SETTINGS** provides information about parameters of the running database.

**Table 15-247** PG_SETTINGS columns

| Name | Type | Description |
| --- | --- | --- |
| name | text | Parameter name |
| setting | text | Current parameter value |
| unit | text | Implicit unit of the parameter |
| category | text | Logical group of the parameter |
| short_desc | text | Brief description of the parameter |
| extra_desc | text | Detailed description of the parameter |
| context | text | Context of parameter values, including **internal**, **postmaster**, **sighup**, **backend**, **superuser**, and **user** |
| vartype | text | Parameter type, including **bool**, **enum**, **integer**, **real**, or **string** |
| source | text | Method of assigning the parameter value |
| min_val | text | Minimum value of the parameter. If the parameter type is not numeric, the value of this column is **null**. |
| max_val | text | Maximum value of the parameter. If the parameter type is not numeric, the value of this column is **null**. |
| enumvals | text[] | Valid values of an enum-type parameter. If the parameter type is not enum, the value of this column is **null**. |
| boot_val | text | Default parameter value used upon the database startup |
| reset_val | text | Default parameter value used upon the database reset |
| sourcefile | text | Configuration file used to set parameter values. If parameter values are not configured using the configuration file, the value of this column is **null**. |
| sourceline | integer | Row number of the configuration file for setting parameter values. If parameter values are not configured using the configuration file, the value of this column is **null**. |

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# 15.3.143 PG_SHADOW

**PG_SHADOW** displays the attributes of all roles marked with rolcanlogin in **PG_AUTHID**. Only the system administrator can access this system view.

The name stems from the fact that this view should not be readable by the public since it contains passwords. **15.3.182 PG_USER** is a publicly readable view on **PG_SHADOW** that blanks out the password column.

**Table 15-248** PG_SHADOW columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| usename | name | **rolname** in **15.2.42 PG_AUTHID** | Username |
| usesysid | oid | OID in **15.2.42 PG_AUTHID** | ID of this user |
| usecreatedb | boolean | - | Whether the user has the permission to create databases<br>• **t** (true): yes<br>• **f** (false): no |
| usesuper | boolean | - | Whether the user is a system administrator<br>• **t** (true): yes<br>• **f** (false): no |
| usecatupd | boolean | - | Whether the user can update a view. Even the system administrator cannot do this unless this column is **true**.<br>• **t** (true): yes<br>• **f** (false): no |
| userepl | boolean | - | Whether the user can initiate streaming replication and put the system in and out of backup mode<br>• **t** (true): yes<br>• **f** (false): no |
| passwd | text | - | Password (possibly encrypted); **null** if none. See **15.2.42 PG_AUTHID** for details about how encrypted passwords are stored. |
| valbegin | timestamp with time zone | - | Account validity period start time (**null** if no start time) |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| valuntil | timestamp with time zone | - | Password expiry time (**null** if no expiration) |
| respool | name | - | Resource pool used by the user |
| parent | oid | - | Parent resource pool |
| spacelimit | text | - | Storage space of the permanent table |
| useconfig | text[ ] | - | Session defaults for runtime configuration variables |
| tempspacelimit | text | - | Storage space of the temporary table |
| spillspacelimit | text | - | Operator disk flushing space |
| usemonitoradmin | boolean | - | Whether the user is a monitor administrator<br>• **t** (true): yes<br>• **f** (false): no |
| useoperatoradmin | boolean | - | Whether the user is an O&M administrator<br>• **t** (true): yes<br>• **f** (false): no |
| usepolicyadmin | boolean | - | Whether the user is a security policy administrator<br>• **t** (true): yes<br>• **f** (false): no |

## 15.3.144 PG_SHARED_MEMORY_DETAIL

**PG_SHARED_MEMORY_DETAIL** queries usage information about all the shared memory contexts.

**Table 15-249** PG_SHARED_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| contextname | text | Name of the memory context |
| level | smallint | Hierarchy of the memory context |
| parent | text | Name of the parent memory context |

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| Name | Type | Description |
| --- | --- | --- |
| totalsize | bigint | Total size of the shared memory, in bytes |
| freesize | bigint | Remaining size of the shared memory, in bytes |
| usedsize | bigint | Used size of the shared memory, in bytes |

## 15.3.145 PG_STATS

**PG_STATS** provides access to the single-column statistics stored in the **pg_statistic** table. The **autovacuum_naptime** parameter specifies the interval for updating statistics recorded in the view.

**Table 15-250** PG_STATS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| schemaname | name | 15.2.70 PG_NAMESPACE.nspname | Name of the schema that contains a table |
| tablename | name | **relname** in 15.2.46 PG_CLASS | Table name |
| attname | name | 15.2.41 PG_ATTRIBUTE.attname | Field name |
| inherited | boolean | - | Includes inherited sub-columns if the value is **true**; otherwise, it indicates the column in a specified table. |
| null_frac | real | - | Percentage of column entries that are null |
| avg_width | integer | - | Average width in bytes of column's entries |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| n_distinct | real | - | • Estimated number of distinct values in the column if the value is greater than 0<br>• Negative of the number of distinct values divided by the number of rows if the value is less than 0<br>1. The negated form is used when **ANALYZE** believes that the number of distinct values is likely to increase as the table grows.<br>2. The positive form is used when the column seems to have a fixed number of possible values. For example, **–1** indicates that the number of distinct values is the same as the number of rows for a column combination. |
| n_dndistinct | real | - | Number of unique non-null data values in the **dn1** column<br>• Exact number of distinct values if the value is greater than **0**.<br>• Negative of the number of distinct values divided by the number of rows if the value is less than 0 (For example, if the value of a column appears twice in average, set **n_dndistinct=-0.5**.)<br>• The number of distinct values is unknown if the value is **0**. |
| most_common_vals | anyarray | - | List of the most common values in a column. (**NULL** if no values in the column seem to be more common than any others) |
| most_common_freqs | real[] | - | List of the frequencies of the most common values, that is, number of occurrences of each divided by total number of rows. (**NULL** if **most_common_vals** is **NULL**) |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| histogram_bounds | anyarray | - | List of values that divide the column's values into groups of equal proportion. The values in **most_common_vals**, if present, are omitted from this histogram calculation. This field is null if the field data type does not have a **<** operator or if the **most_common_vals** list accounts for the entire population. |
| correlation | real | - | Statistical correlation between physical row ordering and logical ordering of the column values. It ranges from -1 to +1. When the value is near to -1 or +1, an index scan on the column is estimated to be cheaper than when it is near to zero, due to reduction of random access to the disk. This column is null if the column data type does not have a < operator. |
| most_common_elems | anyarray | - | A list of non-null element values most often appearing |
| most_common_elem_freqs | real[] | - | A list of the frequencies of the most common element values |
| elem_count_histogram | real[] | - | A histogram of the counts of distinct non-null element values |

## 15.3.146 PG_STAT_ACTIVITY

**PG_STAT_ACTIVITY** displays information about the current user's queries. The columns save information about the last query.

**Table 15-251** PG_STAT_ACTIVITY columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the user session connects to in the backend. |
| datname | name | Name of the database that the user session connects to in the backend. |

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| Name | Type | Description |
| --- | --- | --- |
| pid | bigint | Thread ID of the backend. |
| sessionid | bigint | Session ID. |
| usesysid | oid | OID of the user logged in to the backend. |
| usename | name | Name of the user logged in to the backend. |
| application_name | text | Name of the application connected to the backend. |
| client_addr | inet | IP address of the client connected to the backend. If this column is null, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with the backend (**–1** if a Unix socket is used) |
| backend_start | timestamp with time zone | Time when this process was started, that is, when the client connected to the server. |
| xact_start | timestamp with time zone | Time when current transaction was started (null if no transaction is active). If the current query is the first of its transaction, the value of this column is the same as that of the **query_start** column. |
| query_start | timestamp with time zone | Time when the currently active query was started, or if **state** is not set to **active**, when the last query was started. |
| state_change | timestamp with time zone | Time when **state** was last modified. |
| waiting | boolean | Whether the backend is currently waiting on a lock. If it is, the value is **true**. Otherwise, the value is **false**. |

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| Name | Type | Description |
| --- | --- | --- |
| enqueue | text | Queuing status of a statement. Its value can be:<br>• **waiting in queue**: The statement is in the queue.<br>• Empty: The statement is running. |
| state | text | Overall status of this backend. Its value can be:<br>• **active**: The backend is executing a query.<br>• **idle**: The backend is waiting for a new client command.<br>• **idle in transaction**: The backend is in a transaction, but there is no statement being executed in the transaction.<br>• **idle in transaction** (aborted): The backend is in a transaction, but there are statements failed in the transaction.<br>• **fastpath function call**: The backend is executing a fast-path function.<br>• **disabled**: This state is reported if **track_activities** is disabled in this backend.<br>**NOTE**<br>Common users can view their own session status only. The state information of other accounts is empty. For example, after user **judy** is connected to the database, the state information of user **joe** and the initial user **omm** in **pg_stat_activity** is empty.<br>SELECT datname, usename, usesysid, state,pid FROM pg_stat_activity;<br>datname \| usename \| usesysid \| state \| pid<br>----------+---------+----------+--------+-----------------<br>postgres \| omm \| 10 \| \| 139968752121616<br>postgres \| omm \| 10 \| \| 139968903116560<br>db_tpcds \| judy \| 16398 \| active \| 139968391403280<br>postgres \| omm \| 10 \| \| 139968643069712<br>postgres \| omm \| 10 \| \| 139968680818448<br>postgres \| joe \| 16390 \| \| 139968563377936<br>(6 rows) |

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| Name | Type | Description |
| --- | --- | --- |
| resource_pool | name | Resource pool used by the user. |
| query_id | bigint | ID of a query. |
| query | text | Text of this backend's most recent query. If the value of **state** is **active**, this column shows the ongoing query. In all other states, it shows the last query that was executed. |
| connection_info | text | A string in JSON format recording the driver type, driver version, driver deployment path, and process owner of the connected database. For details, see **connection_info**. |
| global_sessionid | text | Global session ID. |
| unique_sql_id | bigint | Unique SQL statement ID. |
| trace_id | text | Driver-specific trace ID, which is associated with an application request. |

## 15.3.147 PG_STAT_ACTIVITY_NG

**PG_STAT_ACTIVITY_NG** displays information about all queries in the logical cluster of the current user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 15-252** PG_STAT_ACTIVITY_NG columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the user session connects to in the backend |
| datname | name | Name of the database that the user session connects to in the backend |
| pid | bigint | Process ID of the backend |
| sessionid | bigint | Session ID |
| global_sessionid | text | Global session ID |
| usesysid | oid | OID of the user logged in to the backend |
| usename | name | OID of the user logged in to the backend |

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| Name | Type | Description |
| --- | --- | --- |
| application_name | text | Name of the application connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is **null**, either the client is connected via a Unix socket on the server machine or this is an internal process such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will only be non-null for IP connections, and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with this backend (**-1** if a Unix socket is used) |
| backend_start | timestamp with time zone | Time when this process was started, that is, when the client connected to the server |
| xact_start | timestamp with time zone | Time when current transaction was started (null if no transaction is active) If the current query is the first of its transaction, this column is equal to the **query_start** column. |
| query_start | timestamp with time zone | Time when the currently active query was started, or if **state** is not **active**, when the last query was started |
| state_change | timestamp with time zone | Time when the **status** was changed in the previous time |
| waiting | boolean | Whether the backend is currently waiting on a lock. If it is, its value is **true**. Otherwise, the value is **false**. |
| enqueue | text | Queuing status of a statement. The value must be one of the following:<br>• **waiting in queue**: The statement is in the queue.<br>• Empty: The statement is running. |

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| Name | Type | Description |
| --- | --- | --- |
| state | text | Backend status. The value must be one of the following:<br>• **active**: The backend is executing a query.<br>• **idle**: The backend is waiting for a new client command.<br>• **idle in transaction**: The backend is in a transaction, but there is no statement being executed in the transaction.<br>• **idle in transaction** (aborted): The backend is in a transaction, but there are statements failed in the transaction.<br>• **fastpath function call**: The backend is executing a fast-path function.<br>• **disabled**: This state is reported if **track_activities** is disabled in this backend.<br>**NOTE**<br>Common users can view only their own session status. The state information of other accounts is empty. For example, after user **judy** is connected to the database, the state information of user **joe** and the initial user **omm** in **pg_stat_activity** is empty.<br>SELECT datname, usename, usesysid, state,pid FROM pg_stat_activity_ng;<br>datname \| usename \| usesysid \| state \| pid<br>----------+---------+----------+--------+-----------------<br>postgres \| omm \| 10 \| \| 139968752121616<br>postgres \| omm \| 10 \| \| 139968903116560<br>db_tpcds \| judy \| 16398 \| active \| 139968391403280<br>postgres \| omm \| 10 \| \| 139968643069712<br>postgres \| omm \| 10 \| \| 139968680818448<br>postgres \| joe \| 16390 \| \| 139968563377936<br>(6 rows) |
| resource_pool | name | Resource pool used by the user |
| query_id | bigint | ID of a query |

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| Name | Type | Description |
| --- | --- | --- |
| query | text | Latest query at the backend. If **state** is **active**, this column shows the executing query. In all other states, it shows the last query that was executed. |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

## 15.3.148 PG_STAT_ALL_INDEXES

**PG_STAT_ALL_INDEXES** contains one row for each index in the current database, showing statistics about accesses to that specific index.

Indexes can be used via either simple index scans or "bitmap" index scans. In a bitmap scan the output of several indexes can be combined via AND or OR rules, so it is difficult to associate individual heap row fetches with specific indexes when a bitmap scan is used. Therefore, a bitmap scan increments the **pg_stat_all_indexes.idx_tup_read** count(s) for the index(es) it uses, and it increments the **pg_stat_all_tables.idx_tup_fetch** count for the table, but it does not affect **pg_stat_all_indexes.idx_tup_fetch**.

**Table 15-253** PG_STAT_ALL_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table for this index |
| indexrelid | oid | OID of this index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

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# 15.3.149 PG_STAT_ALL_TABLES

**PG_STAT_ALL_TABLES** contains one row for each table in the current database (including TOAST tables), showing statistics about accesses to that specific table.

**Table 15-254** PG_STAT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (that is, with no separate index update required) |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time when the table was cleared |
| last_autovacuum | timestamp with time zone | Last time at which the table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time when the table was analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which the table was analyzed by the autovacuum daemon |
| vacuum_count | bigint | Number of times the table is cleared |

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| Name | Type | Description |
| --- | --- | --- |
| autovacuum_count | bigint | Number of times the table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times the table has been manually analyzed |
| autoanalyze_count | bigint | Number of times the table has been analyzed by the autovacuum daemon |
| last_data_changed | timestamp with time zone | Last time at which the table was updated (by **INSERT**/**UPDATE**/**DELETE** or **EXCHANGE**/**TRUNCATE**/**DROP** *partition*). This column is not recorded in the system catalog but is recorded on the local CN. |

## 15.3.150 PG_STAT_BAD_BLOCK

**PG_STAT_BAD_BLOCK** shows statistics about Page or CU verification failures after a node is started.

**Table 15-255** PG_STAT_BAD_BLOCK columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |
| databaseid | integer | OID of a database |
| tablespaceid | integer | Tablespace OID |
| relfilenode | integer | File object ID |
| bucketid | smallint | ID of the bucket for consistent hashing |
| forknum | integer | File type. The values are as follows:<br>**0**: main data file.<br>**1**: FSM file.<br>**2**: VM file.<br>**3**: BCM file.<br>If the value is greater than 4, it indicates a data file of each column in a column-store table. |
| error_count | integer | Number of verification failures |

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| Name | Type | Description |
| --- | --- | --- |
| first_time | timestamp with time zone | Time of the first verification failure |
| last_time | timestamp with time zone | Time of the latest verification failure |

## 15.3.151 PG_STAT_BGWRITER

**PG_STAT_BGWRITER** showing statistics about the background writer process's activity.

**Table 15-256** PG_STAT_BGWRITER columns

| Name | Type | Description |
| --- | --- | --- |
| checkpoints_timed | bigint | Number of scheduled checkpoints that have been performed |
| checkpoints_req | bigint | Number of requested checkpoints that have been performed |
| checkpoint_write_time | double precision | Total amount of time that has been spent in the portion of checkpoint processing where files are written to disk, in milliseconds |
| checkpoint_sync_time | double precision | Total amount of time that has been spent in the portion of checkpoint processing where files are synchronized to disk, in milliseconds |
| buffers_checkpoint | bigint | Number of buffers written during checkpoints |
| buffers_clean | bigint | Number of buffers written by the background writer |
| maxwritten_clean | bigint | Number of times the background writer stopped a cleaning scan because it had written too many buffers |
| buffers_backend | bigint | Number of buffers written directly by a backend |

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| Name | Type | Description |
| --- | --- | --- |
| buffers_backend_fsync | bigint | Number of times a backend had to execute its own fsync call (normally the background writer handles those even when the backend does its own write) |
| buffers_alloc | bigint | Number of buffers allocated |
| stats_reset | timestamp with time zone | Time at which these statistics were last reset |

## 15.3.152 PG_STAT_DATABASE

**PG_STAT_DATABASE** contains database statistics for each database in the cluster.

**Table 15-257** PG_STAT_DATABASE columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of a database |
| datname | name | Name of the database |
| numbackends | integer | Number of backends currently connected to this database. This is the only column in this view that returns a value reflecting the current state; all other columns return the accumulated values since the last reset. |
| xact_commit | bigint | Number of transactions in this database that have been committed |
| xact_rollback | bigint | Number of transactions in this database that have been rolled back |
| blks_read | bigint | Number of disk blocks read in this database |
| blks_hit | bigint | Number of times disk blocks were found already in the buffer cache, so that a read was not necessary (this only includes hits in the PostgreSQL buffer cache, not the operating system's file system cache) |
| tup_returned | bigint | Number of rows returned by queries in this database |
| tup_fetched | bigint | Number of rows fetched by queries in this database |

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| Name | Type | Description |
| --- | --- | --- |
| tup_inserted | bigint | Number of rows inserted by queries in this database |
| tup_updated | bigint | Number of rows updated by queries in this database |
| tup_deleted | bigint | Number of rows deleted by queries in this database |
| conflicts | bigint | Number of queries canceled due to database recovery conflicts (conflicts occurring only on the standby server). For details, see **15.3.153 PG_STAT_DATABASE_CONFLICTS**. |
| temp_files | bigint | Number of temporary files created by queries in this database. All temporary files are counted, regardless of why the temporary file was created (for example, sorting or hashing), and regardless of the **log_temp_files** setting. |
| temp_bytes | bigint | Total amount of data written to temporary files by queries in this database. All temporary files are counted, regardless of why the temporary file was created, and regardless of the **log_temp_files** setting. |
| deadlocks | bigint | Number of deadlocks detected in this database |
| blk_read_time | double precision | Time spent reading data file blocks by backends in this database, in milliseconds |
| blk_write_time | double precision | Time spent reading data file blocks by backends in this database, in milliseconds |
| stats_reset | timestamp with time zone | Time at which the current statistics were reset |

## 15.3.153 PG_STAT_DATABASE_CONFLICTS

**PG_STAT_DATABASE_CONFLICTS** displays statistics about database conflicts.

**Table 15-258** PG_STAT_DATABASE_CONFLICTS columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | ID of a database |

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| Name | Type | Description |
| --- | --- | --- |
| datname | name | Database name |
| confl_tablespace | bigint | Number of conflicting tablespaces |
| confl_lock | bigint | Number of conflicting locks |
| confl_snapshot | bigint | Number conflicting snapshots |
| confl_bufferpin | bigint | Number of conflicting buffers |
| confl_deadlock | bigint | Number of conflicting deadlocks |

## 15.3.154 PG_STAT_REPLICATION

**PG_STAT_REPLICATION** displays information about log synchronization status, such as the locations of the sender sending logs and the receiver receiving logs.

**Table 15-259** PG_STAT_REPLICATION columns

| Name | Type | Description |
| --- | --- | --- |
| pid | bigint | PID of the thread |
| usesysid | oid | User system ID |
| usename | name | Username |
| application_name | text | Program name |
| client_addr | inet | Client address |
| client_hostname | text | Client name |
| client_port | integer | Port of the client |
| backend_start | timestamp with time zone | Start time of the program |
| state | text | Log replication state (catch-up or consistent streaming) |
| sender_sent_location | text | Location where the transmit sends logs |
| receiver_write_location | text | Location where the receive end writes logs |
| receiver_flush_location | text | Location where the receive end flushes logs |
| receiver_replay_location | text | Location where the receive end replays logs |

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| Name | Type | Description |
| --- | --- | --- |
| sync_priority | integer | Priority of synchronous duplication (**0** indicates asynchronization.) |
| sync_state | text | Synchronization state:<br>• Asynchronous replication<br>• Synchronous replication<br>• Potential synchronization<br>• Qurom: switches between synchronous and asynchronous state to ensure that there are more than a certain number of synchronous standby servers. Generally, the number of synchronous standby servers is (n+1)/2-1, where **n** indicates the total number of copies. Whether the standby server is synchronous depends on whether logs are received first. For details, see the description of the **synchronous_standby_names** parameter. |

## 15.3.155 PG_STAT_SUBSCRIPTION

**PG_STAT_SUBSCRIPTION** displays the detailed synchronization information about a subscription.

**Table 15-260** PG_STAT_SUBSCRIPTION columns

| Name | Type | Description |
| --- | --- | --- |
| subid | oid | Subscription OID |
| subname | name | Subscription name |

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| Name | Type | Description |
| --- | --- | --- |
| pid | integer | ID of the background Apply thread |
| received_lsn | text | Latest LSN received from the publisher. |
| last_msg_send_time | timestamp with time zone | Time when the last message is sent from the publisher |
| last_msg_receipt_time | timestamp with time zone | Time when the last message is received by the subscriber |
| latest_end_lsn | text | LSN of the publisher when the last keepalive message is received |
| latest_end_time | timestamp with time zone | Time when the last keepalive message is received |

## 15.3.156 PG_STAT_SYS_INDEXES

**PG_STAT_SYS_INDEXES** displays index status information about all the system catalogs in the **pg_catalog** and **information_schema** schemas.

**Table 15-261** PG_STAT_SYS_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table for this index |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

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# 15.3.157 PG_STAT_SYS_TABLES

**PG_STAT_SYS_TABLES** displays statistics about the system catalogs of all the namespaces in **pg_catalog** and **information_schema** schemas.

**Table 15-262** PG_STAT_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which the table was manually vacuumed (excluding **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |

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| Name | Type | Description |
| --- | --- | --- |
| vacuum_count | bigint | Number of times the table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | bigint | Number of times the table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times the table has been manually analyzed |
| autoanalyze_count | bigint | Number of times the table has been analyzed by the autovacuum daemon |
| last_data_changed | timestamp with time zone | Last modification time of the table data |

## 15.3.158 PG_STAT_USER_FUNCTIONS

**PG_STAT_USER_FUNCTIONS** shows user-defined function status information in the namespace. (The language of the function is non-internal language.)

**Table 15-263** PG_STAT_USER_FUNCTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| funcid | oid | OID of a function |
| schemaname | name | Schema name |
| funcname | name | Function name |
| calls | bigint | Number of times the function has been called |
| total_time | double precision | Total time spent in the function and all other functions called by it |
| self_time | double precision | Total time spent in the function itself, excluding other functions called by it |

## 15.3.159 PG_STAT_USER_INDEXES

**PG_STAT_USER_INDEXES** displays information about the index status of user-defined ordinary tables and TOAST tables.

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**Table 15-264** PG_STAT_USER_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table for this index |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

## 15.3.160 PG_STAT_USER_TABLES

**PG_STAT_USER_TABLES** displays information about user-defined ordinary tables and TOAST tables in the namespaces.

**Table 15-265** PG_STAT_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |

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| Name | Type | Description |
| --- | --- | --- |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which the table was manually vacuumed (excluding **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which the table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which the table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which the table was analyzed by the autovacuum daemon |
| vacuum_count | bigint | Number of times the table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | bigint | Number of times the table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times the table has been manually analyzed |
| autoanalyze_count | bigint | Number of times the table has been analyzed by the autovacuum daemon |
| last_data_changed | timestamp with time zone | Last modification time of the table data |

## 15.3.161 PG_STAT_XACT_ALL_TABLES

**PG_STAT_XACT_ALL_TABLES** displays transaction status information about all ordinary tables and TOAST tables in the namespaces.

**Table 15-266** PG_STAT_XACT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table |

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| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

## 15.3.162 PG_STAT_XACT_SYS_TABLES

**PG_STAT_XACT_SYS_TABLES** displays transaction status information of the system catalog in the namespace.

**Table 15-267** PG_STAT_XACT_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

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## 15.3.163 PG_STAT_XACT_USER_FUNCTIONS

**PG_STAT_XACT_USER_FUNCTIONS** contains statistics on the execution of each function.

**Table 15-268** PG_STAT_XACT_USER_FUNCTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| funcid | oid | OID of a function |
| schemaname | name | Schema name |
| funcname | name | Function name |
| calls | bigint | Number of times that the function has been called |
| total_time | double precision | Total time spent in the function and all other functions called by it |
| self_time | double precision | Total time spent in the function itself, excluding other functions called by it |

## 15.3.164 PG_STAT_XACT_USER_TABLES

**PG_STAT_XACT_USER_TABLES** displays transaction status information of the user table in the namespace.

**Table 15-269** PG_STAT_XACT_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |

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| Name | Type | Description |
| --- | --- | --- |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

## 15.3.165 PG_STATIO_ALL_INDEXES

**PG_STATIO_ALL_INDEXES** contains one row for each index in the current database, showing I/O statistics about accesses to that specific index.

**Table 15-270** PG_STATIO_ALL_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table for this index |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_blks_read | bigint | Number of disk blocks read from the index |
| idx_blks_hit | bigint | Number of cache hits in the index |

## 15.3.166 PG_STATIO_ALL_SEQUENCES

**PG_STATIO_ALL_SEQUENCES** contains the I/O statistics of each sequence in the current database.

**Table 15-271** PG_STATIO_ALL_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of this sequence |
| schemaname | name | Name of the schema where the sequence is in |
| relname | name | Name of the sequence |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Cache hits in the sequence |

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## 15.3.167 PG_STATIO_ALL_TABLES

**PG_STATIO_ALL_TABLES** contains I/O statistics for each table (including the TOAST table) in the current database.

**Table 15-272** PG_STATIO_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |
| heap_blks_hit | bigint | Number of cache hits in the table |
| idx_blks_read | bigint | Number of disk blocks read from all indexes in the table |
| idx_blks_hit | bigint | Number of cache hits of all indexes in the table |
| toast_blks_read | bigint | Number of disk blocks read from the TOAST table (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in the TOAST table (if any) in the table |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST table index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer-hits in the TOAST table index (if any) in the table |

## 15.3.168 PG_STATIO_SYS_INDEXES

**PG_STATIO_SYS_INDEXES** displays I/O status information for all system catalog indexes in a namespace.

**Table 15-273** PG_STATIO_SYS_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table for this index |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |

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| Name | Type | Description |
| --- | --- | --- |
| idx_blks_read | bigint | Number of disk blocks read from the index |
| idx_blks_hit | bigint | Number of cache hits in the index |

## 15.3.169 PG_STATIO_SYS_SEQUENCES

**PG_STATIO_SYS_SEQUENCES** displays I/O status information about all the sequences in the namespace.

**Table 15-274** PG_STATIO_SYS_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of this sequence |
| schemaname | name | Name of the schema where the sequence is in |
| relname | name | Name of the sequence |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Cache hits in the sequence |

## 15.3.170 PG_STATIO_SYS_TABLES

**PG_STATIO_SYS_TABLES** shows I/O status information about all the system catalogs in the namespace.

**Table 15-275** PG_STATIO_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |
| heap_blks_hit | bigint | Number of cache hits in the table |
| idx_blks_read | bigint | Number of disk blocks read from the index in the table |
| idx_blks_hit | bigint | Number of cache hits in the table |

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| Name | Type | Description |
| --- | --- | --- |
| toast_blks_read | bigint | Number of disk blocks read from the TOAST table (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in the TOAST table (if any) in the table |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST table index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer-hits in the TOAST table index (if any) in the table |

## 15.3.171 PG_STATIO_USER_INDEXES

**PG_STATIO_USER_INDEXES** displays I/O status information about all the user relationship table indexes in the namespace.

**Table 15-276** PG_STATIO_USER_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table for this index |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_blks_read | bigint | Number of disk blocks read from the index |
| idx_blks_hit | bigint | Number of cache hits in the index |

## 15.3.172 PG_STATIO_USER_SEQUENCES

**PG_STATIO_USER_SEQUENCES** shows I/O status information about all the user relationship table sequences in the namespace.

**Table 15-277** PG_STATIO_USER_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of this sequence |

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| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema where the sequence is in |
| relname | name | Name of the sequence |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Cache hits in the sequence |

## 15.3.173 PG_STATIO_USER_TABLES

**PG_STATIO_USER_TABLES** displays I/O status information about all the user relationship tables in the namespace.

**Table 15-278** PG_STATIO_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |
| heap_blks_hit | bigint | Number of cache hits in the table |
| idx_blks_read | bigint | Number of disk blocks read from the index in the table |
| idx_blks_hit | bigint | Number of cache hits in the table |
| toast_blks_read | bigint | Number of disk blocks read from the TOAST table (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in the TOAST table (if any) in the table |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST table index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer-hits in the TOAST table index (if any) in the table |

## 15.3.174 PG_THREAD_WAIT_STATUS

**PG_THREAD_WAIT_STATUS** allows you to test the block waiting status about the backend thread and auxiliary thread of the current instance.

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**Table 15-279** PG_THREAD_WAIT_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name |
| db_name | text | Database name |
| thread_name | text | Thread name |
| query_id | bigint | Query ID. It is equivalent to **debug_query_id**. |
| tid | bigint | Thread ID of the current thread |
| sessionid | bigint | Current session ID |
| lwtid | integer | Lightweight thread ID of the current thread |
| psessionid | bigint | Parent session ID |
| tlevel | integer | Level of the streaming thread |
| smpid | integer | Concurrent thread ID |
| wait_status | text | For details about the waiting status of the current thread, see **Table 15-280**. |
| wait_event | text | Event that the current thread is waiting for |
| locktag | text | Information about the lock that the current thread is waiting for |
| lockmode | text | Lock mode that the current thread is waiting to obtain. The values include table-level lock, row-level lock, and page-level lock modes. |
| block_sessionid | bigint | ID of the session that blocks the current thread from obtaining the lock |
| global_sessionid | text | Global session ID |

The waiting states in the **wait_status** column are as follows:

**Table 15-280** Waiting state list

| Value | Description |
| --- | --- |
| none | Waiting for no event |
| acquire lock | Waiting for locking until the locking succeeds or times out |
| acquire lwlock | Waiting for a lightweight lock |
| wait io | Waiting for I/O completion |

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| Value | Description |
| --- | --- |
| wait cmd | Waiting for reading network communication packets to complete |
| wait pooler get conn | Waiting for pooler to obtain connections |
| wait pooler abort conn | Waiting for pooler to terminate connections |
| wait pooler clean conn | Waiting for pooler to clear connections |
| pooler create conn: [nodename], total N | Waiting for the pooler to set up a connection. The connection is being established with the node specified by *nodename*, and there are *N* connections waiting to be set up. |
| get conn | Obtaining the connection to other nodes |
| set cmd: [nodename] | Waiting for running the **SET**, **RESET**, **TRANSACTION BLOCK LEVEL PARA SET**, or **SESSION LEVEL PARA SET** statement on the connection. The statement is being executed on the node specified by *nodename*. |
| cancel query | Canceling the SQL statement that is being executed through the connection |
| stop query | Stopping the query that is being executed through the connection |
| wait node: [nodename](plevel), total N, [phase] | Waiting for receiving data from a connected node. The thread is waiting for data from the plevel thread of the node specified by *nodename*. The data of *N* connections is waiting to be returned. If *phase* is included, the possible phases are as follows:<br>• **begin**: The transaction is being started.<br>• **commit**: The transaction is being committed.<br>• **rollback**: The transaction is being rolled back. |
| wait transaction sync: xid | Waiting for synchronizing the transaction specified by *xid* |
| wait wal sync | Waiting for the completion of WAL of synchronization from the specified LSN to the standby instance |
| wait data sync | Waiting for the completion of data page synchronization to the standby instance |

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| Value | Description |
| --- | --- |
| wait data sync queue | Waiting for putting the data pages that are in the row-store or the CU in the column-store into the synchronization queue |
| flush data: [nodename](plevel), [phase] | Waiting for sending data to the plevel thread of the node specified by *nodename*. If *phase* is included, the possible phase is **wait quota**, indicating that the current communication flow is waiting for the quota value. |
| stream get conn: [nodename], total N | Waiting for connecting to the consumer object of the node specified by *nodename* when the stream flow is initialized. There are *N* consumers waiting to be connected. |
| wait producer ready: [nodename](plevel), total N | Waiting for each producer to be ready when the stream flow is initialized. The thread is waiting for the procedure of the plevel thread on the *nodename* node to be ready. There are *N* producers waiting to be ready. |
| synchronize quit | Waiting for the threads in the stream thread group to quit when the stream plan ends |
| nodegroup destroy | Waiting for destroying the stream node group when the stream plan ends |
| wait active statement | Waiting for job execution under resource and load control. |
| gtm connect | Waiting for connecting to GTM |
| gtm get gxid | Wait for obtaining transaction IDs from GTM |
| gtm get snapshot | Wait for obtaining transaction snapshots from GTM |
| gtm begin trans | Waiting for GTM to start a transaction |
| gtm commit trans | Waiting for GTM to commit a transaction |
| gtm rollback trans | Waiting for GTM to roll back a transaction |
| gtm start prepare trans | Waiting for GTM to start the prepare phase of a two-phase transaction |
| gtm prepare trans | Waiting for GTM to complete the prepare phase of a two-phase transaction |
| gtm open sequence | Waiting for GTM to open a sequence |
| gtm close sequence | Waiting for GTM to close a sequence |
| gtm create sequence | Waiting for GTM to create a sequence |

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| Value | Description |
| --- | --- |
| gtm alter sequence | Waiting for GTM to modify a sequence |
| gtm get sequence val | Waiting for obtaining the next value of a sequence from GTM |
| gtm set sequence val | Waiting for GTM to set a sequence value |
| gtm drop sequence | Waiting for GTM to delete a sequence |
| gtm rename sequece | Waiting for GTM to rename a sequence |
| analyze: [relname], [phase] | The thread is doing **ANALYZE** to the *relname* table. If *phase* is included, the possible phase is **autovacuum**, indicating that the database automatically enables the AutoVacuum thread to execute **ANALYZE**. |
| vacuum: [relname], [phase] | The thread is doing **VACUUM** to the *relname* table. If *phase* is included, the possible phase is **autovacuum**, indicating that the database automatically enables the AutoVacuum thread to execute **VACUUM**. |
| vacuum full: [relname] | The thread is doing **VACUUM FULL** to the *relname* table. |
| create index | An index is being created |
| HashJoin - [ build hash \| write file ] | The **HashJoin** operator is being executed. In this phase, you need to pay attention to the execution time-consuming.<br>• **build hash**: The **HashJoin** operator is creating a hash table.<br>• **write file**: The **HashJoin** operator is writing data to disks. |
| HashAgg - [ build hash \| write file ] | The **HashAgg** operator is being executed. In this phase, you need to pay attention to the execution time-consuming.<br>• **build hash**: The **HashAgg** operator is creating a hash table.<br>• **write file**: The **HashAgg** operator is writing data to disks. |
| HashSetop - [build hash \| write file ] | The **HashSetop** operator is being executed. In this phase, you need to pay attention to the execution time-consuming.<br>• **build hash**: The **HashSetop** operator is creating a hash table.<br>• **write file**: The **HashSetop** operator is writing data to disks. |

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| Value | Description |
| --- | --- |
| Sort \| Sort - [fetch tuple \| write file] | The **Sort** operator is used for sorting. **fetch tuple** indicates that the **Sort** operator is obtaining tuples, and **write file** indicates that the **Sort** operator is writing data to disks. |
| Material \| Material - write file | The **Material** operator is being executed. **write file** indicates that the **Material** operator is writing data to disks. |
| standby read recovery conflict | The read-only mode of the standby node conflicts with the log replay mode. |
| standby get snapshot | The standby node obtains the snapshot in read-only mode. |

If **wait_status** is **acquire lwlock**, **acquire lock**, or **wait io**, there is an event performing I/O operations or waiting for obtaining the corresponding lightweight lock or transaction lock.

The following table describes the corresponding wait events when **wait_status** is **acquire lwlock**. If **wait_event** is **extension**, the lightweight lock is dynamically allocated and is not monitored.

**Table 15-281** List of wait events corresponding to lightweight locks

| wait_event | Description |
| --- | --- |
| ShmemIndexLock | Used to protect the primary index table, a hash table, in shared memory |
| OidGenLock | Used to prevent different threads from generating the same OID |
| XidGenLock | Used to prevent two transactions from obtaining the same XID |
| ProcArrayLock | Used to prevent concurrent access to or concurrent modification on the ProcArray shared array |
| SInvalReadLock | Used to prevent concurrent execution with invalid message deletion |
| SInvalWriteLock | Used to prevent concurrent execution with invalid message write and deletion |
| WALInsertLock | Used to prevent concurrent execution with WAL insertion |
| WALWriteLock | Used to prevent concurrent write from a WAL buffer to a disk |

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| wait_event | Description |
| --- | --- |
| ControlFileLock | Used to prevent concurrent read/write or concurrent write/write on the **pg_control** file |
| CheckpointLock | Used to prevent multi-checkpoint concurrent execution |
| CLogControlLock | Used to prevent concurrent access to or concurrent modification on the Clog control data structure |
| SubtransControlLock | Used to prevent concurrent access to or concurrent modification on the subtransaction control data structure |
| MultiXactGenLock | Used to allocate a unique MultiXact ID in serial mode |
| MultiXactOffsetControlLock | Used to prevent concurrent read/write or concurrent write/write on **pg_multixact/offset** |
| MultiXactMemberControl-Lock | Used to prevent concurrent read/write or concurrent write/write on **pg_multixact/members** |
| RelCacheInitLock | Used to add a lock before any operations are performed on the **init** file when messages are invalid |
| CheckpointerCommLock | Used to send file flush requests to a checkpointer. The request structure needs to be inserted to a request queue in serial mode. |
| TwoPhaseStateLock | Used to prevent concurrent access to or modification on two-phase information sharing arrays |
| TablespaceCreateLock | Used to check whether a tablespace exists. |
| BtreeVacuumLock | Used to prevent **VACUUM** from clearing pages that are being used by B-tree indexes |
| AlterPortLock | Used to protect the CN's operation of changing the registered port number. |
| AutovacuumLock | Used to access the autovacuum worker array in serial mode |
| AutovacuumScheduleLock | Used to distribute tables requiring **VACUUM** in serial mode |
| AutoanalyzeLock | Used to obtain and release resources related to a task that allows for autoanalyze execution |
| SyncScanLock | Used to determine the start position of a relfilenode during heap scanning |

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| wait_event | Description |
| --- | --- |
| NodeTableLock | Used to protect a shared structure that stores CN and DN node information. |
| PoolerLock | Used to prevent two threads from simultaneously obtaining the same connection from a connection pool |
| RelationMappingLock | Used to wait for the mapping file between system catalogs and storage locations to be updated |
| Async Ctl | Used to protect the async buffer. |
| AsyncCtlLock | Used to prevent concurrent access to or concurrent modification on the sharing notification status |
| AsyncQueueLock | Used to prevent concurrent access to or concurrent modification on the sharing notification queue |
| SerializableXactHashLock | Used to prevent concurrent read/write or concurrent write/write on a sharing structure for serializable transactions |
| SerializableFinishedListLock | Used to prevent concurrent read/write or concurrent write/write on a shared linked list for completed serial transactions |
| SerializablePredicateLockList-Lock | Used to protect a linked list of serializable transactions that have locks |
| OldSerXidLock | Used to protect a structure that records serializable transactions that have conflicts |
| FileStatLock | Used to protect a data structure that stores statistics file information |
| SyncRepLock | Used to protect Xlog synchronization information during primary-standby replication |
| DataSyncRepLock | Used to protect data page synchronization information during primary-standby replication |
| CStoreColspaceCacheLock | Used to add a lock when CU space is allocated for a column-store table |
| CStoreCUCacheSweepLock | Used to add a lock when CU caches used by a column-store table are cyclically washed out |
| MetaCacheSweepLock | Used to add a lock when metadata is cyclically washed out |

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| wait_event | Description |
| --- | --- |
| dummyServerInfoCacheLock | Used to protect a global hash table where the information about cluster connections is cached. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) |
| ExtensionConnectorLibLock | Used to add a lock when a specific dynamic library is loaded or uninstalled in ODBC connection initialization scenarios |
| SearchServerLibLock | Used to add a lock on the file read operation when a specific dynamic library is initially loaded in GPU-accelerated scenarios |
| LsnXlogChkFileLock | Used to serially update the Xlog flush points for primary and standby servers recorded in a specific structure |
| GTMHostInfoLock | Used to prevent concurrent access to or concurrent modification on GTM host information |
| ReplicationSlotAllocation-Lock | Used to add a lock when a primary server allocates stream replication slots during primary-standby replication |
| ReplicationSlotControlLock | Used to prevent concurrent update of replication slot status during primary-standby replication |
| ResourcePoolHashLock | Used to prevent concurrent access to or concurrent modification on a resource pool table, a hash table |
| WorkloadStatHashLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains SQL requests from the CN side |
| WorkloadIoStatHashLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains I/O information of the current DN |
| WorkloadCGroupHashLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains Cgroup information |
| OBSGetPathLock | Used to prevent concurrent read/write or concurrent write/write on an OBS path |
| WorkloadUserInfoLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains user information about load management. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

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| wait_event | Description |
| --- | --- |
| WorkloadRecordLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains requests received by CNs during adaptive memory management |
| WorkloadIOUtilLock | Used to protect a structure that records **iostat** and CPU load information |
| WorkloadNodeGroupLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains node group information in memory |
| JobShmemLock | Used to protect global variables in the shared memory that is periodically read during a scheduled task where MPP is compatible with Oracle |
| OBSRuntimeLock | Used to obtain environment variables, for example, GASSHOME |
| LLVMDumpIRLock | Used to export the assembly language for dynamically generating functions. The current feature is a lab feature. Contact Huawei technical support before using it. |
| LLVMParseIRLock | Used to compile and parse a finished IR function from the IR file at the start position of a query. The current feature is a lab feature. Contact Huawei technical support before using it. |
| RPNumberLock | Used by a DN on a cluster to count the number of threads for a task where plans are being executed. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) |
| ClusterRPLock | Used by a cluster to control concurrent access on cluster load data maintained in a CCN of the cluster. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) |
| CriticalCacheBuildLock | Used to load caches from a shared or local cache initialization file |
| WaitCountHashLock | Used to protect a shared structure in user statement counting scenarios |
| BufMappingLock | Used to protect operations on a table mapped to shared buffer |
| LockMgrLock | Used to protect a common lock structure |

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| wait_event | Description |
| --- | --- |
| PredicateLockMgrLock | Used to protect a lock structure that has serializable transactions |
| OperatorRealTLock | Used to prevent concurrent access to or concurrent modification on a global structure that contains real-time data at the operator level |
| OperatorHistLock | Used to prevent concurrent access to or concurrent modification on a global structure that contains historical data at the operator level |
| SessionRealTLock | Used to prevent concurrent access to or concurrent modification on a global structure that contains real-time data at the query level |
| SessionHistLock | Used to prevent concurrent access to or concurrent modification on a global structure that contains historical data at the query level |
| CacheSlotMappingLock | Used to protect global CU cache information |
| BarrierLock | Used to ensure that only one thread is creating a barrier at a time |
| StartBlockMappingLock | Used by globalstat to obtain information such as startblockarray from pgstat. |
| ConsumerStateLock | Used to update the working state of the time series consumer. |
| DeleteConsumerLock | Used to maintain the time series consumer hash table. |
| NgroupDestoryLock | Adds a lock to the concurrent modification of the Node Group hash table. |
| NGroupMappingLock | Adds a lock to the concurrent modification of a single bucket that protects the NodeGroup hash table. |
| GlobalSeqLock | Used to manage global sequence numbers. |
| MatviewSeqnoLock | Used to manage the cache of materialized views. |
| GPCCommitLock | Used to protect the addition of the global Plan Cache hash table. The current feature is a lab feature. Contact Huawei technical support before using it. |

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| wait_event | Description |
| --- | --- |
| GPCClearLock | Used to protect the clearing of the global plan cache hash table. The current feature is a lab feature. Contact Huawei technical support before using it. |
| GPCTimelineLock | Used to protect the timeline check of the global plan cache hash table. The current feature is a lab feature. Contact Huawei technical support before using it. |
| GPCMappingLock | Used to manage the global plan cache. The current feature is a lab feature. Contact Huawei technical support before using it. |
| GPCPrepareMappingLock | Used to manage the global plan cache. The current feature is a lab feature. Contact Huawei technical support before using it. |
| GPRCMappingLock | Used to manage the access and modification operations of the global cache hash table of autonomous transactions. |
| PldebugLock | Used to debug stored procedures and perform concurrent maintenance operations. |
| BufFreelistLock | Used to ensure the atomicity of free list operations in the shared buffer. |
| AddinShmemInitLock | Used to protect the initialization of the shared memory object. |
| wait active statement | Waiting for job execution under resource and load control. |
| wait memory | Waiting for obtaining the memory. |
| DnUsedSpaceHashLock | Used to update space usage information corresponding to a session. |
| InstanceRealTLock | Used to protect the update of the hash table that stores shared instance statistics. |
| IOStatLock | Used to concurrently maintain the hash table of resource management I/O statistics. |

The following table describes the corresponding wait events when **wait_status** is **wait io**.

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**Table 15-282** List of wait events corresponding to I/Os

| wait_event | Description |
| --- | --- |
| BufFileRead | Reads data from a temporary file to a specified buffer. |
| BufFileWrite | Writes the content of a specified buffer to a temporary file. |
| ControlFileRead | Reads the **pg_control** file, mainly during database startup, checkpoint execution, and primary/standby verification. |
| ControlFileSync | Flushes the **pg_control** file to a disk, during database initialization. |
| ControlFileSyncUpdate | Flushes the **pg_control** file to a disk, mainly during database startup, checkpoint execution, and primary/standby verification. |
| ControlFileWrite | Writes to the **pg_control** file, during database initialization. |
| ControlFileWriteUpdate | Updates the **pg_control** file, mainly during database startup, checkpoint execution, and primary/standby verification. |
| CopyFileRead | Reads a file during file copying. |
| CopyFileWrite | Writes a file during file copying. |
| DataFileExtend | Writes a file during file name extension. |
| DataFileFlush | Flushes a table data file to a disk. |
| DataFileImmediateSync | Flushes a table data file to a disk immediately. |
| DataFilePrefetch | Reads a table data file asynchronously. |
| DataFileRead | Reads a table data file synchronously. |
| DataFileSync | Flushes table data file modifications to a disk. |
| DataFileTruncate | Truncates a table data file. |
| DataFileWrite | Writes a table data file. |
| LockFileAddToDataDirRead | Reads the **postmaster.pid** file. |
| LockFileAddToDataDirSync | Flushes the **postmaster.pid** file to a disk. |
| LockFileAddToDataDirWrite | Writes PID information into the **postmaster.pid** file. |
| LockFileCreateRead | Read the LockFile file **%s.lock**. |
| LockFileCreateSync | Flushes the LockFile file **%s.lock** to a disk. |

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| wait_event | Description |
| --- | --- |
| LockFileCreateWRITE | Writes PID information into the LockFile file **%s.lock**. |
| RelationMapRead | Reads the mapping file between system catalogs and storage locations. |
| RelationMapSync | Flushes the mapping file between system catalogs and storage locations to a disk. |
| RelationMapWrite | Writes the mapping file between system catalogs and storage locations. |
| ReplicationSlotRead | Reads a stream replication slot file during a restart. |
| ReplicationSlotRestoreSync | Flushes a stream replication slot file to a disk during a restart. |
| ReplicationSlotSync | Flushes a temporary stream replication slot file to a disk during checkpoint execution. |
| ReplicationSlotWrite | Writes a temporary stream replication slot file during checkpoint execution. |
| SLRUFlushSync | Flushes the **pg_clog**, **pg_subtrans**, and **pg_multixact** files to a disk, mainly during checkpoint execution and database shutdown. |
| SLRURead | Reads the **pg_clog**, **pg_subtrans**, and **pg_multixact** files. |
| SLRUSync | Writes dirty pages into the **pg_clog**, **pg_subtrans**, and **pg_multixact** files, and flushes the files to a disk, mainly during checkpoint execution and database shutdown. |
| SLRUWrite | Writes the **pg_clog**, **pg_subtrans**, and **pg_multixact** files. |
| TimelineHistoryRead | Reads the timeline history file during database startup. |
| TimelineHistorySync | Flushes the timeline history file to a disk during database startup. |
| TimelineHistoryWrite | Writes to the timeline history file during database startup. |
| TwophaseFileRead | Reads the **pg_twophase** file, mainly during two-phase transaction commit and restoration. |
| TwophaseFileSync | Flushes the **pg_twophase** file to a disk, mainly during two-phase transaction commit and restoration. |

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| wait_event | Description |
| --- | --- |
| TwophaseFileWrite | Writes the **pg_twophase** file, mainly during two-phase transaction commit and restoration. |
| WALBootstrapSync | Flushes an initialized WAL file to a disk during database initialization. |
| WALBootstrapWrite | Writes an initialized WAL file during database initialization. |
| WALCopyRead | Read operation generated when an existing WAL file is read for replication after archiving and restoration. |
| WALCopySync | Flushes a replicated WAL file to a disk after archiving and restoration. |
| WALCopyWrite | Write operation generated when an existing WAL file is read for replication after archiving and restoration. |
| WALInitSync | Flushes a newly initialized WAL file to a disk during log reclaiming or writing. |
| WALInitWrite | Initializes a newly created WAL file to **0** during log reclaiming or writing. |
| WALRead | Reads data from Xlogs during redo operations on two-phase files. |
| WALSyncMethodAssign | Flushes all open WAL files to a disk. |
| WALWrite | Writes a WAL file. |

The following table describes the corresponding wait events when **wait_status** is **acquire lock**.

**Table 15-283** List of wait events corresponding to transaction locks

| wait_event | Description |
| --- | --- |
| relation | Adds a lock to a table. |
| extend | Adds a lock to a table being scaled out. |
| partition | Adds a lock to a partitioned table. |
| partition_seq | Adds a lock to a partition of a partitioned table. |
| page | Adds a lock to a table page. |
| tuple | Adds a lock to a tuple on a page. |
| transactionid | Adds a lock to a transaction ID. |

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| wait_event | Description |
| --- | --- |
| virtualxid | Adds a lock to a virtual transaction ID. |
| object | Adds a lock to an object. |
| cstore_freespace | Adds a lock to idle column-store space. |
| userlock | Adds a lock to a user. |
| advisory | Adds an advisory lock. |

## 15.3.175 PG_TABLES

**PG_TABLES** provides access to each table in the database.

**Table 15-284** PG_TABLES columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| schemaname | name | 15.2.70 PG_NAMESPACE.nspname | Name of the schema that contains a table |
| tablename | name | 15.2.46 PG_CLASS.relname | Table name |
| tableowner | name | pg_get_userbyid(15.2.46 PG_CLASS.relowner) | Table owner |
| tablespace | name | 15.2.94 PG_TABLESPACE.spcname | Tablespace that contains the table (default value: **null**) |
| hasindexes | boolean | 15.2.46 PG_CLASS.relhasindex | Whether the table has (or recently had) an index. If it does, the value is **true**. Otherwise, the value is **false**. |
| hasrules | boolean | 15.2.46 PG_CLASS.relhasruls | Whether the table has rules. If it does, the value is **true**. Otherwise, the value is **false**. |
| hastriggers | boolean | 15.2.46 PG_CLASS.RELHASTRIGGERS | The value is **true** if the table has triggers; otherwise, the value is **false**. |
| tablecreator | name | pg_get_userbyid(15.2.71 PG_OBJECT.creator) | Table creator. |

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| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| created | timestamp with time zone | 15.2.71 PG_OBJECT.ctime | Time when the table is created. |
| last_ddl_time | timestamp with time zone | 15.2.71 PG_OBJECT.mtime | Time when the DDL operation is performed on the table for the last time. |

## 15.3.176 PG_TDE_INFO

**PG_TDE_INFO** provides encryption information of all clusters.

**Table 15-285** PG_TDE_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| is_encrypt | boolean | Whether the cluster is an encryption cluster.<br>• **f**: Non-encryption cluster<br>• **t**: Encryption cluster |
| g_tde_algo | text | Encryption algorithm<br>• SM4-CTR-128<br>• AES-CTR-128 |
| remain | text | Reserved |

## 15.3.177 PG_TIMEZONE_ABBREVS

**PG_TIMEZONE_ABBREVS** displays information about all available time zones.

**Table 15-286** PG_TIMEZONE_ABBREVS columns

| Name | Type | Description |
| --- | --- | --- |
| abbrev | text | Abbreviation of the time zone name |
| utc_offset | interval | Offset from UTC |
| is_dst | boolean | Whether DST is used. If DST is used, the value is **true**. Otherwise, the value is **false**. |

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## 15.3.178 PG_TIMEZONE_NAMES

**PG_TIMEZONE_NAMES** displays all time zone names that can be recognized by **SET TIMEZONE**, along with their abbreviations, UTC offsets, and daylight saving time (DST) statuses.

**Table 15-287** PG_TIMEZONE_NAMES columns

| Name | Type | Description |
| --- | --- | --- |
| name | text | Name of the time zone |
| abbrev | text | Abbreviation of the time zone name |
| utc_offset | interval | Offset from UTC |
| is_dst | boolean | Whether DST is used. If DST is used, the value is **true**. Otherwise, the value is **false**. |

## 15.3.179 PG_TOTAL_MEMORY_DETAIL

**PG_TOTAL_MEMORY_DETAIL** displays memory usage of a node in the database.

**Table 15-288** PG_TOTAL_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |
| memorytype | text | Memory name |
| memorymbytes | integer | Size of the used memory, in MB |

## 15.3.180 PG_TOTAL_USER_RESOURCE_INFO

**PG_TOTAL_USER_RESOURCE_INFO** displays resource usage of all users. Only administrators can query this view. This view is valid only when **use_workload_manager** is set to **on**. I/O monitoring items are valid only when **enable_logical_io_statistics** is set to **on**.

**Table 15-289** PG_TOTAL_USER_RESOURCE_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| username | name | Username |
| used_memory | integer | Used memory, in MB |

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| Name | Type | Description |
| --- | --- | --- |
| total_memory | integer | Available memory, in MB. The value **0** indicates that the available memory is not limited and depends on the maximum memory available in the database. |
| used_cpu | double precision | Number of CPU cores in use. CPU usage data is collected only in complex jobs, and the value is the CPU usage of the related Cgroup. |
| total_cpu | integer | Total number of CPU cores of the Cgroup associated with the user on the node |
| used_space | bigint | Used permanent table storage space, in KB |
| total_space | bigint | Available permanent table storage space, in KB (**-1** if the storage space is not limited) |
| used_temp_space | bigint | Used temporary space, in KB |
| total_temp_space | bigint | Total available temporary space, in KB (**-1** if the temporary space is not limited) |
| used_spill_space | bigint | Size of the used operator flushing space, in KB |
| total_spill_space | bigint | Total size of the available operator flushing space, in KB (**-1** if the space is not limited) |
| read_kbytes | bigint | CN: total bytes read by the user's complex jobs on all DNs in the last 5 seconds, in KB<br>DN: total bytes read by the user's complex jobs from the instance startup time to the current time, in KB |
| write_kbytes | bigint | CN: total bytes written by the user's complex jobs on all DNs in the last 5 seconds, in KB<br>DN: total bytes written by the user's complex jobs from the instance startup time to the current time, in KB |
| read_counts | bigint | CN: total number of read times of the user's complex jobs on all DNs in the last 5 seconds<br>DN: total number of read times of the user's complex jobs from the instance startup time to the current time |
| write_counts | bigint | CN: total number of write times of the user's complex jobs on all DNs in the last 5 seconds<br>DN: total number of write times of the user's complex jobs from the instance startup time to the current time |

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| Name | Type | Description |
| --- | --- | --- |
| read_speed | double precision | CN: average read rate of the user's complex jobs on a single DN in the last 5 seconds, in KB/s<br>DN: average read rate of the user's complex jobs on the DN in the last 5 seconds, in KB/s |
| write_speed | double precision | CN: average write rate of the user's complex jobs on a single DN in the last 5 seconds, in KB/s<br>DN: average write rate of the user's complex jobs on a single DN in the last 5 seconds, in KB/s |

## 15.3.181 PG_TOTAL_USER_RESOURCE_INFO_OID

**PG_TOTAL_USER_RESOURCE_INFO_OID** displays resource usage of all users. Only administrators can query this view. This view is valid only when **use_workload_manager** is set to **on**.

**Table 15-290** PG_TOTAL_USER_RESOURCE_INFO_OID columns

| Name | Type | Description |
| --- | --- | --- |
| userid | oid | User ID |
| used_memory | integer | Used memory, in MB |
| total_memory | integer | Available memory, in MB. The value **0** indicates that the available memory is not limited and depends on the maximum memory available in the database. |
| used_cpu | double precision | Number of CPU cores in use |
| total_cpu | integer | Total number of CPU cores of the Cgroup associated with the user on the node |
| used_space | bigint | Used storage space, in KB |
| total_space | bigint | Available storage space, in KB. The value **-1** indicates that the space is not limited. |
| used_temp_space | bigint | Used temporary storage space, in KB |
| total_temp_space | bigint | Total available temporary space, in KB. The value **-1** indicates that the space is not limited. |
| used_spill_space | bigint | Used disk space for spilling, in KB |

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| Name | Type | Description |
| --- | --- | --- |
| total_spill_space | bigint | Total available disk space for spilling, in KB. The value **-1** indicates that the space is not limited. |
| read_kbytes | bigint | Volume of data read from the disk, in KB. |
| write_kbytes | bigint | Volume of data written to the disk, in KB. |
| read_counts | bigint | Number of disk read times. |
| write_counts | bigint | Number of disk write times. |
| read_speed | double precision | Disk read rate, in B/ms. |
| write_speed | double precision | Disk write rate, in B/ms. |

## 15.3.182 PG_USER

**PG_USER** provides information about database users. By default, only the initial user and users with the sysadmin attribute can view the information. Other users can view the information only after being granted permissions.

**Table 15-291** PG_USER columns

| Name | Type | Description |
| --- | --- | --- |
| usename | name | Username |
| usesysid | oid | ID of this user |
| usecreatedb | boolean | Whether the user has the permissions to create databases<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| usesuper | boolean | whether the user is the initial system administrator with the highest rights<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| usecatupd | boolean | whether the user can directly update system tables. Only the initial system administrator whose **usesysid** is **10** has this permission. It is unavailable for other users.<br>• **t (true)**: yes.<br>• **f (false)**: no. |

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| Name | Type | Description |
| --- | --- | --- |
| userepl | boolean | Whether the user has the permissions to duplicate data streams<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| passwd | text | Encrypted user password. The value is displayed as ********. |
| valbegin | timestamp with time zone | Start time for account validity (**null** if no start time) |
| valuntil | timestamp with time zone | End time for account validity (**null** if no end time) |
| respool | name | Resource pool where the user is in |
| parent | oid | Parent user OID |
| spacelimit | text | Storage space of the permanent table |
| useconfig | text[] | Session defaults for runtime configuration variables |
| nodegroup | name | Name of the logical (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) associated with the user. If no logical cluster is associated, this column is left blank. |
| tempspacelimit | text | Storage space of the temporary table |
| spillspacelimit | text | Operator disk flushing space |
| usemonitoradmin | boolean | Whether the user is a monitor administrator<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| useoperatoradmin | boolean | Whether the user is an O&M administrator<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| usepolicyadmin | boolean | Whether the user is a security policy administrator<br>• **t (true)**: yes.<br>• **f (false)**: no. |

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## 15.3.183 PG_USER_MAPPINGS

**PG_USER_MAPPINGS** provides access to information about user mappings.

All users can view the report.

**Table 15-292** PG_USER_MAPPINGS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| umid | oid | 15.2.102 PG_USER_MAPPING.oid | OID of the user mapping |
| srvid | oid | 15.2.60 PG_FOREIGN_SERVER.oid | OID of the foreign server that contains the mapping |
| srvname | name | 15.2.60 PG_FOREIGN_SERVER.srvname | Name of the foreign server |
| umuser | oid | 15.2.42 PG_AUTHID.oid | OID of the local role being mapped (**0** if the user mapping is public) |
| usename | name | - | Name of the local user to be mapped |
| umoptions | text[ ] | - | User mapping specific options. If the current user is the owner of the foreign server, the value is **keyword=value strings**. Otherwise, the value is **null**. |

## 15.3.184 PG_VARIABLE_INFO

**PGXC_VARIABLE_INFO** records information about transaction IDs and OIDs of the current node in a cluster.

**Table 15-293** PG_VARIABLE_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| next_oid | oid | OID generated next time for the node |
| next_xid | xid | Transaction ID generated next time for the node |
| oldest_xid | xid | Oldest transaction ID on the node |

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| Name | Type | Description |
| --- | --- | --- |
| xid_vac_limit | xid | Critical point (transaction ID) that triggers forcible autovacuum |
| oldest_xid_db | oid | OID of the database that has the minimum datafrozenxid on the node |
| last_extend_csn_logpage | xid | Number of the last extended csnlog page |
| start_extend_csn_logpage | xid | Number of the page from which csnlog extending starts |
| next_commit_seqno | xid | CSN generated next time for the node |
| latest_completed_xid | xid | Latest transaction ID on the node after the transaction commission or rollback |
| startup_max_xid | xid | Last transaction ID before the node is powered off |

## 15.3.185 PG_VIEWS

**PG_VIEWS** provides access to basic information about each view in the database.

**Table 15-294** PG_VIEWS columns

| Name | Type | Reference | Description |
| --- | --- | --- | --- |
| schemaname | name | **15.2.70 PG_NAMESPACE**.nspname | Name of the schema that contains the view |
| viewname | name | **15.2.46 PG_CLASS**.relname | View name |
| viewowner | name | **15.2.42 PG_AUTHID**.Erolname | Owner of the view |
| definition | text | - | Definition of the view |

## 15.3.186 PG_WLM_STATISTICS

**PG_WLM_STATISTICS** shows information about workload management after the task is complete or the exception has been handled. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the sysadmin user can query this view.

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**Table 15-295** PG_WLM_STATISTICS columns

| Name | Type | Description |
| --- | --- | --- |
| statement | text | Statement executed for exception handling |
| block_time | bigint | Block time before the statement is executed |
| elapsed_time | bigint | Elapsed time when the statement is executed |
| total_cpu_time | bigint | Total time used by the CPU on the DN when the statement is executed for exception handling |
| qualification_time | bigint | Period when the statement checks the inclination ratio |
| cpu_skew_percent | integer | CPU usage skew on the DN when the statement is executed for exception handling |
| control_group | text | Cgroup used when the statement is executed for exception handling |
| status | text | Statement status after it is executed for exception handling<br>• **pending**: The statement is waiting to be executed.<br>• **running**: The statement is being executed.<br>• **finished**: The execution is finished normally.<br>• **abort**: The execution is unexpectedly terminated. |
| action | text | Actions when statements are executed for exception handling<br>• **abort**: terminating the operation.<br>• **adjust**: executing the Cgroup adjustment operations. Currently, you can only perform the demotion operation.<br>• **finish**: The operation is normally finished. |

## 15.3.187 PGXC_COMM_DELAY

**PGXC_COMM_DELAY** displays the communication library delay status of all DNs. Only system admin and monitor admin can view the status.

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**Table 15-296** PGXC_COMM_DELAY columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| remote_name | text | Peer node name |
| remote_host | text | IP address of the peer node |
| stream_num | integer | Number of logical stream connections used by the current physical connection |
| min_delay | integer | Minimum delay of the current physical connection within 1 minute, in microsecond<br>**NOTE**<br>A negative result is invalid. Wait until the delay status is updated and query again. |
| average | integer | Average delay of the current physical connection within 1 minute, in microsecond |
| max_delay | integer | Maximum delay of the current physical connection within 1 minute, in microsecond |

## 15.3.188 PGXC_COMM_RECV_STREAM

**PGXC_COMM_RECV_STREAM** displays the receiving stream status of the communication libraries for all the DNs.

**Table 15-297** PGXC_COMM_RECV_STREAM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| local_tid | bigint | ID of the thread using this stream |
| remote_name | text | Peer node name |
| remote_tid | bigint | Peer thread ID |
| idx | integer | Peer DN ID in the local DN |
| sid | integer | Stream ID in the physical connection |
| tcp_sock | integer | TCP socket used in the stream |

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| Name | Type | Description |
| --- | --- | --- |
| state | text | Status of the stream<br>• **UNKNOWN**: The logical connection status is unknown.<br>• **READY**: The logical connection is ready.<br>• **RUN**: The logical connection sends packets normally.<br>• **HOLD**: The logical connection is waiting to send packets.<br>• **CLOSED**: The logical connection is closed.<br>• **TO_CLOSED**: The logical connection will be closed. |
| query_id | bigint | **debug_query_id** corresponding to the stream |
| pn_id | integer | **plan_node_id** of the query executed by the stream |
| send_smp | integer | **smpid** of the sender of the query executed by the stream |
| recv_smp | integer | **smpid** of the receiver of the query executed by the stream |
| recv_bytes | bigint | Total data volume received from the stream, in byte |
| time | bigint | Current lifecycle service duration of the stream, in ms |
| speed | bigint | Average receiving rate of the stream, in byte/s |
| quota | bigint | Current communication quota value of the stream, in byte |
| buff_usize | bigint | Current size of the data cache of the stream, in byte |

## 15.3.189 PGXC_COMM_SEND_STREAM

**PGXC_COMM_SEND_STREAM** displays the sending stream status of the communication libraries for all the DNs.

**Table 15-298** PGXC_COMM_SEND_STREAM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| local_tid | bigint | ID of the thread using this stream |

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| Name | Type | Description |
| --- | --- | --- |
| remote_name | text | Peer node name |
| remote_tid | bigint | Peer thread ID |
| idx | integer | Peer DN ID in the local DN |
| sid | integer | Stream ID in the physical connection |
| tcp_sock | integer | TCP socket used in the stream |
| state | text | Status of the stream<br>The options are as follows:<br>• **UNKNOWN**: The connection status is unknown.<br>• **READY**: The connection is ready.<br>• **RUN**: The connection sends packets normally.<br>• **HOLD**: The connection is waiting to send packets.<br>• **CLOSED**: The connection is closed.<br>• **TO_CLOSED**: The connection will be closed. |
| query_id | bigint | **debug_query_id** corresponding to the stream |
| pn_id | integer | **plan_node_id** of the query executed by the stream |
| send_smp | integer | **smpid** of the sender of the query executed by the stream |
| recv_smp | integer | **smpid** of the receiver of the query executed by the stream |
| send_bytes | bigint | Total data volume sent by the stream, in byte |
| time | bigint | Current lifecycle service duration of the stream, in ms |
| speed | bigint | Average sending rate of the stream, in byte/s |
| quota | bigint | Current communication quota value of the stream, in byte |
| wait_quota | bigint | Extra time generated when the stream waits the quota value, in ms |

## 15.3.190 PGXC_COMM_STATUS

**PGXC_COMM_STATUS** displays the communication library status for all the DNs.

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**Table 15-299** PGXC_COMM_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| rxpck_rate | integer | Receiving rate of the communication library on the node, in byte/s |
| txpck_rate | integer | Sending rate of the communication library on the node, in byte/s |
| rxkbyte_rate | bigint | Receiving rate of the communication library on the node, in kbyte/s |
| txkbyte_rate | bigint | Sending rate of the communication library on the node, in kbyte/s |
| buffer | bigint | Size of the buffer of the Cmailbox |
| memkbyte_libcomm | bigint | Communication memory size of the **libcomm** process, in bytes |
| memkbyte_libpq | bigint | Communication memory size of the **libpq** process, in bytes |
| used_pm | integer | Real-time usage of the postmaster thread |
| used_sflow | integer | Real-time usage of the **gs_sender_flow_controller** thread |
| used_rflow | integer | Real-time usage of the **gs_receiver_flow_controller** thread |
| used_rloop | integer | Highest real-time usage among multiple **gs_receivers_loop** threads |
| stream | integer | Total number of used logical connections. |

## 15.3.191 PGXC_GET_STAT_ALL_TABLES

**PGXC_GET_STAT_ALL_TABLES** obtains information about insertion, update, and deletion operations on tables and the dirty page rate of tables. Before running **VACUUM FULL** to a system catalog with a high dirty page rate, ensure that no user is performing operations on it. This view is a new function in GaussDB. After an upgrade to this version, statistics about insert, update, and deletion operations performed before the upgrade will not be collected. You are advised to run **VACUUM FULL** to tables (excluding system catalogs) whose dirty page rate exceeds 30% or run it based on service scenarios. Only users with the system admin or monitor admin permission can view the information.

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**Table 15-300** PGXC_GET_STAT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| relname | name | Table name |
| schemaname | name | Schema name of the table |
| n_tup_ins | numeric | Number of inserted tuples |
| n_tup_upd | numeric | Number of updated tuples |
| n_tup_del | numeric | Number of deleted tuples |
| n_live_tup | numeric | Number of live tuples |
| n_dead_tup | numeric | Number of dead tuples |
| dirty_page_rate | numeric(5,2) | Dirty page rate (%) of a table |

## 15.3.192 PGXC_GET_TABLE_SKEWNESS

**PGXC_GET_TABLE_SKEWNESS** stores the data skew on tables in the current database. Only the system administrator has the permission to access.

**Table 15-301** PGXC_GET_TABLE_SKEWNESS columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Schema name of a table |
| tablename | name | Table name |
| totalsize | numeric | Total size of the table, in bytes |
| avgsize | numeric(1000,0) | Average table size (total table size divided by the number of DNs), which is the ideal size of tables distributed on each DN |
| maxratio | numeric(4,3) | Ratio of the maximum table size on a single DN to the total table size |
| minratio | numeric(4,3) | Ratio of the minimum table size on a single DN to the total table size |
| skewsize | bigint | Table skew rate (the maximum table size on a single DN minus the minimum table size on a single DN) |
| skewratio | numeric(4,3) | Table skew rate (skew size divided by total table size) |

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| Name | Type | Description |
| --- | --- | --- |
| skewstddev | numeric(1000,0) | Standard deviation of table distribution (For two tables of the same size, a larger deviation indicates a more severe skew.) |

## 15.3.193 PGXC_NODE_ENV

**PGXC_NODE_ENV** provides environmental variables of all nodes in a cluster. This view can be viewed only by the monitor admin and sysadmin users.

**Table 15-302** PGXC_NODE_ENV columns

| Name | Type | Description |
| --- | --- | --- |
| node_name1 | text | All node names in the cluster |
| host1 | text | Host names of all the nodes in the cluster |
| process1 | integer | Process IDs of all the nodes in the cluster |
| port1 | integer | Port numbers of all the nodes in the cluster |
| installpath1 | text | Installation directory of all the nodes in the cluster |
| datapath1 | text | Data directory of all the nodes in the cluster |
| log_directory1 | text | Log directory of all the nodes in the cluster |

## 15.3.194 PGXC_OS_THREADS

PGXC_OS_THREADS provides information about the thread status of all normal nodes in the current cluster. Only the system administrator and monitor administrator can access this view.

**Table 15-303** PGXC_OS_THREADS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | All normal node names in the cluster |
| pid | bigint | IDs of running threads among all the normal node processes in the current cluster |
| lwpid | integer | Lightweight thread ID corresponding to the PID |

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| Name | Type | Description |
| --- | --- | --- |
| thread_name | text | Thread name corresponding to the PID |
| creation_time | timestamp with time zone | Thread creation time corresponding to the PID |

## 15.3.195 PGXC_PREPARED_XACTS

**PGXC_PREPARED_XACTS** displays two-phase transactions in the **prepared** phase. Only users with the system admin or monitor admin permission can view the information.

**Table 15-304** PGXC_PREPARED_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| pgxc_prepared_xact | text | Displays the two-phase transaction in the **prepared** phase. |

## 15.3.196 PGXC_RUNNING_XACTS

**PGXC_RUNNING_XACTS** displays information about running transactions on each node in the cluster. The content is the same as that displayed by **PG_RUNNING_XACTS**. Only users with the system admin or monitor admin permission can view the information.

**Table 15-305** PGXC_RUNNING_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| handle | integer | Handle corresponding to the transaction in GTM |
| gxid | xid | Transaction ID |
| state | tinyint | Transaction status (**3**: prepared; **0**: starting) |
| node | text | Node name |
| xmin | xid | Minimum transaction ID on the node |
| vacuum | boolean | Whether the current transaction is lazy vacuum<br>• **t (true)**: yes.<br>• **f (false)**: no. |
| timeline | bigint | Number of database restarts |

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| Name | Type | Description |
| --- | --- | --- |
| prepare_xid | xid | Transaction ID in the **prepared** state (**0** if the state is not **prepared**) |
| pid | bigint | Thread ID corresponding to the transaction |
| next_xid | xid | Transaction ID sent from a CN to a DN |

## 15.3.197 PGXC_STAT_ACTIVITY

**PGXC_STAT_ACTIVITY** displays information about the current user's queries on all CNs in the current cluster. Only users with the **monitor admin** or **sysadmin** permission can view the view.

**Table 15-306** PGXC_STAT_ACTIVITY columns

| Name | Type | Description |
| --- | --- | --- |
| coorname | text | Name of a CN in the current cluster |
| datid | oid | OID of the database that the user session connects to in the backend |
| datname | text | Name of the database that the user session connects to in the backend |
| pid | bigint | Process ID of the backend |
| sessionid | bigint | Session ID |
| usesysid | oid | OID of the user logged in to the backend |
| username | text | Name of the user logged in to the backend |
| application_name | text | Name of the application connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is **null**, either the client is connected via a Unix socket on the server machine or this is an internal process such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null for IP connections only when **log_hostname** is enabled. |

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| Name | Type | Description |
| --- | --- | --- |
| client_port | integer | TCP port number that the client uses for communication with the backend (**–1** if a Unix socket is used) |
| backend_start | timestamp with time zone | Time when this process was started, that is, when the client connected to the server |
| xact_start | timestamp with time zone | Time when the current transaction was started (**null** if no transaction is active). If the current query is the first of its transaction, this column is equal to the **query_start** column. |
| query_start | timestamp with time zone | Time when the currently active query was started, or if **state** is not **active**, when the last query was started |
| state_change | timestamp with time zone | Time when the last **status** was changed |
| waiting | boolean | Whether the backend is currently waiting on a lock. If it is, the value is **true**. Otherwise, the value is **false**. |
| enqueue | text | Queuing status of a statement. Its value can be:<br>• **waiting in queue**: The statement is in the queue.<br>• **Empty**: The statement is running. |

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| Name | Type | Description |
| --- | --- | --- |
| state | text | Backend status. Its value can be:<br>• **active**: The backend is executing a query.<br>• **idle**: The backend is waiting for a new client command.<br>• **idle in transaction**: The backend is in a transaction, but there is no statement being executed in the transaction.<br>• **idle in transaction** (aborted): The backend is in a transaction, but there are statements failed in the transaction.<br>• **fastpath function call**: The backend is executing a fast-path function.<br>• **disabled**: This state is reported if **track_activities** is disabled in this backend.<br>**NOTE**<br>Only system administrators can view the session status of their accounts. The state information of other accounts is empty. For example, after user **judy** is connected to the database, the state information of user **joe** and the initial user **omm** in **pgxc_stat_activity** is empty.<br>SELECT datname, usename, usesysid, state,pid FROM pgxc_stat_activity;<br>datname \| usename \| usesysid \| state \| pid<br>----------+---------+----------+--------+-----------------<br>postgres \| omm \| 10 \| \| 139968752121616<br>postgres \| omm \| 10 \| \| 139968903116560<br>db_tpcds \| judy \| 16398 \| active \| 139968391403280<br>postgres \| omm \| 10 \| \| 139968643069712<br>postgres \| omm \| 10 \| \| 139968680818448<br>postgres \| joe \| 16390 \| \| 139968563377936<br>(6 rows) |
| resource_pool | name | Resource pool used by the user |
| query_id | bigint | ID of a query |
| query | text | Latest query at the backend. If **state** is **active**, this column shows the ongoing query. In all other states, it shows the last query that was executed. |

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| Name | Type | Description |
| --- | --- | --- |
| connection_info | text | A string in JSON format recording the driver type, driver version, driver deployment path, and process owner of the connected database. For details, see **connection_info**. |
| global_sessionid | text | Global session ID |
| unique_sql_id | bigint | Unique SQL statement ID |
| trace_id | text | Driver-specific trace ID, which is associated with an application request |

## 15.3.198 PGXC_STAT_BAD_BLOCK

**PGXC_STAT_BAD_BLOCK** shows statistics about Page or CU verification failures after all nodes in a cluster are started. This view can be viewed only by the monitor admin and sysadmin users.

**Table 15-307** PGXC_STAT_BAD_BLOCK columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |
| databaseid | integer | Database OID |
| tablespaceid | integer | Tablespace OID |
| relfilenode | integer | File object ID |
| forknum | integer | File type |
| error_count | integer | Number of verification failures |
| first_time | timestamp with time zone | Time of the first verification failure |
| last_time | timestamp with time zone | Time of the latest verification failure |

## 15.3.199 PGXC_SQL_COUNT

**PGXC_SQL_COUNT** displays node-level and user-level statistical results for the **SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO** statements in real time, identifies query types with heavy load, and measures the capability of a cluster or node to perform a specific type of query. For example, you can calculate QPS based on the quantities of the five types of SQL statements at certain time points. **USER1 SELECT** is counted as **X1** at T1 and as **X2** at T2. The **SELECT** QPS of the user can be calculated as follows: (X2 – X1)/(T2 – T1). In this way, the system can

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draw cluster-user-level QPS curve graphs and determine cluster throughput, tracing changes in the service load of each user. If there are drastic changes, the system can locate the specific statement type (such as **SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO**). You can also observe QPS curves to determine the time points when problems occur and then locate the problems using other tools. The curves provide a basis for optimizing cluster performance and locating problems. This view can be viewed only by the monitor admin and sysadmin users. The query can be performed only on the CN. The **execute direct on (dn)'select * from PGXC_SQL_COUNT';** statement is not supported.

Columns in the **PGXC_SQL_COUNT** view are the same as those in the **GS_SQL_COUNT** view. For details, see **Table 15-181**.

NOTE

If a **MERGE INTO** statement can be pushed down and a DN receives it, the statement will be counted on the DN and the value of the **mergeinto_count** column will be incremented by 1. If pushdown is not allowed, the DN will receive an **UPDATE** or **INSERT** statement. In this case, the **update_count** or **insert_count** column will be incremented by 1.

## 15.3.200 PGXC_THREAD_WAIT_STATUS

In **PGXC_THREAD_WAIT_STATUS**, you can see all the call layer hierarchy relationship between threads of the SQL statements on all the nodes in a cluster, and the waiting status of the block for each thread, so that you can easily locate the causes of process response failures and similar phenomena.

The definitions of **PGXC_THREAD_WAIT_STATUS** view and **PG_THREAD_WAIT_STATUS** view are the same, because the essence of the **PGXC_THREAD_WAIT_STATUS** view is the query summary of the **PG_THREAD_WAIT_STATUS** view on each node in the cluster.

**Table 15-308** PGXC_THREAD_WAIT_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name |
| db_name | text | Database name |
| thread_name | text | Thread name |
| query_id | bigint | Query ID. It is equivalent to **debug_query_id**. |
| tid | bigint | Thread ID of the current thread |
| sessionid | bigint | Session ID |
| lwtid | integer | Lightweight thread ID of the current thread |
| psessionid | bigint | Parent session ID |
| tlevel | integer | Level of the streaming thread |
| smpid | integer | Concurrent thread ID |
| wait_status | text | Detailed information about the waiting status of the current thread |

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| Name | Type | Description |
| --- | --- | --- |
| wait_event | text | Event that the current thread is waiting for. For details, see **Table 15-280**. |
| locktag | text | Information about the lock that the current thread is waiting for |
| lockmode | text | Lock mode that the current thread is waiting to obtain |
| block_sessionid | bigint | ID of the session that blocks the current thread from obtaining the lock |
| global_sessionid | text | Global session ID |

Example:

If you run a statement on coordinator1 and no response is returned after a long period of time, establish another connection to coordinator1 to check the thread status on it.

```
openGauss=# select * from pg_thread_wait_status where query_id > 0;
  node_name   | db_name  | thread_name  | query_id |       tid        | lwtid | ptid  | tlevel | smpid |
wait_status   |   wait_event
--------------+----------+--------------+----------+------------------+-------+-------+--------+-------
+----------------------
 coordinator1 | postgres | gsql         | 20971544 | 140274089064208 | 22579 |       |      0 |     0 | wait node:
datanode4 |
(1 rows)
openGauss=# select * from pgxc_thread_wait_status where query_id > 0;
  node_name   | db_name  | thread_name |     query_id      |      tid       |   sessionid    | lwtid  | psessionid |
tlevel | smpid | wait_status | wait_event
--------------+----------+--------------+-------------------+----------------+----------------+--------+------------
+--------+-------+-------------+------------
 coordinator1 | postgres | gsql         | 77687093572155050 | 47212704827136 | 47212704827136 |  63191
|            |      0 |     0 | none        |
 coordinator2 | postgres | coordinator1 | 77687093572155050 | 47403117319936 | 47403117319936 |
159322 |            |      0 |     0 | none        |
 data_node1   | postgres | coordinator1 | 77687093572155050 | 47723869374208 | 47723869374208 |
159320 |            |      0 |     0 | none        |
 data_node2   | postgres | coordinator1 | 77687093572155050 | 47852867290880 | 47852867290880 |
159321 |            |      0 |     0 | none        |
(4 rows)
```

## 15.3.201 PGXC_TOTAL_MEMORY_DETAIL

**PGXC_TOTAL_MEMORY_DETAIL** displays memory usage in the cluster. The query can be performed only on the CN. The **execute direct on (dn)'select * from PGXC_TOTAL_MEMORY_DETAIL';** statement is not supported. Only users with the sysadmin or monitor admin permission can query this view.

**Table 15-309** PGXC_TOTAL_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |

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| Name | Type | Description |
| --- | --- | --- |
| memorytype | text | Memory name<br>• **max_process_memory**: memory occupied by a GaussDB cluster instance<br>• **process_used_memory**: memory occupied by a GaussDB process<br>• **max_dynamic_memory**: maximum dynamic memory<br>• **dynamic_used_memory**: used dynamic memory<br>• **dynamic_peak_memory**: dynamic memory peak<br>• **dynamic_used_shrctx**: maximum dynamic shared memory context<br>• **dynamic_peak_shrctx**: dynamic peak value of the shared memory context<br>• **max_shared_memory**: maximum shared memory<br>• **shared_used_memory**: used shared memory<br>• **max_cstore_memory**: maximum memory allowed by column-storage<br>• **cstore_used_memory**: memory used in column-storage<br>• **max_sctpcomm_memory**: maximum memory allowed for the communication library<br>• **sctpcomm_used_memory**: memory used by the communication library<br>• **sctpcomm_peak_memory**: memory peak of the communication library<br>• **other_used_memory**: other used memory |
| memorymbytes | integer | Size of the used memory, in MB |

## 15.3.202 PGXC_VARIABLE_INFO

**PGXC_VARIABLE_INFO** records information about transaction IDs and OIDs of all nodes in a cluster. This view can be viewed only by the monitor admin and sysadmin users. The query can be performed only on the CN. The **execute direct on (dn)'select * from PGXC_VARIABLE_INFO';** statement is not supported.

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**Table 15-310** PGXC_VARIABLE_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| next_oid | oid | OID generated next time for the node |
| next_xid | xid | Transaction ID generated next time for the node |
| oldest_xid | xid | Oldest transaction ID on the node |
| xid_vac_limit | xid | Critical point (transaction ID) that triggers forcible autovacuum |
| oldest_xid_db | oid | OID of the database that has the minimum datafrozenxid on the node |
| last_extend_csn_logpage | xid | Number of the last extended csnlog page |
| start_extend_csn_logpage | xid | Number of the page from which csnlog extending starts |
| next_commit_seqno | xid | CSN generated next time for the node |
| latest_completed_xid | xid | Latest transaction ID on the node after the transaction commission or rollback |
| startup_max_xid | xid | Last transaction ID before the node is powered off |

## 15.3.203 PGXC_WLM_EC_OPERATOR_HISTORY

**PGXC_WLM_EC_OPERATOR_HISTORY** displays operator information of completed Extension Connector jobs executed on all CNs. Only the user with sysadmin permission can query this view. The current feature is a lab feature. Contact Huawei technical support before using it.

Records in the view are cleared every 3 minutes.

For details about the columns, see **15.2.30 GS_WLM_EC_OPERATOR_INFO**.

## 15.3.204 PGXC_WLM_EC_OPERATOR_INFO

**PGXC_WLM_EC_OPERATOR_INFO** displays operator information of completed Extension Connector jobs executed on all CNs. Only the user with sysadmin permission can query this view. The current feature is a lab feature. Contact Huawei technical support before using it.

The data in this view is obtained from **15.2.30 GS_WLM_EC_OPERATOR_INFO**.

For details about the columns, see **15.2.30 GS_WLM_EC_OPERATOR_INFO**.

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## 15.3.205 PGXC_WLM_EC_OPERATOR_STATISTICS

**PGXC_WLM_EC_OPERATOR_STATISTICS** displays operator information about running Extension Connector jobs on all CNs. Only the user with sysadmin permission can query this view. The current feature is a lab feature. Contact Huawei technical support before using it.

For details about the columns, see **15.3.77 GS_WLM_EC_OPERATOR_STATISTICS**.

## 15.3.206 PGXC_WLM_OPERATOR_HISTORY

PGXC_WLM_OPERATOR_HISTORY displays the operator information of completed jobs that are cached in the memory on all CN nodes. Only the sysadmin user can query this view.

The data is periodically dumped to the gs_wlm_operator_info table at an interval of 3 minutes.

For details on columns in the view, see **Table 15-29**.

## 15.3.207 PGXC_WLM_OPERATOR_INFO

**PGXC_WLM_OPERATOR_INFO** displays operator information of completed jobs executed on CNs. Only the sysadmin user can query this view.

The data in this view is obtained from **15.2.32 GS_WLM_OPERATOR_INFO**.

For details on columns in the view, see **Table 15-29**.

## 15.3.208 PGXC_WLM_OPERATOR_STATISTICS

**PGXC_WLM_OPERATOR_STATISTICS** displays operator information about running jobs executed on CNs. Only the user with sysadmin permission can query this view.

For details on columns in the view, see **Table 15-187**.

## 15.3.209 PGXC_WLM_REBUILD_USER_RESPOOL

**PGXC_WLM_REBUILD_USER_RESPOOL** is used to rebuild a user's resource pool information in memory on all nodes, with no output. This view is only used as a remedy when resource pool information is missing or misplaced. Only the sysadmin user can query this view.

## 15.3.210 PGXC_WLM_SESSION_HISTORY

**PGXC_WLM_SESSION_HISTORY** displays load management information for completed jobs executed on all CNs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the user with the **sysadmin** or **monitor admin** permission can query this view.

The data is periodically dumped to the **gs_wlm_session_info** table at an interval of 3 minutes. For details, see **15.3.83 GS_WLM_SESSION_HISTORY**.

For details on columns in the view, see **Table 15-190**.

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## 15.3.211 PGXC_WLM_SESSION_INFO

**PGXC_WLM_SESSION_INFO** displays load management information for completed jobs executed on all CNs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the sysadmin user can query this view.

The data in this view is obtained from **15.2.33 GS_WLM_SESSION_QUERY_INFO_ALL**.

For details on columns in the view, see **Table 15-190**.

## 15.3.212 PGXC_WLM_SESSION_STATISTICS

**PGXC_WLM_SESSION_STATISTICS** displays load management information about running jobs executed on CNs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Only the sysadmin user can query this view.

For details on columns in the view, see **Table 15-193**.

## 15.3.213 PGXC_WLM_WORKLOAD_RECORDS

**PGXC_WLM_WORKLOAD_RECORDS** displays the status of job executed by the current user on CNs. Only the sysadmin user can query this view.

**Table 15-311** PGXC_WLM_WORKLOAD_RECORDS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Name of the CN where a job is executed |
| thread_id | bigint | Process ID of the backend |
| processid | integer | Lightweight process ID of a thread |
| time_stamp | bigint | Time when the statement starts to run |
| username | name | Name of the user logged in to the backend |
| memory | integer | Memory required by the statement |
| active_points | integer | Number of resource points consumed by the statement in a resource pool |
| max_points | integer | Maximum number of resource points in a resource pool |
| priority | integer | Priority of a job. A larger value indicates a higher priority. |
| resource_pool | text | Resource pool to which the job belongs |

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| Name | Type | Description |
| --- | --- | --- |
| status | text | Job execution status. The value must be one of the following:<br>• pending<br>• running<br>• finished<br>• aborted<br>• unknown |
| control_group | text | Cgroups used by the job |
| enqueue | text | Queue that the job is in. The value must be one of the following:<br>• **GLOBAL**: global queue<br>• **RESPOOL**: resource pool queue<br>• **Active**: not in a queue |
| query | text | Statement being executed |
| node_group | text | Node group to which the statement belongs |

## 15.3.214 PLAN_TABLE

**PLAN_TABLE** displays plan information collected by **EXPLAIN PLAN**. Plan information is in a session-level lifecycle. After a session exits, the data will be deleted. Data is isolated between sessions and between users.

**Table 15-312** PLAN_TABLE columns

| Name | Type | Description |
| --- | --- | --- |
| statement_id | character varying(30) | Query tag specified by a user |
| plan_id | bigint | Query ID |
| id | int | ID of each operator in a generated plan |
| operation | character varying(30) | Operation description of an operator in a plan |
| options | character varying(255) | Operation action |
| object_name | name | Object name corresponding to the operation, which is not the object alias used in the query. The object name is defined by users. |

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| Name | Type | Description |
| --- | --- | --- |
| object_type | character varying(30) | Object type |
| object_owner | name | Schema to which the object belongs. It is defined by users. |
| projection | character varying(4000) | Returned column information |
| cost | float8 | Execution cost estimated by the optimizer for an operator |
| cardinality | float8 | Number of rows estimated by the optimizer for an operator |

NOTE

- A valid **object_type** value consists of a relkind type defined in **15.2.46 PG_CLASS** (**TABLE**, **INDEX**, **SEQUENCE**, **VIEW**, **FOREIGN TABLE**, **COMPOSITE TYPE**, or **TOASTVALUE TOAST**) and the rtekind type used in the plan (**SUBQUERY**, **JOIN**, **FUNCTION**, **VALUES**, **CTE**, or **REMOTE_QUERY**).
- For RangeTableEntry (RTE), **object_owner** is the object description used in the plan. Non-user-defined objects do not have **object_owner**.
- Information in the **statement_id**, **object_name**, **object_owner**, and **projection** columns is stored in letter cases specified by users and information in other columns is stored in uppercase.
- **PLAN_TABLE** supports only **SELECT** and **DELETE** and does not support other DML operations.

## 15.3.215 PV_FILE_STAT

**PV_FILE_STAT** records statistics about data file I/O to indicate I/O performance and detect performance problems such as abnormal I/O operations.

**Table 15-313** PV_FILE_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| filenum | oid | File ID |
| dbid | oid | Database ID |
| spcid | oid | Tablespace ID |
| phyrds | bigint | Number of times of reading physical files |
| phywrts | bigint | Number of times of writing into physical files |
| phyblkrd | bigint | Number of times of reading physical file blocks |

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| Name | Type | Description |
| --- | --- | --- |
| phyblkwrt | bigint | Number of times of writing into physical file blocks |
| readtim | bigint | Total duration of reading, in microseconds |
| writetim | bigint | Total duration of writing, in microseconds |
| avgiotim | bigint | Average duration of reading and writing, in microseconds |
| lstiotim | bigint | Duration of the last file reading, in microseconds |
| miniotim | bigint | Minimum duration of reading and writing, in microseconds |
| maxiowtm | bigint | Maximum duration of reading and writing, in microseconds |

## 15.3.216 PV_INSTANCE_TIME

**PV_INSTANCE_TIME** records time consumption information of the current node. The time consumption information is classified into the following types:

- DB_TIME: effective time spent by jobs in multi-core scenarios
- CPU_TIME: CPU time spent
- EXECUTION_TIME: time spent in executors
- PARSE_TIME: time spent in parsing SQL statements
- PLAN_TIME: time spent on generating plans
- REWRITE_TIME: time spent for SQL rewriting
- PL_EXECUTION_TIME: execution time of the PL/pgSQL stored procedure
- PL_COMPILATION_TIME: compilation time of the PL/pgSQL stored procedure
- NET_SEND_TIME: time spent on the network
- DATA_IO_TIME: I/O time spent

**Table 15-314** PV_INSTANCE_TIME columns

| Name | Category | Description |
| --- | --- | --- |
| stat_id | integer | Statistics ID |
| stat_name | text | Type name |
| value | bigint | Time value, in μs |

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## 15.3.217 PV_OS_RUN_INFO

**PV_OS_RUN_INFO** displays the running status of the OS.

**Table 15-315** PV_OS_RUN_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| id | integer | ID |
| name | text | Name of the OS running status |
| value | numeric | Value of the OS running status |
| comments | text | Remarks of the OS running status |
| cumulative | boolean | Whether the value of the OS running status is cumulative |

## 15.3.218 PV_REDO_STAT

**PV_REDO_STAT** displays statistics on the replay of session thread logs.

**Table 15-316** PV_REDO_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| phywrts | bigint | Number of times that data is written during log replay |
| phyblkwrt | bigint | Number of data blocks written during log replay |
| writetim | bigint | Total time required for writing data during log replay |
| avgiotim | bigint | Average time required for writing data during log replay |
| lstiotim | bigint | Time consumed by the last data write operation during log replay |
| miniotim | bigint | Minimum time consumed by a single data write operation during log replay |
| maxiowtm | bigint | Maximum time consumed by a single data write operation during log replay |

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## 15.3.219 PV_SESSION_MEMORY

**PV_SESSION_MEMORY** collects statistics about memory usage at the session level, including all the memory allocated to Postgres and Stream threads on DNs for jobs currently executed by users.

**Table 15-317** PV_SESSION_MEMORY columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Thread start time and ID |
| init_mem | integer | Memory allocated to the currently executed jobs before they enter the executor, in MB |
| used_mem | integer | Memory allocated to the currently executed jobs, in MB |
| peak_mem | integer | Peak memory allocated to the currently executed jobs, in MB |

## 15.3.220 PV_SESSION_MEMORY_CONTEXT

**PV_SESSION_MEMORY_CONTEXT** displays statistics on memory usage of all sessions based on the MemoryContext node. This view is valid only when **enable_thread_pool** is set to **on**.

The memory context **TempSmallContextGroup** collects information about all memory contexts whose value in the **totalsize** column is less than 8192 bytes in the current thread, and the number of the collected memory contexts is recorded in the **usedsize** column. Therefore, the **totalsize** and **freesize** columns for **TempSmallContextGroup** in the view display the corresponding information about all the memory contexts whose value in the **totalsize** column is less than 8192 bytes in the current thread, and the **usedsize** column displays the number of these memory contexts.

**Table 15-318** PV_SESSION_MEMORY_CONTEXT columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Session start time + session ID (character string: *timestamp.sessionid*) |
| threadid | bigint | ID of the thread bound to a session (**-1** if no thread is bound) |
| contextname | text | Name of the memory context |
| level | smallint | Hierarchy of the memory context |
| parent | text | Name of the parent memory context |
| totalsize | bigint | Total size of the memory context, in bytes |

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| Name | Type | Description |
| --- | --- | --- |
| freesize | bigint | Total size of released memory in the current memory context, in bytes |
| usedsize | bigint | Size of used memory in the memory context, in bytes. For **TempSmallContextGroup**, this parameter specifies the number of collected memory contexts. |

## 15.3.221 PV_SESSION_MEMORY_DETAIL

**PV_SESSION_MEMORY_DETAIL** collects statistics about thread memory usage by the memory context. When **enable_thread_pool** is set to **on**, this view contains memory usage of all threads and sessions.

The memory context **TempSmallContextGroup** collects information about all memory contexts whose value in the **totalsize** column is less than 8192 bytes in the current thread, and the number of the collected memory contexts is recorded in the **usedsize** column. Therefore, the **totalsize** and **freesize** columns for **TempSmallContextGroup** in the view display the corresponding information about all the memory contexts whose value in the **totalsize** column is less than 8192 bytes in the current thread, and the **usedsize** column displays the number of these memory contexts.

You can run the **SELECT * FROM pv_session_memctx_detail (***threadid***,'');** statement to record information about all memory contexts of a thread into the *threadid_timestamp***.log** file in the *$GAUSSLOG*/pg_log/${node_name}/dumpmem directory. *threadid* can be obtained from **sessid** in the following table.

**Table 15-319** PV_SESSION_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | 1. When the thread pool is disabled (**enable_thread_pool = off**), this column indicates the thread start time + session ID (string: **timestamp.sessionid**).<br>2. When the thread pool is enabled (**enable_thread_pool = on**): If the memory context is at the thread level, this column indicates the thread start time + thread ID (string: **timestamp.threadid**). If the memory context is at the session level, the column indicates the thread start time + session ID (string: **timestamp.sessionid**). |
| sesstype | text | Thread name |
| contextname | text | Name of the memory context |
| level | smallint | Hierarchy of the memory context |

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| Name | Type | Description |
| --- | --- | --- |
| parent | text | Name of the parent memory context |
| totalsize | bigint | Total size of the memory context, in bytes |
| freesize | bigint | Total size of released memory in the current memory context, in bytes |
| usedsize | bigint | Size of used memory in the memory context, in bytes. For **TempSmallContextGroup**, this parameter specifies the number of collected memory contexts. |

## 15.3.222 PV_SESSION_STAT

**PV_SESSION_STAT** collects statistics about session states based on session threads or the **AutoVacuum** thread.

**Table 15-320** PV_SESSION_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Thread ID and start time |
| statid | integer | Statistics ID |
| statname | text | Name of the statistics session |
| statunit | text | Unit of the statistics session |
| value | bigint | Value of the statistics session |

## 15.3.223 PV_SESSION_TIME

**PV_SESSION_TIME** collects statistics about the running time of session threads and time consumed in each execution phase.

**Table 15-321** PV_SESSION_TIME columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Thread ID and start time |
| stat_id | integer | Statistics ID |

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| Name | Type | Description |
| --- | --- | --- |
| stat_name | text | Name of the session type<br>• **DB_TIME**: effective time spent by jobs in multi-core scenarios<br>• **CPU_TIME**: CPU time spent<br>• **EXECUTION_TIME**: time spent within executors<br>• **PARSE_TIME**: time spent on parsing SQL statements<br>• **PLAN_TIME**: time spent on generating plans<br>• **REWRITE_TIME**: time spent on rewriting SQL statements<br>• **PL_EXECUTION_TIME**: execution time of the PL/pgSQL stored procedure<br>• **PL_COMPILATION_TIME**: compilation time of the PL/pgSQL stored procedure<br>• **NET_SEND_TIME**: time spent on the network.<br>• **DATA_IO_TIME**: I/O time spent |
| value | bigint | Session value |

## 15.3.224 PV_THREAD_MEMORY_CONTEXT

**PV_THREAD_MEMORY_CONTEXT** displays statistics about memory usage of all threads based on MemoryContext nodes. This view is equivalent to the **PV_SESSION_MEMORY_DETAIL** view when **enable_thread_pool** is set to **off**.

The memory context **TempSmallContextGroup** collects information about all memory contexts whose value in the **totalsize** column is less than 8192 bytes in the current thread, and the number of the collected memory contexts is recorded in the **usedsize** column. Therefore, the **totalsize** and **freesize** columns for **TempSmallContextGroup** in the view display the corresponding information about all the memory contexts whose value in the **totalsize** column is less than 8192 bytes in the current thread, and the **usedsize** column displays the number of these memory contexts.

**Table 15-322** PV_THREAD_MEMORY_CONTEXT columns

| Name | Type | Description |
| --- | --- | --- |
| threadid | text | Thread start time + thread ID (string: *timestamp.tsessionid*) |
| tid | bigint | Thread ID |

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| Name | Type | Description |
| --- | --- | --- |
| thrdtype | text | Thread type It can be any thread type in the system, such as postgresql and wlmmonitor. |
| contextname | text | Name of the memory context |
| level | smallint | Hierarchy of the memory context |
| parent | text | Name of the parent memory context |
| totalsize | bigint | Total size of the memory context, in bytes |
| freesize | bigint | Total size of released memory in the current memory context, in bytes |
| usedsize | bigint | Size of used memory in the memory context, in bytes. For **TempSmallContextGroup**, this parameter specifies the number of collected memory contexts. |

## 15.3.225 PV_TOTAL_MEMORY_DETAIL

**PV_TOTAL_MEMORY_DETAIL** collects statistics about memory usage of the current database node.

**Table 15-323** PV_TOTAL_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |

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| Name | Type | Description |
| --- | --- | --- |
| memorytype | text | Memory type. The value must be one of the following:<br>• **max_process_memory**: memory occupied by a GaussDB cluster instance<br>• **process_used_memory**: memory occupied by a GaussDB process<br>• **max_dynamic_memory**: maximum dynamic memory<br>• **dynamic_used_memory**: used dynamic memory<br>• **dynamic_peak_memory**: dynamic memory peak<br>• **dynamic_used_shrctx**: maximum dynamic shared memory context<br>• **dynamic_peak_shrctx**: dynamic peak value of the shared memory context<br>• **max_shared_memory**: maximum shared memory<br>• **shared_used_memory**: used shared memory<br>• **max_cstore_memory**: maximum memory allowed by column-storage<br>• **cstore_used_memory**: memory used in column-storage<br>• **max_sctpcomm_memory**: maximum memory allowed for the communication library<br>• **sctpcomm_used_memory**: memory used by the communication library<br>• **sctpcomm_peak_memory**: memory peak of the communication library<br>• **other_used_memory**: other used memory |
| memorymbytes | integer | Size of allocated memory-typed memory |

## 15.3.226 SYS_DUMMY

**SYS_DUMMY** is automatically created by the database based on the data dictionary. It has only one text column in only one row for storing expression calculation results. It is accessible to all users. This view exists in both PG_CATALOG and SYS schema.

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**Table 15-324** SYS_DUMMY columns

| Name | Type | Description |
| --- | --- | --- |
| DUMMY | text | Expression calculation result |

# 16 Schemas

The following table describes the schemas supported in GaussDB.

**Table 16-1** Schemas supported in GaussDB

| Schema | Description |
| --- | --- |
| blockchain | Stores the user history table that is automatically created when a tamper-proof table is created in the ledger database. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| cstore | Stores auxiliary tables related to column-store tables, such as CUDesc and Delta tables. |
| dbe_perf | Diagnoses performance issues and is also the data source of WDR snapshots. After a database is installed, only the initial user and monitoring administrator have permission to view views and functions in the **DBE_PERF** scheme by default. |
| snapshot | Manages data related to WDR snapshots. By default, the initial user or monitoring administrator can access the data. |
| sqladvsior | Recommends distribution columns. For details, see **12.5.33 Distribution Column Recommendation Functions**. |
| sys | Provides the system information view APIs. |
| pg_catalog | Maintains system catalog information, including system catalogs and all built-in data types, functions, and operators. |
| pg_toast | Stores large objects (for internal use). |
| public | Public schema. By default, created tables (and other objects) are automatically put into this schema. |
| pkg_service | Manages information about the package service. |
| pkg_util | Manages information about the package tool. |

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| Schema | Description |
| --- | --- |
| dbe_raw | Advanced function package dbe_raw, which is used to convert raw data, obtain substrings, and calculate the length. |
| dbe_session | Advanced function package **dbe_session**, which is used to set the value of a specified attribute and support user query and verification. |
| dbe_lob | Advanced function package **dbe_lob**, which is used to read, write, and copy large files (CLOB/BLOB). |
| dbe_match | Advanced function package **dbe_match**, which is used to compare character string similarity. |
| dbe_task | Advanced function package **dbe_task**, which is used to schedule job tasks, including submitting tasks, canceling tasks, synchronizing task status, and updating task information, so that the database can periodically execute specific tasks. |
| dbe_sql | Advanced function package **dbe_sql**, which is used to execute dynamic SQL statements and construct query and other commands during application running. |
| dbe_file | Advanced function package **dbe_file**, which is used to read, copy, write, delete, and rename external database files. |
| dbe_output | Advanced function package **dbe_output**, which is used to print output information. |
| dbe_random | Advanced function package **dbe_random**, which is used to generate random seeds and random numbers. |
| dbe_application_info | Advanced function package **dbe_application_info**, which is used for recording client information. |
| dbe_utility | Advanced function package **dbe_utility**, which is used to invoke the debugging tool in a stored procedure, for example, to print error stacks. |
| dbe_scheduler | Advanced function package **dbe_scheduler**, which is used to create scheduled tasks and enable the database to periodically execute specified tasks through programs and schedules. You can also perform external database tasks by authorizing and providing certificates. |
| information_schema | Stores information about objects defined in the current database. |

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**Table 16-2** Schemas disabled in GaussDB

| Schema | Description |
| --- | --- |
| dbe_pldebugger | This view is used to debug plpgsql functions and stored procedures. Currently, this view is not supported. An error message "unsupported" is displayed when the interface is invoked in this view. |
| db4ai | Manages data of different versions in AI training. |
| dbe_pldeveloper | Compiles and debugs user stored procedures. |
| dbe_sql_util | Manages statement patches. |

The following APIs are not supported in distributed deployment mode:

- bool dbe_sql_util.create_hint_sql_patch(name, bigint, text, text DEFAULT NULL::text, boolean DEFAULT true)
- bool dbe_sql_util.create_abort_sql_patch(name, bigint, text DEFAULT NULL::text, boolean DEFAULT true)
- bool dbe_sql_util.drop_sql_patch(name)
- bool dbe_sql_util.enable_sql_patch(name)
- bool dbe_sql_util.disable_sql_patch(name)
- record dbe_sql_util.show_sql_patch(patch_name name, OUT unique_sql_id bigint, OUT enable boolean, OUT abort boolean, OUT hint_str text)

# 16.1 Information Schema

An information schema named **INFORMATION_SCHEMA** automatically exists in all databases. An information schema consists of a group of views that contain information about objects defined in the current database. The owner of this schema is the initial database user. However, all users have only the permission to use this schema and do not have the permission to create objects such as tables and functions.

Information schemas are inherited from the open-source PGXC and PG. For details, visit the following links to see the official PGXC and PG documents:

http://postgres-xc.sourceforge.net/docs/1_1/information-schema.html

https://www.postgresql.org/docs/9.2/information-schema.html

The preceding links describe details about constraint_table_usage, domain_constraints, domain_udt_usage, domains, enabled_roles, key_column_usage, parameters, referential_constraints, applicable_roles, administrable_role_authorizations, attributes, character_sets, check_constraint_routine_usage, check_constraints, collations, collation_character_set_applicability, column_domain_usage, column_privileges, column_udt_usage, columns, constraint_column_usage, role_column_grants, routine_privileges, role_routine_grants, routines, schemata, sequences,

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table_constraints, table_privileges, role_table_grants, tables, triggered_update_columns, triggers, udt_privileges, role_udt_grants, usage_privileges, role_usage_grants, user_defined_types, view_column_usage, view_routine_usage, view_table_usage, views, data_type_privileges, element_types, column_options, foreign_data_wrapper_options, foreign_data_wrappers, foreign_server_options, foreign_servers, foreign_table_options, foreign_tables, user_mapping_options, user_mappings, sql_features, sql_implementation_info, sql_languages, sql_packages, sql_parts, sql_sizing, and sql_sizing_profiles.

The following sections display only the views that are not listed in the preceding links.

## 16.1.1 _PG_FOREIGN_DATA_WRAPPERS

**_PG_FOREIGN_DATA_WRAPPERS** displays information about a foreign-data wrapper. Only the sysadmin user has the permission to view this view.

**Table 16-3** _PG_FOREIGN_DATA_WRAPPERS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | OID of the foreign-data wrapper |
| fdwowner | oid | OID of the owner of the foreign-data wrapper |
| fdwoptions | text[] | Foreign-data wrapper specific option, expressed in a string in the format of *keyword*=*value* |
| foreign_data_wrapper_catalog | information_schema.sql_identifier | Name of the database where the foreign-data wrapper is located (always the current database) |
| foreign_data_wrapper_name | information_schema.sql_identifier | Name of the foreign-data wrapper |
| authorization_identifier | information_schema.sql_identifier | Role of the owner of the foreign-data wrapper |
| foreign_data_wrapper_language | information_schema.character_data | Programming language of the foreign-data wrapper |

## 16.1.2 _PG_FOREIGN_SERVERS

**_PG_FOREIGN_SERVERS** displays information about a foreign server. Only the sysadmin user has the permission to view this view.

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**Table 16-4** _PG_FOREIGN_SERVERS columns

| Name | Type | Description |
| --- | --- | --- |
| oid | oid | OID of the foreign server |
| srvoptions | text[] | Foreign server specific options, expressed in a string in the format of *keyword=value* |
| foreign_server_catalog | information_schema.sql_identifier | Name of the database where the foreign server is located (always the current database) |
| foreign_server_name | information_schema.sql_identifier | Name of the foreign server |
| foreign_data_wrapper_catalog | information_schema.sql_identifier | Name of the database where the foreign-data wrapper is located (always the current database) |
| foreign_data_wrapper_name | information_schema.sql_identifier | Name of the foreign-data wrapper |
| foreign_server_type | information_schema.character_data | Type of the foreign server |
| foreign_server_version | information_schema.character_data | Version of the foreign server |
| authorization_identifier | information_schema.sql_identifier | Role of the owner of the foreign server |

## 16.1.3 _PG_FOREIGN_TABLE_COLUMNS

**_PG_FOREIGN_TABLE_COLUMNS** displays column information about a foreign table. Only the sysadmin user has the permission to view this view.

**Table 16-5** _PG_FOREIGN_TABLE_COLUMNS columns

| Name | Type | Description |
| --- | --- | --- |
| nspname | name | Schema name |
| relname | name | Table name |
| attname | name | Column name |

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| | | |
|---|---|---|
| attfdwoptions | text[] | Attribute-level foreign data wrapper options, expressed in a string in the format of *keyword=value* |

## 16.1.4 _PG_FOREIGN_TABLES

**_PG_FOREIGN_TABLES** stores information about all foreign tables defined in the current database, whereas displays information about foreign tables accessible to the current user. Only the sysadmin user has the permission to view this view.

**Table 16-6** _PG_FOREIGN_TABLES columns

| Name | Type | Description |
|---|---|---|
| foreign_table_catalog | information_schema.sql_identifier | Name of the database where the foreign table is located (always the current database) |
| foreign_table_schema | name | Name of the schema that the foreign table is in |
| foreign_table_name | name | Name of the foreign table |
| ftoptions | text[] | Foreign table options |
| foreign_server_catalog | information_schema.sql_identifier | Name of the database where the foreign server is located (always the current database) |
| foreign_server_name | information_schema.sql_identifier | Name of the foreign server |
| authorization_identifier | information_schema.sql_identifier | Role of the owner |

## 16.1.5 _PG_USER_MAPPINGS

**_PG_USER_MAPPINGS** stores mappings from local users to remote users. Only the sysadmin user has the permission to view this view.

**Table 16-7** _PG_USER_MAPPINGS columns

| Name | Type | Description |
|---|---|---|
| oid | oid | OID of the mapping from the local user to a remote user |

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| | | |
|---|---|---|
| umoptions | text[] | User mapping specific options, expressed in a string in the format of *keyword=value* |
| umuser | oid | OID of the local user being mapped (**0** if the user mapping is public) |
| authorization_identifier | information_schema.sql_identifier | Role of the local user |
| foreign_server_catalog | information_schema.sql_identifier | Name of the database where the foreign server is defined in |
| foreign_server_name | information_schema.sql_identifier | Name of the foreign server |
| srvowner | information_schema.sql_identifier | Owner of the foreign server |

## 16.1.6 INFORMATION_SCHEMA_CATALOG_NAME

**INFORMATION_SCHEMA_CATALOG_NAME** displays the name of the current database.

**Table 16-8** INFORMATION_SCHEMA_CATALOG_NAME columns

| Name | Type | Description |
|---|---|---|
| catalog_name | information_schema.sql_identifier | Current database name |

# 16.2 DBE_PERF Schema

In the **DBE_PERF** schema, views are used to diagnose performance issues and are also the data source of WDR snapshots. After a database is installed, only the initial user and monitoring administrator have permission to view views and functions in the **DBE_PERF** scheme by default. If the database is upgraded from an earlier version, permissions for the **DBE_PERF** schema are the same as those of the earlier version to ensure forward compatibility. Organization views are divided based on multiple dimensions, such as OS, instance, and memory. These views comply with the following naming rules:

- A view starting with **GLOBAL_** requests data from CNs and DNs and returns the data without processing the data.
- A view starting with **SUMMARY_** summarizes data in cluster. In most cases, data from CNs and DNs (sometimes only CNs) is processed, aggregated, and returned.

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- A view that does not start with **GLOBAL_** or **SUMMARY_** is a local view and does not request data from other CNs or DNs.

# 16.2.1 OS

## 16.2.1.1 OS_RUNTIME

**OS_RUNTIME** displays the running status of the current OS.

**Table 16-9** OS_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| id | integer | ID |
| name | text | Name of the OS running status |
| value | numeric | Value of the OS running status |
| comments | text | Remarks of the OS running status |
| cumulative | boolean | Whether the value of the OS running status is cumulative |

## 16.2.1.2 GLOBAL_OS_RUNTIME

**GLOBAL_OS_RUNTIME** records the OS running status information on all normal nodes in the cluster.

**Table 16-10** GLOBAL_OS_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| id | integer | ID |
| name | text | Name of the OS running status |
| value | numeric | Value of the OS running status |
| comments | text | Remarks of the OS running status |
| cumulative | boolean | Whether the value of the OS running status is cumulative |

## 16.2.1.3 OS_THREADS

**OS_THREADS** provides status information about all threads on the current node.

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**Table 16-11** OS_THREADS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name |
| pid | bigint | ID of the thread running within the current node process |
| lwpid | integer | Lightweight thread ID corresponding to **pid** |
| thread_name | text | Name of the thread corresponding to **pid** |
| creation_time | timestamp with time zone | Creation time of the thread corresponding to **pid** |

#### 16.2.1.4 GLOBAL_OS_THREADS

**GLOBAL_OS_THREADS** records the thread status information on all normal nodes in the cluster.

**Table 16-12** GLOBAL_OS_THREADS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name |
| pid | bigint | ID of the thread running within the current node process |
| lwpid | integer | Lightweight thread ID corresponding to **pid** |
| thread_name | text | Name of the thread corresponding to **pid** |
| creation_time | timestamp with time zone | Creation time of the thread corresponding to **pid** |

### 16.2.2 Instance

#### 16.2.2.1 INSTANCE_TIME

**INSTANCE_TIME** records the time consumption information on the current node. The information is classified into the following types:

- DB_TIME: effective time spent by jobs in multi-core scenarios
- CPU_TIME: CPU time spent
- EXECUTION_TIME: time spent within executors

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- PARSE_TIME: time spent on parsing SQL statements
- PLAN_TIME: time spent on generating plans
- REWRITE_TIME: time spent on rewriting SQL statements
- PL_EXECUTION_TIME: execution time of the PL/pgSQL stored procedure
- PL_COMPILATION_TIME: compilation time of the PL/pgSQL stored procedure
- NET_SEND_TIME: time spent on the network
- DATA_IO_TIME: I/O time spent

**Table 16-13** INSTANCE_TIME columns

| Name | Type | Description |
| --- | --- | --- |
| stat_id | integer | Statistics ID |
| stat_name | text | Type name |
| value | bigint | Time value (unit: μs) |

#### 16.2.2.2 GLOBAL_INSTANCE_TIME

**GLOBAL_INSTANCE_TIME** records the time consumption information on all normal nodes in the cluster. For details about the time types, see the **INSTANCE_TIME** view.

**Table 16-14** GLOBAL_INSTANCE_TIME columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| stat_id | integer | Statistics ID |
| stat_name | text | Type name |
| value | bigint | Time value (unit: μs) |

### 16.2.3 Memory

#### 16.2.3.1 MEMORY_NODE_DETAIL

**MEMORY_NODE_DETAIL** displays memory usage of a node in the database.

**Table 16-15** MEMORY_NODE_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |

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| Name | Type | Description |
| --- | --- | --- |
| memorytype | text | Memory name |
| memorymbytes | integer | Size of the used memory (unit: MB) |

### 16.2.3.2 GLOBAL_MEMORY_NODE_DETAIL

**GLOBAL_MEMORY_NODE_DETAIL** displays the memory usage on all normal nodes in the cluster.

**Table 16-16** GLOBAL_MEMORY_NODE_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |

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| Name | Type | Description |
| --- | --- | --- |
| memorytype | text | Memory name<br>• **max_process_memory**: memory occupied by a cluster instance<br>• **process_used_memory**: memory occupied by a process<br>• **max_dynamic_memory**: maximum dynamic memory<br>• **dynamic_used_memory**: used dynamic memory<br>• **dynamic_peak_memory**: dynamic peak memory<br>• **dynamic_used_shrctx**: maximum dynamic shared memory context<br>• **dynamic_peak_shrctx**: dynamic peak value of the shared memory context<br>• **max_shared_memory**: maximum shared memory<br>• **shared_used_memory**: used shared memory<br>• **max_cstore_memory**: maximum memory allowed by column-storage<br>• **cstore_used_memory**: memory used in column-storage<br>• **max_sctpcomm_memory**: maximum memory allowed for TCP proxy communication<br>• **sctpcomm_used_memory**: used memory for TCP proxy communication<br>• **sctpcomm_peak_memory**: peak memory of TCP proxy communication<br>• **other_used_memory**: other used memory<br>• **gpu_max_dynamic_memory**: maximum dynamic GPU memory<br>• **gpu_dynamic_used_memory**: used dynamic GPU memory<br>• **gpu_dynamic_peak_memory**: dynamic peak GPU memory<br>• **pooler_conn_memory**: applied memory in the connection pool<br>• **pooler_freeconn_memory**: memory occupied by idle connections in the connection pool<br>• **storage_compress_memory**: memory used by the storage module for compression<br>• **udf_reserved_memory**: reserved memory for the UDF |
| memorymbytes | integer | Size of the used memory (unit: MB) |

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### 16.2.3.3 MEMORY_NODE_NG_DETAIL

**MEMORY_NODE_NG_DETAIL** displays memory usage of a node group.

**Table 16-17** MEMORY_NODE_NG_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| ngname | text | Node group name |
| memorytype | text | Memory name<br>• **ng_total_memory**: total memory configured in the node group<br>• **ng_used_memory**: used memory<br>• **ng_estimate_memory**: memory used by the optimizer for evaluation<br>• **ng_foreignrp_memsize**: memory configured in the foreign resource pool<br>• **ng_foreignrp_usedsize**: memory used by the foreign resource pool<br>• **ng_foreignrp_peaksize**: peak memory used by the foreign resource pool<br>• **ng_foreignrp_mempct**: percentage of the system memory configured in attributes of the foreign resource pool<br>• **ng_foreignrp_estmsize**: memory used by the optimizer for job evaluation in the foreign resource pool |
| memorymbytes | integer | Size of the used memory (unit: MB) |

### 16.2.3.4 SHARED_MEMORY_DETAIL

**SHARED_MEMORY_DETAIL** displays the usage information about shared memory contexts on the current node.

**Table 16-18** SHARED_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| contextname | text | Name of the memory context |
| level | smallint | Level of the memory context |
| parent | text | Name of the parent memory context |

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| Name | Type | Description |
| --- | --- | --- |
| totalsize | bigint | Total size of the shared memory (unit: byte) |
| freesize | bigint | Remaining size of the shared memory (unit: byte) |
| usedsize | bigint | Used size of the shared memory (unit: byte) |

### 16.2.3.5 GLOBAL_SHARED_MEMORY_DETAIL

**GLOBAL_SHARED_MEMORY_DETAIL** displays the usage information about shared memory contexts on all normal nodes in the cluster.

**Table 16-19** GLOBAL_SHARED_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| contextname | text | Name of the memory context |
| level | smallint | Level of the memory context |
| parent | text | Name of the parent memory context |
| totalsize | bigint | Total size of the shared memory (unit: byte) |
| freesize | bigint | Remaining size of the shared memory (unit: byte) |
| usedsize | bigint | Used size of the shared memory (unit: byte) |

### 16.2.3.6 TRACK_MEMORY_CONTEXT_DETAIL

**TRACK_MEMORY_CONTEXT_DETAIL** queries the detailed memory application information about the memory context set by **DBE_PERF.track_memory_context**. Only the initial user or a user with the **monadmin** permission can execute this function.

**Table 16-20** TRACK_MEMORY_CONTEXT_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| context_name | text | Name of the memory context |

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| Name | Type | Description |
| --- | --- | --- |
| file | text | File to which the memory application location belongs |
| line | integer | Line number of the memory application location |
| size | bigint | Total size of memory that is applied for (unit: byte) |

## 16.2.4 File

### 16.2.4.1 FILE_IOSTAT

**FILE_IOSTAT** records statistics about data file I/Os to indicate I/O performance and detect performance problems such as abnormal I/O operations.

**Table 16-21** FILE_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| filenum | oid | File identifier |
| dbid | oid | Database ID |
| spcid | oid | Tablespace ID |
| phyrds | bigint | Number of times of reading physical files |
| phywrts | bigint | Number of times of writing into physical files |
| phyblkrd | bigint | Number of times of reading physical file blocks |
| phyblkwrt | bigint | Number of times of writing into physical file blocks |
| readtim | bigint | Total duration of reading (unit: μs) |
| writetim | bigint | Total duration of writing (unit: μs) |
| avgiotim | bigint | Average duration of reading and writing (unit: μs) |
| lstiotim | bigint | Duration of the last file reading (unit: μs) |
| miniotim | bigint | Minimum duration of reading and writing (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| maxiowtm | bigint | Maximum duration of reading and writing (unit: μs) |

## 16.2.4.2 SUMMARY_FILE_IOSTAT

**SUMMARY_FILE_IOSTAT** records statistics about data file I/Os in the cluster to reflect performance issues such as exceptions in I/O operations.

**Table 16-22** SUMMARY_FILE_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| filenum | oid | File identifier |
| dbid | oid | Database ID |
| spcid | oid | Tablespace ID |
| phyrds | numeric | Number of times of reading physical files |
| phywrts | numeric | Number of times of writing into physical files |
| phyblkrd | numeric | Number of times of reading physical file blocks |
| phyblkwrt | numeric | Number of times of writing into physical file blocks |
| readtim | numeric | Total duration of reading (unit: μs) |
| writetim | numeric | Total duration of writing (unit: μs) |
| avgiotim | bigint | Average duration of reading and writing (unit: μs) |
| lstiotim | bigint | Duration of the last file reading (unit: μs) |
| miniotim | bigint | Minimum duration of reading and writing (unit: μs) |
| maxiowtm | bigint | Maximum duration of reading and writing (unit: μs) |

## 16.2.4.3 GLOBAL_FILE_IOSTAT

**GLOBAL_FILE_IOSTAT** displays statistics about data file I/Os on all nodes.

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**Table 16-23** GLOBAL_FILE_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| filenum | oid | File identifier |
| dbid | oid | Database ID |
| spcid | oid | Tablespace ID |
| phyrds | bigint | Number of times of reading physical files |
| phywrts | bigint | Number of times of writing into physical files |
| phyblkrd | bigint | Number of times of reading physical file blocks |
| phyblkwrt | bigint | Number of times of writing into physical file blocks |
| readtim | bigint | Total duration of reading (unit: μs) |
| writetim | bigint | Total duration of writing (unit: μs) |
| avgiotim | bigint | Average duration of reading and writing (unit: μs) |
| lstiotim | bigint | Duration of the last file reading (unit: μs) |
| miniotim | bigint | Minimum duration of reading and writing (unit: μs) |
| maxiowtm | bigint | Maximum duration of reading and writing (unit: μs) |

### 16.2.4.4 FILE_REDO_IOSTAT

**FILE_REDO_IOSTAT** records statistics about redo logs (WALs) on the current node.

**Table 16-24** FILE_REDO_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| phywrts | bigint | Number of times writing into the WAL buffer |
| phyblkwrt | bigint | Number of blocks written into the WAL buffer |
| writetim | bigint | Duration of writing into XLOG files (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| avgiotim | bigint | Average duration of writing into XLOG files (unit: μs). **avgiotim** = **writetim**/**phywrts** |
| lstiotim | bigint | Duration of the last writing into XLOG files (unit: μs) |
| miniotim | bigint | Minimum duration of writing into XLOG files (unit: μs) |
| maxiowtm | bigint | Maximum duration of writing into XLOG files (unit: μs) |

### 16.2.4.5 SUMMARY_FILE_REDO_IOSTAT

**SUMMARY_FILE_REDO_IOSTAT** displays statistics about redo logs (WALs) in the cluster.

**Table 16-25** SUMMARY_FILE_REDO_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| phywrts | numeric | Number of times writing into the WAL buffer |
| phyblkwrt | numeric | Number of blocks written into the WAL buffer |
| writetim | numeric | Duration of writing into XLOG files (unit: μs) |
| avgiotim | bigint | Average duration of writing into XLOG files (unit: μs). **avgiotim** = **writetim**/**phywrts** |
| lstiotim | bigint | Duration of the last writing into XLOG files (unit: μs) |
| miniotim | bigint | Minimum duration of writing into XLOG files (unit: μs) |
| maxiowtm | bigint | Maximum duration of writing into XLOG files (unit: μs) |

### 16.2.4.6 GLOBAL_FILE_REDO_IOSTAT

**GLOBAL_FILE_REDO_IOSTAT** displays statistics about redo logs (WALs) on nodes in the cluster.

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**Table 16-26** GLOBAL_FILE_REDO_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| phywrts | bigint | Number of times writing into the WAL buffer |
| phyblkwrt | bigint | Number of blocks written into the WAL buffer |
| writetim | bigint | Duration of writing into XLOG files (unit: μs) |
| avgiotim | bigint | Average duration of writing into XLOG files (unit: μs). **avgiotim** = **writetim**/ **phywrts** |
| lstiotim | bigint | Duration of the last writing into XLOG files (unit: μs) |
| miniotim | bigint | Minimum duration of writing into XLOG files (unit: μs) |
| maxiowtm | bigint | Maximum duration of writing into XLOG files (unit: μs) |

## 16.2.4.7 LOCAL_REL_IOSTAT

**LOCAL_REL_IOSTAT** displays the accumulated I/O status of all data files on the current node.

**Table 16-27** LOCAL_REL_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| phyrds | bigint | Number of times of reading physical files |
| phywrts | bigint | Number of times of writing into physical files |
| phyblkrd | bigint | Number of times of reading physical file blocks |
| phyblkwrt | bigint | Number of times of writing into physical file blocks |

## 16.2.4.8 GLOBAL_REL_IOSTAT

**GLOBAL_REL_IOSTAT** displays statistics about data file I/Os on all nodes.

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**Table 16-28** GLOBAL_REL_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| phyrds | bigint | Number of times of reading physical files |
| phywrts | bigint | Number of times of writing into physical files |
| phyblkrd | bigint | Number of times of reading physical file blocks |
| phyblkwrt | bigint | Number of times of writing into physical file blocks |

### 16.2.4.9 SUMMARY_REL_IOSTAT

**SUMMARY_REL_IOSTAT** displays statistics about data file I/Os on all nodes.

**Table 16-29** SUMMARY_REL_IOSTAT columns

| Name | Type | Description |
| --- | --- | --- |
| phyrds | numeric | Number of times of reading physical files |
| phywrts | numeric | Number of times of writing into physical files |
| phyblkrd | numeric | Number of times of reading physical file blocks |
| phyblkwrt | numeric | Number of times of writing into physical file blocks |

## 16.2.5 Object

### 16.2.5.1 STAT_USER_TABLES

**STAT_USER_TABLES** displays the status information about user-defined ordinary tables in all namespaces on the current node.

**Table 16-30** STAT_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |

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| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |
| vacuum_count | bigint | Number of times this table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | bigint | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times this table has been manually analyzed |

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| Name | Type | Description |
| --- | --- | --- |
| autoanalyze_count | bigint | Number of times this table has been analyzed by the autovacuum daemon |

### 16.2.5.2 SUMMARY_STAT_USER_TABLES

**SUMMARY_STAT_USER_TABLES** displays the status information about user-defined ordinary tables in all namespaces in the cluster.

**Table 16-31** SUMMARY_STAT_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | numeric | Number of sequential scans initiated on the table |
| seq_tup_read | numeric | Number of live rows fetched by sequential scans |
| idx_scan | numeric | Number of index scans initiated on the table |
| idx_tup_fetch | numeric | Number of live rows fetched by index scans |
| n_tup_ins | numeric | Number of rows inserted |
| n_tup_upd | numeric | Number of rows updated |
| n_tup_del | numeric | Number of rows deleted |
| n_tup_hot_upd | numeric | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | numeric | Estimated number of live rows |
| n_dead_tup | numeric | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |

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| Name | Type | Description |
| --- | --- | --- |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |
| vacuum_count | numeric | Number of times this table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | numeric | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | numeric | Number of times this table has been manually analyzed |
| autoanalyze_count | numeric | Number of times this table has been analyzed by the autovacuum daemon |

### 16.2.5.3 GLOBAL_STAT_USER_TABLES

**GLOBAL_STAT_USER_TABLES** displays the status information about user-defined ordinary tables in all namespaces on each node.

**Table 16-32** GLOBAL_STAT_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |

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| Name | Type | Description |
| --- | --- | --- |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting VACUUM FULL) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |
| vacuum_count | bigint | Number of times this table has been manually vacuumed (not counting VACUUM FULL) |
| autovacuum_count | bigint | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times this table has been manually analyzed |
| autoanalyze_count | bigint | Number of times this table has been analyzed by the autovacuum daemon |

## 16.2.5.4 STAT_USER_INDEXES

**STAT_USER_INDEXES** displays the index status information about user-defined ordinary tables in the current database.

**Table 16-33** STAT_USER_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |

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| Name | Type | Description |
| --- | --- | --- |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

### 16.2.5.5 SUMMARY_STAT_USER_INDEXES

**SUMMARY_STAT_USER_INDEXES** displays the index status information about user-defined ordinary tables in all databases in the cluster.

**Table 16-34** SUMMARY_STAT_USER_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | numeric | Number of index scans initiated on the index |
| idx_tup_read | numeric | Number of index entries returned by scans on the index |
| idx_tup_fetch | numeric | Number of live table rows fetched by simple index scans using the index |

### 16.2.5.6 GLOBAL_STAT_USER_INDEXES

**GLOBAL_STAT_USER_INDEXES** displays the index status information about user-defined ordinary tables on each node.

**Table 16-35** GLOBAL_STAT_USER_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the table that the index is created for |

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| Name | Type | Description |
| --- | --- | --- |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

### 16.2.5.7 STAT_SYS_TABLES

**STAT_SYS_TABLES** displays statistics about all the system catalogs in the **pg_catalog**, **information_schema**, and **pg_toast** schemas on a single node.

**Table 16-36** STAT_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

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| Name | Type | Description |
| --- | --- | --- |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |
| vacuum_count | bigint | Number of times this table has been manually vacuumed (not counting VACUUM FULL) |
| autovacuum_count | bigint | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times this table has been manually analyzed |
| autoanalyze_count | bigint | Number of times this table has been analyzed by the autovacuum daemon |

## 16.2.5.8 SUMMARY_STAT_SYS_TABLES

**SUMMARY_STAT_SYS_INDEXES** displays statistics about all system catalogs in the **pg_catalog**, **information_schema**, and **pg_toast** schemas in the cluster.

**Table 16-37** SUMMARY_STAT_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | numeric | Number of sequential scans initiated on the table |
| seq_tup_read | numeric | Number of live rows fetched by sequential scans |

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| Name | Type | Description |
| --- | --- | --- |
| idx_scan | numeric | Number of index scans initiated on the table |
| idx_tup_fetch | numeric | Number of live rows fetched by index scans |
| n_tup_ins | numeric | Number of rows inserted |
| n_tup_upd | numeric | Number of rows updated |
| n_tup_del | numeric | Number of rows deleted |
| n_tup_hot_upd | numeric | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | numeric | Estimated number of live rows |
| n_dead_tup | numeric | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |
| vacuum_count | numeric | Number of times this table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | numeric | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | numeric | Number of times this table has been manually analyzed |
| autoanalyze_count | numeric | Number of times this table has been analyzed by the autovacuum daemon |

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## 16.2.5.9 GLOBAL_STAT_SYS_TABLES

**GLOBAL_STAT_SYS_TABLES** displays statistics about all the system catalogs in the **pg_catalog**, **information_schema**, and **pg_toast** schemas on each node in the cluster.

**Table 16-38** GLOBAL_STAT_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |

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| Name | Type | Description |
| --- | --- | --- |
| vacuum_count | bigint | Number of times this table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | bigint | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times this table has been manually analyzed |
| autoanalyze_count | bigint | Number of times this table has been analyzed by the autovacuum daemon |

## 16.2.5.10 STAT_SYS_INDEXES

**STAT_SYS_INDEXES** displays the index status information about all system catalogs in the **pg_catalog**, **information_schema**, and **pg_toast** schemas.

**Table 16-39** STAT_SYS_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

## 16.2.5.11 SUMMARY_STAT_SYS_INDEXES

**SUMMARY_STAT_SYS_INDEXES** displays the index status information about all system catalogs in the **pg_catalog**, **information_schema**, and **pg_toast** schemas in the cluster.

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**Table 16-40** SUMMARY_STAT_SYS_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | numeric | Number of index scans initiated on the index |
| idx_tup_read | numeric | Number of index entries returned by scans on the index |
| idx_tup_fetch | numeric | Number of live table rows fetched by simple index scans using the index |

## 16.2.5.12 GLOBAL_STAT_SYS_INDEXES

**GLOBAL_STAT_SYS_INDEXES** displays the index status information about all system catalogs in the **pg_catalog**, **information_schema**, and **pg_toast** schemas on each node.

**Table 16-41** GLOBAL_STAT_SYS_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the table for this index |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

## 16.2.5.13 STAT_ALL_TABLES

**STAT_ALL_TABLES** displays statistics about one row for each table (including TOAST tables) in databases on the current node.

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**Table 16-42** STAT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |
| vacuum_count | bigint | Number of times this table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | bigint | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times this table has been manually analyzed |

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| Name | Type | Description |
| --- | --- | --- |
| autoanalyze_count | bigint | Number of times this table has been analyzed by the autovacuum daemon |

## 16.2.5.14 SUMMARY_STAT_ALL_TABLES

SUMMARY_STAT_ALL_TABLES displays statistics about a row in each table (including the TOAST table) in databases in the cluster.

**Table 16-43** SUMMARY_STAT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | numeric | Number of sequential scans initiated on the table |
| seq_tup_read | numeric | Number of live rows fetched by sequential scans |
| idx_scan | numeric | Number of index scans initiated on the table |
| idx_tup_fetch | numeric | Number of live rows fetched by index scans |
| n_tup_ins | numeric | Number of rows inserted |
| n_tup_upd | numeric | Number of rows updated |
| n_tup_del | numeric | Number of rows deleted |
| n_tup_hot_upd | numeric | Number of rows HOT updated (with no separate index update required) |
| n_live_tup | numeric | Estimated number of live rows |
| n_dead_tup | numeric | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |

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| Name | Type | Description |
| --- | --- | --- |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |
| vacuum_count | numeric | Number of times this table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | numeric | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | numeric | Number of times this table has been manually analyzed |
| autoanalyze_count | numeric | Number of times this table has been analyzed by the autovacuum daemon |

## 16.2.5.15 GLOBAL_STAT_ALL_TABLES

**GLOBAL_STAT_ALL_TABLES** displays statistics about a row of each table (including TOAST tables) on each node.

**Table 16-44** GLOBAL_STAT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

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| Name | Type | Description |
| --- | --- | --- |
| n_live_tup | bigint | Estimated number of live rows |
| n_dead_tup | bigint | Estimated number of dead rows |
| last_vacuum | timestamp with time zone | Last time at which this table was manually vacuumed (not counting **VACUUM FULL**) |
| last_autovacuum | timestamp with time zone | Last time at which this table was vacuumed by the autovacuum daemon |
| last_analyze | timestamp with time zone | Last time at which this table was manually analyzed |
| last_autoanalyze | timestamp with time zone | Last time at which this table was analyzed by the autovacuum daemon |
| vacuum_count | bigint | Number of times this table has been manually vacuumed (not counting **VACUUM FULL**) |
| autovacuum_count | bigint | Number of times this table has been vacuumed by the autovacuum daemon |
| analyze_count | bigint | Number of times this table has been manually analyzed |
| autoanalyze_count | bigint | Number of times this table has been analyzed by the autovacuum daemon |

## 16.2.5.16 STAT_ALL_INDEXES

**STAT_ALL_INDEXES** displays the access information of each index on the current node.

**Table 16-45** STAT_ALL_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |

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| Name | Type | Description |
| --- | --- | --- |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

## 16.2.5.17 SUMMARY_STAT_ALL_INDEXES

**SUMMARY_STAT_ALL_INDEXES** displays the access information of each index in the cluster.

**Table 16-46** SUMMARY_STAT_ALL_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |
| indexrelname | name | Index name |
| idx_scan | numeric | Number of index scans initiated on the index |
| idx_tup_read | numeric | Number of index entries returned by scans on the index |
| idx_tup_fetch | numeric | Number of live table rows fetched by simple index scans using the index |

## 16.2.5.18 GLOBAL_STAT_ALL_INDEXES

**GLOBAL_STAT_ALL_INDEXES** displays the access information of each index on each node in the cluster.

**Table 16-47** GLOBAL_STAT_ALL_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table for the index |

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| Name | Type | Description |
| --- | --- | --- |
| indexrelname | name | Index name |
| idx_scan | bigint | Number of index scans initiated on the index |
| idx_tup_read | bigint | Number of index entries returned by scans on the index |
| idx_tup_fetch | bigint | Number of live table rows fetched by simple index scans using the index |

### 16.2.5.19 STAT_DATABASE

**STAT_DATABASE** contains statistics about each database on the current node.

**Table 16-48** STAT_DATABASE columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database |
| datname | name | Name of the database |
| numbackends | integer | Number of backends currently connected to this database. This is the only column in this view that returns a value reflecting the current state; all other columns return the accumulated values since the last reset. |
| xact_commit | bigint | Number of transactions in this database that have been committed |
| xact_rollback | bigint | Number of transactions in this database that have been rolled back |
| blks_read | bigint | Number of disk blocks read in this database |
| blks_hit | bigint | Number of times disk blocks were found in the buffer cache (unnecessary as the number includes only hits in the PostgreSQL buffer cache) |
| tup_returned | bigint | Number of rows returned by queries in this database |
| tup_fetched | bigint | Number of rows fetched by queries in this database |
| tup_inserted | bigint | Number of rows inserted by queries in this database |
| tup_updated | bigint | Number of rows updated by queries in this database |

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| Name | Type | Description |
| --- | --- | --- |
| tup_deleted | bigint | Number of rows deleted by queries in this database |
| conflicts | bigint | Number of queries canceled due to database recovery conflicts (conflicts occurring only on the standby server). For details, see **16.2.5.22 STAT_DATABASE_CONFLICTS**. |
| temp_files | bigint | Number of temporary files created by queries in this database. All temporary files are counted, regardless of why the temporary file was created (for example, sorting or hashing), and regardless of the **log_temp_files** setting. |
| temp_bytes | bigint | Total amount of data written to temporary files by queries in this database. All temporary files are counted, regardless of why the temporary file was created, and regardless of the **log_temp_files** setting. |
| deadlocks | bigint | Number of deadlocks detected in this database |
| blk_read_time | double precision | Time spent reading data file blocks by backends in this database (unit: ms) |
| blk_write_time | double precision | Time spent reading data file blocks by backends in this database (unit: ms) |
| stats_reset | timestamp with time zone | Time at which the current statistics were reset |

## 16.2.5.20 SUMMARY_STAT_DATABASE

**SUMMARY_STAT_DATABASE** contains statistics about each database in the cluster.

**Table 16-49** SUMMARY_STAT_DATABASE columns

| Name | Type | Description |
| --- | --- | --- |
| datname | name | Name of the database |
| numbackends | bigint | Number of backends currently connected to this database. This is the only column in this view that returns a value reflecting the current state; all other columns return the accumulated values since the last reset. |

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| Name | Type | Description |
| --- | --- | --- |
| xact_commit | numeric | Number of transactions in this database that have been committed |
| xact_rollback | numeric | Number of transactions in this database that have been rolled back |
| blks_read | numeric | Number of disk blocks read in this database |
| blks_hit | numeric | Number of times disk blocks were found in the buffer cache (unnecessary as the number includes only hits in the PostgreSQL buffer cache) |
| tup_returned | numeric | Number of rows returned by queries in this database |
| tup_fetched | numeric | Number of rows fetched by queries in this database |
| tup_inserted | bigint | Number of rows inserted by queries in this database |
| tup_updated | bigint | Number of rows updated by queries in this database |
| tup_deleted | bigint | Number of rows deleted by queries in this database |
| conflicts | bigint | Number of queries canceled due to database recovery conflicts (conflicts occurring only on the standby server). For details, see **16.2.5.22 STAT_DATABASE_CONFLICTS**. |
| temp_files | numeric | Number of temporary files created by queries in this database. All temporary files are counted, regardless of why the temporary file was created (for example, sorting or hashing), and regardless of the log_temp_files setting. |
| temp_bytes | numeric | Total amount of data written to temporary files by queries in this database. All temporary files are counted, regardless of why the temporary file was created, and regardless of the log_temp_files setting. |
| deadlocks | bigint | Number of deadlocks detected in this database |
| blk_read_time | double precision | Time spent reading data file blocks by backends in this database (unit: ms) |

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| Name | Type | Description |
| --- | --- | --- |
| blk_write_time | double precision | Time spent reading data file blocks by backends in this database (unit: ms) |
| stats_reset | timestamp with time zone | Time at which the current statistics were reset |

## 16.2.5.21 GLOBAL_STAT_DATABASE

**GLOBAL_STAT_DATABASE** contains statistics about databases on each node in the cluster.

**Table 16-50** GLOBAL_STAT_DATABASE columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| datid | oid | OID of the database |
| datname | name | Name of the database |
| numbackends | integer | Number of backends currently connected to this database. This is the only column in this view that returns a value reflecting the current state; all other columns return the accumulated values since the last reset. |
| xact_commit | bigint | Number of transactions in this database that have been committed |
| xact_rollback | bigint | Number of transactions in this database that have been rolled back |
| blks_read | bigint | Number of disk blocks read in this database |
| blks_hit | bigint | Number of times disk blocks were found in the buffer cache (unnecessary as the number includes only hits in the database kernel buffer cache) |
| tup_returned | bigint | Number of rows returned by queries in this database |
| tup_fetched | bigint | Number of rows fetched by queries in this database |
| tup_inserted | bigint | Number of rows inserted by queries in this database |

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| Name | Type | Description |
| --- | --- | --- |
| tup_updated | bigint | Number of rows updated by queries in this database |
| tup_deleted | bigint | Number of rows deleted by queries in this database |
| conflicts | bigint | Number of queries canceled due to database recovery conflicts (conflicts occurring only on the standby server). For details, see **16.2.5.22 STAT_DATABASE_CONFLICTS**. |
| temp_files | bigint | Number of temporary files created by queries in this database. All temporary files are counted, regardless of why the temporary file was created (for example, sorting or hashing), and regardless of the log_temp_files setting. |
| temp_bytes | bigint | Total amount of data written to temporary files by queries in this database. All temporary files are counted, regardless of why the temporary file was created, and regardless of the **log_temp_files** setting. |
| deadlocks | bigint | Number of deadlocks detected in this database |
| blk_read_time | double precision | Time spent reading data file blocks by backends in this database (unit: ms) |
| blk_write_time | double precision | Time spent reading data file blocks by backends in this database (unit: ms) |
| stats_reset | timestamp with time zone | Time at which the current statistics were reset |

## 16.2.5.22 STAT_DATABASE_CONFLICTS

**STAT_DATABASE_CONFLICTS** displays statistics about database conflicts on the current node.

**Table 16-51** STAT_DATABASE_CONFLICTS columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | Database ID |
| datname | name | Database name |

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| Name | Type | Description |
| --- | --- | --- |
| confl_tablespace | bigint | Number of conflicting tablespaces |
| confl_lock | bigint | Number of conflicting locks |
| confl_snapshot | bigint | Number conflicting snapshots |
| confl_bufferpin | bigint | Number of conflicting buffers |
| confl_deadlock | bigint | Number of conflicting deadlocks |

## 16.2.5.23 SUMMARY_STAT_DATABASE_CONFLICTS

**SUMMARY_STAT_DATABASE_CONFLICTS** displays statistics about database conflicts in the cluster.

**Table 16-52** SUMMARY_STAT_DATABASE_CONFLICTS columns

| Name | Type | Description |
| --- | --- | --- |
| datname | name | Database name |
| confl_tablespace | bigint | Number of conflicting tablespaces |
| confl_lock | bigint | Number of conflicting locks |
| confl_snapshot | bigint | Number conflicting snapshots |
| confl_bufferpin | bigint | Number of conflicting buffers |
| confl_deadlock | bigint | Number of conflicting deadlocks |

## 16.2.5.24 GLOBAL_STAT_DATABASE_CONFLICTS

**GLOBAL_STAT_DATABASE_CONFLICTS** displays statistics about database conflicts on each node.

**Table 16-53** GLOBAL_STAT_DATABASE_CONFLICTS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| datid | oid | Database ID |
| datname | name | Database name |

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| Name | Type | Description |
| --- | --- | --- |
| confl_tablespace | bigint | Number of conflicting tablespaces |
| confl_lock | bigint | Number of conflicting locks |
| confl_snapshot | bigint | Number conflicting snapshots |
| confl_bufferpin | bigint | Number of conflicting buffers |
| confl_deadlock | bigint | Number of conflicting deadlocks |

## 16.2.5.25 STAT_XACT_ALL_TABLES

**STAT_XACT_ALL_TABLES** displays the transaction status information about all ordinary tables and TOAST tables in the current namespace.

**Table 16-54** STAT_XACT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

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## 16.2.5.26 SUMMARY_STAT_XACT_ALL_TABLES

**SUMMARY_STAT_XACT_ALL_TABLES** displays the transaction status information about all common tables and TOAST tables in namespaces in the cluster.

**Table 16-55** SUMMARY_STAT_XACT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | numeric | Number of sequential scans initiated on the table |
| seq_tup_read | numeric | Number of live rows fetched by sequential scans |
| idx_scan | numeric | Number of index scans initiated on the table |
| idx_tup_fetch | numeric | Number of live rows fetched by index scans |
| n_tup_ins | numeric | Number of rows inserted |
| n_tup_upd | numeric | Number of rows updated |
| n_tup_del | numeric | Number of rows deleted |
| n_tup_hot_upd | numeric | Number of rows HOT updated (with no separate index update required) |

## 16.2.5.27 GLOBAL_STAT_XACT_ALL_TABLES

**GLOBAL_STAT_XACT_ALL_TABLES** displays the transaction status information about all ordinary tables and TOAST tables in namespaces on each node.

**Table 16-56** GLOBAL_STAT_XACT_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |

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| Name | Type | Description |
| --- | --- | --- |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

## 16.2.5.28 STAT_XACT_SYS_TABLES

**STAT_XACT_SYS_TABLES** displays the transaction status information about the system catalogs in namespaces on the current node.

**Table 16-57** STAT_XACT_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

## 16.2.5.29 SUMMARY_STAT_XACT_SYS_TABLES

**SUMMARY_STAT_XACT_SYS_TABLES** displays the transaction status information about the system catalogs in namespaces in the cluster.

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**Table 16-58** SUMMARY_STAT_XACT_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | numeric | Number of sequential scans initiated on the table |
| seq_tup_read | numeric | Number of live rows fetched by sequential scans |
| idx_scan | numeric | Number of index scans initiated on the table |
| idx_tup_fetch | numeric | Number of live rows fetched by index scans |
| n_tup_ins | numeric | Number of rows inserted |
| n_tup_upd | numeric | Number of rows updated |
| n_tup_del | numeric | Number of rows deleted |
| n_tup_hot_upd | numeric | Number of rows HOT updated (with no separate index update required) |

## 16.2.5.30 GLOBAL_STAT_XACT_SYS_TABLES

**GLOBAL_STAT_XACT_SYS_TABLES** displays the transaction status information about the system catalogs in namespaces on each node.

**Table 16-59** GLOBAL_STAT_XACT_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |

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| Name | Type | Description |
| --- | --- | --- |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

## 16.2.5.31 STAT_XACT_USER_TABLES

**STAT_XACT_USER_TABLES** displays the transaction status information about the user tables in namespaces on the current node.

**Table 16-60** STAT_XACT_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

## 16.2.5.32 SUMMARY_STAT_XACT_USER_TABLES

**SUMMARY_STAT_XACT_USER_TABLES** displays the transaction status information about the user tables in namespaces in the cluster.

**Table 16-61** SUMMARY_STAT_XACT_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |

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| Name | Type | Description |
| --- | --- | --- |
| relname | name | Table name |
| seq_scan | numeric | Number of sequential scans initiated on the table |
| seq_tup_read | numeric | Number of live rows fetched by sequential scans |
| idx_scan | numeric | Number of index scans initiated on the table |
| idx_tup_fetch | numeric | Number of live rows fetched by index scans |
| n_tup_ins | numeric | Number of rows inserted |
| n_tup_upd | numeric | Number of rows updated |
| n_tup_del | numeric | Number of rows deleted |
| n_tup_hot_upd | numeric | Number of rows HOT updated (with no separate index update required) |

## 16.2.5.33 GLOBAL_STAT_XACT_USER_TABLES

**GLOBAL_STAT_XACT_USER_TABLES** displays the transaction status information about the user tables in namespaces on each node.

**Table 16-62** GLOBAL_STAT_XACT_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| seq_scan | bigint | Number of sequential scans initiated on the table |
| seq_tup_read | bigint | Number of live rows fetched by sequential scans |
| idx_scan | bigint | Number of index scans initiated on the table |
| idx_tup_fetch | bigint | Number of live rows fetched by index scans |
| n_tup_ins | bigint | Number of rows inserted |
| n_tup_upd | bigint | Number of rows updated |
| n_tup_del | bigint | Number of rows deleted |

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| Name | Type | Description |
| --- | --- | --- |
| n_tup_hot_upd | bigint | Number of rows HOT updated (with no separate index update required) |

## 16.2.5.34 STAT_XACT_USER_FUNCTIONS

**STAT_XACT_USER_FUNCTIONS** displays statistics about function executions in the current transaction.

**Table 16-63** STAT_XACT_USER_FUNCTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| funcid | oid | OID of the function |
| schemaname | name | Schema name |
| funcname | name | Function name |
| calls | bigint | Number of times the function has been called |
| total_time | double precision | Total time spent in this function and all other functions called by it |
| self_time | double precision | Total time spent in this function, excluding other functions called by it |

## 16.2.5.35 SUMMARY_STAT_XACT_USER_FUNCTIONS

**SUMMARY_STAT_XACT_USER_FUNCTIONS** displays statistics about function executions in the current transaction in the cluster.

**Table 16-64** SUMMARY_STAT_XACT_USER_FUNCTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Schema name |
| funcname | name | Function name |
| calls | numeric | Number of times the function has been called |
| total_time | double precision | Total time spent in this function and all other functions called by it |
| self_time | double precision | Total time spent in this function, excluding other functions called by it |

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## 16.2.5.36 GLOBAL_STAT_XACT_USER_FUNCTIONS

**GLOBAL_STAT_XACT_USER_FUNCTIONS** displays statistics about function executions in transactions on each node.

**Table 16-65** GLOBAL_STAT_XACT_USER_FUNCTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| funcid | oid | OID of the function |
| schemaname | name | Schema name |
| funcname | name | Function name |
| calls | bigint | Number of times the function has been called |
| total_time | double precision | Total time spent in this function and all other functions called by it |
| self_time | double precision | Total time spent in this function, excluding other functions called by it |

## 16.2.5.37 STAT_BAD_BLOCK

**STAT_BAD_BLOCK** displays the information about table and index read failures on the current node.

**Table 16-66** STAT_BAD_BLOCK columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |
| databaseid | integer | OID of the database |
| tablespaceid | integer | OID of the tablespace |
| relfilenode | integer | File node of this relation |
| forknum | integer | Fork number |
| error_count | integer | Number of errors |
| first_time | timestamp with time zone | Time when the first bad block occurred |
| last_time | timestamp with time zone | Time when the last bad block occurred |

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## 16.2.5.38 SUMMARY_STAT_BAD_BLOCK

**SUMMARY_STAT_BAD_BLOCK** displays the information about table and index read failures in the cluster.

**Table 16-67** SUMMARY_STAT_BAD_BLOCK columns

| Name | Type | Description |
| --- | --- | --- |
| databaseid | integer | OID of the database |
| tablespaceid | integer | OID of the tablespace |
| relfilenode | integer | File node of this relation |
| forknum | bigint | Fork number |
| error_count | bigint | Number of errors |
| first_time | timestamp with time zone | Time when the first bad block occurred |
| last_time | timestamp with time zone | Time when the last bad block occurred |

## 16.2.5.39 GLOBAL_STAT_BAD_BLOCK

**GLOBAL_STAT_BAD_BLOCK** displays the information about table and index read failures on each node.

**Table 16-68** GLOBAL_STAT_BAD_BLOCK columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| databaseid | integer | OID of the database |
| tablespaceid | integer | OID of the tablespace |
| relfilenode | integer | File node of this relation |
| forknum | integer | Fork number |
| error_count | integer | Number of errors |
| first_time | timestamp with time zone | Time when the first bad block occurred |
| last_time | timestamp with time zone | Time when the last bad block occurred |

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## 16.2.5.40 STAT_USER_FUNCTIONS

**STAT_USER_FUNCTIONS** displays the status information about user-defined functions in the current namespace. (The language of the function is non-internal language.)

**Table 16-69** STAT_USER_FUNCTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| funcid | oid | OID of the function |
| schemaname | name | Schema name |
| funcname | name | Function name |
| calls | bigint | Number of times the function has been called |
| total_time | double precision | Total time spent in this function and all other functions called by it (unit: ms) |
| self_time | double precision | Total time spent in this function, excluding other functions called by it (unit: ms) |

## 16.2.5.41 SUMMARY_STAT_USER_FUNCTIONS

**SUMMARY_STAT_USER_FUNCTIONS** collects statistics about user-defined views in the cluster.

**Table 16-70** SUMMARY_STAT_USER_FUNCTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Schema name |
| funcname | name | Function name |
| calls | numeric | Number of times that the function has been called |
| total_time | double precision | Total time spent in this function and all other functions called by it (unit: ms) |
| self_time | double precision | Total time spent in this function, excluding other functions called by it (unit: ms) |

## 16.2.5.42 GLOBAL_STAT_USER_FUNCTIONS

**GLOBAL_STAT_USER_FUNCTIONS** displays statistics about user-defined functions on each node in the entire cluster.

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**Table 16-71** GLOBAL_STAT_USER_FUNCTIONS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | OID of the function |
| funcid | oid | ID of the function |
| schemaname | name | Schema name |
| funcname | name | Function name |
| calls | bigint | Number of times that the function has been called |
| total_time | double precision | Total time spent in this function and all other functions called by it (unit: ms) |
| self_time | double precision | Total time spent in this function, excluding other functions called by it (unit: ms) |

## 16.2.6 Workload

### 16.2.6.1 WORKLOAD_SQL_COUNT

**WORKLOAD_SQL_COUNT** displays the distribution of SQL statements in workloads on the current node. Common users can view only the distribution of SQL statements executed by themselves in workloads, whereas user **monadmin** can view the overall load status of workloads.

**Table 16-72** WORKLOAD_SQL_COUNT columns

| Name | Type | Description |
| --- | --- | --- |
| workload | name | Workload name |
| select_count | bigint | Number of **SELECT** statements |
| update_count | bigint | Number of **UPDATE** statements |
| insert_count | bigint | Number of **INSERT** statements |
| delete_count | bigint | Number of **DELETE** statements |
| ddl_count | bigint | Number of DDL statements |
| dml_count | bigint | Number of DML statements |
| dcl_count | bigint | Number of DCL statements |

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### 16.2.6.2 SUMMARY_WORKLOAD_SQL_COUNT

**SUMMARY_WORKLOAD_SQL_COUNT** displays the distribution of SQL statements in workloads on each CN in the cluster.

**Table 16-73** SUMMARY_WORKLOAD_SQL_COUNT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| workload | name | Workload name |
| select_count | bigint | Number of **SELECT** statements |
| update_count | bigint | Number of **UPDATE** statements |
| insert_count | bigint | Number of **INSERT** statements |
| delete_count | bigint | Number of **DELETE** statements |
| ddl_count | bigint | Number of DDL statements |
| dml_count | bigint | Number of DML statements |
| dcl_count | bigint | Number of DCL statements |

### 16.2.6.3 WORKLOAD_TRANSACTION

**WORKLOAD_TRANSACTION** displays the information about transactions on the current node.

**Table 16-74** WORKLOAD_TRANSACTION columns

| Name | Type | Description |
| --- | --- | --- |
| workload | name | Workload name |
| commit_counter | bigint | Number of user transactions committed |
| rollback_counter | bigint | Number of user transactions rolled back |
| resp_min | bigint | Minimum response time of user transactions (unit: μs) |
| resp_max | bigint | Maximum response time of user transactions (unit: μs) |
| resp_avg | bigint | Average response time of user transactions (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| resp_total | bigint | Total response time of user transactions (unit: μs) |
| bg_commit_counter | bigint | Number of background transactions committed |
| bg_rollback_counter | bigint | Number of background transactions rolled back |
| bg_resp_min | bigint | Minimum response time of background transactions (unit: μs) |
| bg_resp_max | bigint | Maximum response time of background transactions (unit: μs) |
| bg_resp_avg | bigint | Average response time of background transactions (unit: μs) |
| bg_resp_total | bigint | Total response time of background transactions (unit: μs) |

### 16.2.6.4 SUMMARY_WORKLOAD_TRANSACTION

**SUMMARY_WORKLOAD_TRANSACTION** displays the information about transactions in the cluster.

**Table 16-75** SUMMARY_WORKLOAD_TRANSACTION columns

| Name | Type | Description |
| --- | --- | --- |
| workload | name | Workload name |
| commit_counter | numeric | Number of user transactions committed |
| rollback_counter | numeric | Number of user transactions rolled back |
| resp_min | bigint | Minimum response time of user transactions (unit: μs) |
| resp_max | bigint | Maximum response time of user transactions (unit: μs) |
| resp_avg | bigint | Average response time of user transactions (unit: μs) |
| resp_total | numeric | Total response time of user transactions (unit: μs) |
| bg_commit_counter | numeric | Number of background transactions committed |
| bg_rollback_counter | numeric | Number of background transactions rolled back |

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| Name | Type | Description |
| --- | --- | --- |
| bg_resp_min | bigint | Minimum response time of background transactions (unit: μs) |
| bg_resp_max | bigint | Maximum response time of background transactions (unit: μs) |
| bg_resp_avg | bigint | Average response time of background transactions (unit: μs) |
| bg_resp_total | numeric | Total response time of background transactions (unit: μs) |

### 16.2.6.5 GLOBAL_WORKLOAD_TRANSACTION

**GLOBAL_WORKLOAD_TRANSACTION** displays the information about workloads on each node.

**Table 16-76** GLOBAL_WORKLOAD_TRANSACTION columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| workload | name | Workload name |
| commit_counter | bigint | Number of user transactions committed |
| rollback_counter | bigint | Number of user transactions rolled back |
| resp_min | bigint | Minimum response time of user transactions (unit: μs) |
| resp_max | bigint | Maximum response time of user transactions (unit: μs) |
| resp_avg | bigint | Average response time of user transactions (unit: μs) |
| resp_total | bigint | Total response time of user transactions (unit: μs) |
| bg_commit_counter | bigint | Number of background transactions committed |
| bg_rollback_counter | bigint | Number of background transactions rolled back |
| bg_resp_min | bigint | Minimum response time of background transactions (unit: μs) |
| bg_resp_max | bigint | Maximum response time of background transactions (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| bg_resp_avg | bigint | Average response time of background transactions (unit: μs) |
| bg_resp_total | bigint | Total response time of background transactions (unit: μs) |

### 16.2.6.6 WORKLOAD_SQL_ELAPSE_TIME

**WORKLOAD_SQL_ELAPSE_TIME** collects statistics about SUIDs in workloads.

**Table 16-77** WORKLOAD_SQL_ELAPSE_TIME columns

| Name | Type | Description |
| --- | --- | --- |
| workload | name | Workload name |
| total_select_elapse | bigint | Total response time of **SELECT** statements (unit: μs) |
| max_select_elapse | bigint | Maximum response time of **SELECT** statements (unit: μs) |
| min_select_elapse | bigint | Minimum response time of **SELECT** statements (unit: μs) |
| avg_select_elapse | bigint | Average response time of **SELECT** statements (unit: μs) |
| total_update_elapse | bigint | Total response time of **UPDATE** statements (unit: μs) |
| max_update_elapse | bigint | Maximum response time of **UPDATE** statements (unit: μs) |
| min_update_elapse | bigint | Minimum response time of **UPDATE** statements (unit: μs) |
| avg_update_elapse | bigint | Average response time of **UPDATE** statements (unit: μs) |
| total_insert_elapse | bigint | Total response time of **INSERT** statements (unit: μs) |
| max_insert_elapse | bigint | Maximum response time of **INSERT** statements (unit: μs) |
| min_insert_elapse | bigint | Minimum response time of **INSERT** statements (unit: μs) |
| avg_insert_elapse | bigint | Average response time of **INSERT** statements (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| total_delete_elapse | bigint | Total response time of **DELETE** statements (unit: μs) |
| max_delete_elapse | bigint | Maximum response time of **DELETE** statements (unit: μs) |
| min_delete_elapse | bigint | Minimum response time of **DELETE** statements (unit: μs) |
| avg_delete_elapse | bigint | Average response time of **DELETE** statements (unit: μs) |

## 16.2.6.7 SUMMARY_WORKLOAD_SQL_ELAPSE_TIME

**SUMMARY_WORKLOAD_SQL_ELAPSE_TIME** collects statistics about SUIDs in service workloads on all CNs.

**Table 16-78** SUMMARY_WORKLOAD_SQL_ELAPSE_TIM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| workload | name | Workload name |
| total_select_elapse | bigint | Total response time of **SELECT** statements (unit: μs) |
| max_select_elapse | bigint | Maximum response time of **SELECT** statements (unit: μs) |
| min_select_elapse | bigint | Minimum response time of **SELECT** statements (unit: μs) |
| avg_select_elapse | bigint | Average response time of **SELECT** statements (unit: μs) |
| total_update_elapse | bigint | Total response time of **UPDATE** statements (unit: μs) |
| max_update_elapse | bigint | Maximum response time of **UPDATE** statements (unit: μs) |
| min_update_elapse | bigint | Minimum response time of **UPDATE** statements (unit: μs) |
| avg_update_elapse | bigint | Average response time of **UPDATE** statements (unit: μs) |
| total_insert_elapse | bigint | Total response time of **INSERT** statements (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| max_insert_elapse | bigint | Maximum response time of **INSERT** statements (unit: μs) |
| min_insert_elapse | bigint | Minimum response time of **INSERT** statements (unit: μs) |
| avg_insert_elapse | bigint | Average response time of **INSERT** statements (unit: μs) |
| total_delete_elapse | bigint | Total response time of **DELETE** statements (unit: μs) |
| max_delete_elapse | bigint | Maximum response time of **DELETE** statements (unit: μs) |
| min_delete_elapse | bigint | Minimum response time of **DELETE** statements (unit: μs) |
| avg_delete_elapse | bigint | Average response time of **DELETE** statements (unit: μs) |

### 16.2.6.8 USER_TRANSACTION

**USER_TRANSACTION** collects statistics about transactions executed by users. Common users can view only transactions executed by themselves, whereas user **monadmin** can view transactions executed by all users.

**Table 16-79** USER_TRANSACTION columns

| Name | Type | Description |
| --- | --- | --- |
| username | name | Username |
| commit_counter | bigint | Number of user transactions committed |
| rollback_counter | bigint | Number of user transactions rolled back |
| resp_min | bigint | Minimum response time of user transactions (unit: μs) |
| resp_max | bigint | Maximum response time of user transactions (unit: μs) |
| resp_avg | bigint | Average response time of user transactions (unit: μs) |
| resp_total | bigint | Total response time of user transactions (unit: μs) |
| bg_commit_counter | bigint | Number of background transactions committed |

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| Name | Type | Description |
| --- | --- | --- |
| bg_rollback_counter | bigint | Number of background transactions rolled back |
| bg_resp_min | bigint | Minimum response time of background transactions (unit: μs) |
| bg_resp_max | bigint | Maximum response time of background transactions (unit: μs) |
| bg_resp_avg | bigint | Average response time of background transactions (unit: μs) |
| bg_resp_total | bigint | Total response time of background transactions (unit: μs) |

## 16.2.6.9 GLOBAL_USER_TRANSACTION

**GLOBAL_USER_TRANSACTION** collects statistics about transactions executed by all users.

**Table 16-80** GLOBAL_USER_TRANSACTION columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| username | name | Username |
| commit_counter | bigint | Number of user transactions committed |
| rollback_counter | bigint | Number of user transactions rolled back |
| resp_min | bigint | Minimum response time of user transactions (unit: μs) |
| resp_max | bigint | Maximum response time of user transactions (unit: μs) |
| resp_avg | bigint | Average response time of user transactions (unit: μs) |
| resp_total | bigint | Total response time of user transactions (unit: μs) |
| bg_commit_counter | bigint | Number of background transactions committed |
| bg_rollback_counter | bigint | Number of background transactions rolled back |
| bg_resp_min | bigint | Minimum response time of background transactions (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| bg_resp_max | bigint | Maximum response time of background transactions (unit: μs) |
| bg_resp_avg | bigint | Average response time of background transactions (unit: μs) |
| bg_resp_total | bigint | Total response time of background transactions (unit: μs) |

## 16.2.7 Session and Thread

### 16.2.7.1 SESSION_STAT

**SESSION_STAT** collects statistics about session status on the current node based on session threads or the **AutoVacuum** thread.

**Table 16-81** SESSION_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Thread start time and ID |
| statid | integer | Statistics ID |
| statname | text | Name of the statistics session |
| statunit | text | Unit of the statistics session |
| value | bigint | Value of the statistics session |

### 16.2.7.2 GLOBAL_SESSION_STAT

**GLOBAL_SESSION_STAT** collects statistics about session status on each node based on session threads or the **AutoVacuum** thread.

**Table 16-82** GLOBAL_SESSION_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| sessid | text | Thread start time and ID |
| statid | integer | Statistics ID |
| statname | text | Name of the statistics session |
| statunit | text | Unit of the statistics session |

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| Name | Type | Description |
| --- | --- | --- |
| value | bigint | Value of the statistics session |

### 16.2.7.3 SESSION_TIME

**SESSION_TIME** collects statistics about the running time of session threads and time consumed in each execution phase on the current node.

**Table 16-83** SESSION_TIME columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Thread start time and ID |
| stat_id | integer | Statistics ID |
| stat_name | text | Session type |
| value | bigint | Session value |

### 16.2.7.4 GLOBAL_SESSION_TIME

**GLOBAL_SESSION_TIME** collects statistics about the running time of session threads and time consumed in each execution phase on each node.

**Table 16-84** GLOBAL_SESSION_TIME columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| sessid | text | Thread start time and ID |
| stat_id | integer | Statistics ID |
| stat_name | text | Session type |
| value | bigint | Session value |

### 16.2.7.5 SESSION_MEMORY

**SESSION_MEMORY** collects statistics about memory usage at the session level in the unit of MB, including all the memory allocated to Postgres and stream threads on DNs for jobs currently executed by users.

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**Table 16-85** SESSION_MEMORY columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Thread start time and ID |
| init_mem | integer | Memory allocated to the currently executed job before the job enters the executor |
| used_mem | integer | Memory allocated to the currently executed job |
| peak_mem | integer | Peak memory allocated to the currently executed job |

## 16.2.7.6 GLOBAL_SESSION_MEMORY

**GLOBAL_SESSION_MEMORY** collects statistics about memory usage at the session level on each node in the unit of MB, including all the memory allocated to Postgres and stream threads on DNs for jobs currently executed by users.

**Table 16-86** GLOBAL_SESSION_MEMORY columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| sessid | text | Thread start time and ID |
| init_mem | integer | Memory allocated to the currently executed job before the job enters the executor |
| used_mem | integer | Memory allocated to the currently executed job |
| peak_mem | integer | Peak memory allocated to the currently executed job |

## 16.2.7.7 SESSION_MEMORY_DETAIL

**SESSION_MEMORY_DETAIL** collects statistics about thread memory usage by MemoryContext node.

**Table 16-87** SESSION_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| sessid | text | Thread start time and ID |
| sesstype | text | Thread name |
| contextname | text | Name of the memory context |
| level | smallint | Level of memory context importance |

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| Name | Type | Description |
| --- | --- | --- |
| parent | text | Name of the parent memory context |
| totalsize | bigint | Size of the applied memory (unit: byte) |
| freesize | bigint | Size of the idle memory (unit: byte) |
| usedsize | bigint | Size of the used memory (unit: byte) |

## 16.2.7.8 GLOBAL_SESSION_MEMORY_DETAIL

**GLOBAL_SESSION_MEMORY_DETAIL** collects statistics about thread memory usage on each node by MemoryContext node.

**Table 16-88** GLOBAL_SESSION_MEMORY_DETAIL columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| sessid | text | Thread start time and ID |
| sesstype | text | Thread name |
| contextname | text | Name of the memory context |
| level | smallint | Level of memory context importance |
| parent | text | Name of the parent memory context |
| totalsize | bigint | Size of the applied memory (unit: byte) |
| freesize | bigint | Size of the idle memory (unit: byte) |
| usedsize | bigint | Size of the used memory (unit: byte) |

## 16.2.7.9 SESSION_STAT_ACTIVITY

**SESSION_STAT_ACTIVITY** displays information about threads that are running on the current node.

**Table 16-89** SESSION_STAT_ACTIVITY columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that the user session connects to in the backend |
| datname | name | Name of the database that the user session connects to in the backend |
| pid | bigint | Backend thread ID |

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| Name | Type | Description |
| --- | --- | --- |
| usesysid | oid | OID of the user logged in to the backend |
| usename | name | Name of the user logged in to the backend |
| application_name | text | Name of the application connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is null, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with the backend (**–1** if a Unix socket is used) |
| backend_start | timestampwith time zone | Time when this process was started, that is, when the client connected to the server |
| xact_start | timestampwith time zone | Time when the current transaction was started (null if no transactions are active). If the current query is the first of its transaction, the value of this column is the same as that of the **query_start** column. |
| query_start | timestampwith time zone | Time when the currently active query was started, or time when the last query was started if **state** is not **active** |
| state_change | timestampwith time zone | Time when the **state** was last changed |
| waiting | boolean | Whether the backend is currently waiting on a lock. If yes, the value is **true**. |
| enqueue | text | Resource status in workload management. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

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| Name | Type | Description |
| --- | --- | --- |
| state | text | Overall status of this backend. Its value can be:<br>• **active**: The backend is executing a query.<br>• **idle**: The backend is waiting for a new client command.<br>• **idle in transaction**: The backend is in a transaction, but is not currently executing a query.<br>• **idle in transaction (aborted)**: This state is similar to **idle in transaction**, except that one of the statements in the transaction caused an error.<br>• **fastpath function call**: The backend is executing a fast-path function.<br>• **disabled**: This state is reported if **track_activities** is disabled in this backend.<br>**NOTE**<br>Common users can view their own session status only. The state information of other accounts is empty. For example, after the **judy** user is connected to the database, the state information of the **joe** user and the initial user **omm** in **pg_stat_activity** is empty.<br>openGauss=# SELECT datname, usename, usesysid,state,pid FROM pg_stat_activity;<br>datname \| usename \| usesysid \| state \| pid<br>----------+---------+----------+--------<br>+-----------------postgres \| omm \| 10 \| \| 139968752121616<br>postgres \| omm \| 10 \| \|139968903116560<br>db_tpcds \| judy \| 16398 \| active \| 139968391403280<br>postgres \| omm \| 10 \| \|139968643069712<br>postgres \| omm \| 10 \| \|139968680818448<br>postgres \| joe \| 16390 \| \|139968563377936<br>(6 rows) |
| resource_pool | name | Resource pool used by the user |
| query_id | bigint | ID of a query |
| query | text | Text of this backend's latest query. If the value of **state** is **active**, this column shows the ongoing query. In all other states, it shows the last query that was executed. |

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| Name | Type | Description |
| --- | --- | --- |
| unique_sql_id | bigint | Unique SQL statement ID |
| trace_id | text | Driver-specific trace ID, which is associated with an application request |

## 16.2.7.10 GLOBAL_SESSION_STAT_ACTIVITY

**GLOBAL_SESSION_STAT_ACTIVITY** displays information about threads that are running on each node in the cluster

**Table 16-90** GLOBAL_SESSION_STAT_ACTIVITY columns

| Name | Type | Description |
| --- | --- | --- |
| coorname | text | CN name |
| datid | oid | OID of the database that the user session connects to in the backend |
| datname | text | Name of the database that the user session connects to in the backend |
| pid | bigint | Backend thread ID |
| usesysid | oid | OID of the user logged in to the backend |
| usename | text | Name of the user logged in to the backend |
| application_name | text | Name of the application connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is null, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with the backend (**–1** if a Unix socket is used) |
| backend_start | timestampwith time zone | Time when this process was started, that is, when the client connected to the server |

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| Name | Type | Description |
| --- | --- | --- |
| xact_start | timestampwith time zone | Time when the current transaction was started (null if no transactions are active). If the current query is the first of its transaction, the value of this column is the same as that of the **query_start** column. |
| query_start | timestampwith time zone | Time when the currently active query was started, or time when the last query was started if the value of **state** is not **active** |
| state_change | timestampwith time zone | Time when the **state** was last changed |
| waiting | boolean | Whether the backend is currently waiting on a lock. If yes, the value is **true**. |
| enqueue | text | Resource status in workload management. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

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| Name | Type | Description |
| --- | --- | --- |
| state | text | Overall status of this backend. Its value can be:<br>• **active**: The backend is executing a query.<br>• **idle**: The backend is waiting for a new client command.<br>• **idle in transaction**: The backend is in a transaction, but is not currently executing a query.<br>• **idle in transaction (aborted)**: This state is similar to **idle in transaction**, except that one of the statements in the transaction caused an error.<br>• **fastpath function call**: The backend is executing a fast-path function.<br>• **disabled**: This state is reported if **track_activities** is disabled in this backend.<br>**NOTE**<br>Common users can view their own session status only. The state information of other accounts is empty. For example, after the **judy** user is connected to the database, the state information of the **joe** user and the initial user **omm** in **pg_stat_activity** is empty.<br>openGauss=# SELECT datname, usename, usesysid,state,pid FROM pg_stat_activity;<br>datname \| usename \| usesysid \| state \| pid<br>----------+---------+----------+--------<br>+-----------------postgres \| omm \| 10 \| \| 139968752121616<br>postgres \| omm \| 10 \| \|139968903116560<br>db_tpcds \| judy \| 16398 \| active \| 139968391403280<br>postgres \| omm \| 10 \| \|139968643069712<br>postgres \| omm \| 10 \| \|139968680818448<br>postgres \| joe \| 16390 \| \|139968563377936<br>(6 rows) |
| resource_pool | name | Resource pool used by the user |
| query_id | bigint | ID of a query |
| query | text | Text of this backend's latest query. If the value of **state** is **active**, this column shows the ongoing query. In all other states, it shows the last query that was executed. |

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| Name | Type | Description |
| --- | --- | --- |
| unique_sql_id | bigint | Unique SQL statement ID |
| trace_id | text | Driver-specific trace ID, which is associated with an application request |

## 16.2.7.11 THREAD_WAIT_STATUS

**THREAD_WAIT_STATUS** allows you to test the block waiting status of the backend thread and auxiliary thread in the current instance. For details about events, see **Table 16-180**.

**Table 16-91** THREAD_WAIT_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name |
| db_name | text | Database name |
| thread_name | text | Thread name |
| query_id | bigint | Query ID. The value of this column is the same as that of **debug_query_id**. |
| tid | bigint | Thread ID of the current thread |
| sessionid | bigint | Session ID |
| lwtid | integer | Lightweight thread ID of the current thread |
| psessionid | bigint | Parent thread of the streaming thread |
| tlevel | integer | Level of the streaming thread |
| smpid | integer | Concurrent thread ID |
| wait_status | text | Waiting status of the current thread. For details about the wait status, see **Table 16-180**. |
| wait_event | text | If **wait_status** is **acquire lock**, **acquire lwlock**, or **wait io**, this column describes the lock, lightweight lock, and I/O information, respectively. If **wait_status** is not any of the three values, this column is empty. |
| locktag | text | Information about the lock that the current thread is waiting for |
| lockmode | text | Lock mode that the current thread is waiting to obtain. The values include table-level lock, row-level lock, and page-level lock modes. |

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| Name | Type | Description |
| --- | --- | --- |
| block_sessionid | bigint | ID of the session that blocks the current thread from obtaining the lock |
| global_sessionid | text | Global session ID |

## 16.2.7.12 GLOBAL_THREAD_WAIT_STATUS

**GLOBAL_THREAD_WAIT_STATUS** allows you to test the block waiting status of backend threads and auxiliary threads on all nodes. For details about the events, see **Table 16-180**.

In **GLOBAL_THREAD_WAIT_STATUS**, you can see all the call hierarchy relationships between threads of the SQL statements on all nodes in the cluster, and the block waiting status for each thread. With this view, you can easily locate the causes of process hang and similar issues.

The definitions of **GLOBAL_THREAD_WAIT_STATUS** and **THREAD_WAIT_STATUS** are the same, because the essence of the **GLOBAL_THREAD_WAIT_STATUS** view is the query summary of the **THREAD_WAIT_STATUS** view on each node in the cluster.

**Table 16-92** GLOBAL_THREAD_WAIT_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Current node name |
| db_name | text | Database name |
| thread_name | text | Thread name |
| query_id | bigint | Query ID. The value of this column is the same as that of **debug_query_id**. |
| tid | bigint | Thread ID of the current thread |
| sessionid | bigint | Session ID |
| lwtid | integer | Lightweight thread ID of the current thread |
| psessionid | bigint | Parent thread of the streaming thread |
| tlevel | integer | Level of the streaming thread |
| smpid | integer | Concurrent thread ID |
| wait_status | text | Waiting status of the current thread. For details about the waiting status, see **Table 16-180**. |

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| Name | Type | Description |
| --- | --- | --- |
| wait_event | text | If **wait_status** is **acquire lock**, **acquire lwlock**, or **wait io**, this column describes the lock, lightweight lock, and I/O information, respectively. If **wait_status** is not any of the three values, this column is empty. |
| locktag | text | Information about the lock that the current thread is waiting for |
| lockmode | text | Lock mode that the current thread is waiting to obtain. The values include table-level lock, row-level lock, and page-level lock modes. |
| block_sessionid | bigint | ID of the session that blocks the current thread from obtaining the lock |
| global_sessionid | text | Global session ID |

## 16.2.7.13 LOCAL_THREADPOOL_STATUS

**LOCAL_THREADPOOL_STATUS** displays the status of worker threads and sessions in the thread pool. This view is valid only when **enable_thread_pool** is set to **on**.

**Table 16-93** LOCAL_THREADPOOL_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| group_id | integer | ID of the thread pool group |
| bind_numa_id | integer | NUMA ID to which the thread pool group is bound |
| bind_cpu_number | integer | Information about the CPU to which the thread pool group is bound. If no CPUs are bound, the value is **NULL**. |
| listener | integer | Number of listener threads in the thread pool group |

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| Name | Type | Description |
| --- | --- | --- |
| worker_info | text | Information about threads in the thread pool, including:<br>• **default**: number of initial threads in the thread pool<br>• **new**: number of new threads in the thread pool<br>• **expect**: number of expected threads in the thread pool<br>• **actual**: number of actual threads in the thread pool<br>• **idle**: number of idle threads in the thread pool<br>• **pending**: number of waiting threads in the thread pool |
| session_info | text | Information about sessions in the thread pool, including:<br>• **total**: number of all sessions in the thread pool<br>• **waiting**: number of sessions waiting to be scheduled in the thread pool<br>• **running**: number of running sessions in the thread pool<br>• **idle**: number of idle sessions in the thread pool |
| stream_info | text | Information about streams in the thread pool, including:<br>• **total**: number of all stream threads in the thread pool<br>• **running**: number of running stream threads in the thread pool<br>• **idle**: number of idle stream threads in the thread pool |

## 16.2.7.14 GLOBAL_THREADPOOL_STATUS

**GLOBAL_THREADPOOL_STATUS** displays the status of worker threads and sessions in thread pools on all nodes. Columns in this view are the same as those in **Table 16-93**.

## 16.2.7.15 SESSION_CPU_RUNTIME

**SESSION_CPU_RUNTIME** displays CPU usage information about ongoing complex jobs executed by the current user.

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**Table 16-94** SESSION_CPU_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that this backend is connected to |
| usename | name | Name of the user logged in to the backend |
| pid | bigint | Backend thread ID |
| start_time | timestamp with time zone | Time when the statement starts to be executed |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs, in ms |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs, in ms |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs, in ms |
| query | text | Statement being executed |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| top_cpu_dn | text | Top N CPU usage |

## 16.2.7.16 SESSION_MEMORY_RUNTIME

**SESSION_MEMORY_RUNTIME** displays memory usage information about ongoing complex jobs executed by the current user.

**Table 16-95** SESSION_MEMORY_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that this backend is connected to |
| usename | name | Name of the user logged in to the backend |
| pid | bigint | Backend thread ID |
| start_time | timestamp with time zone | Time when the statement starts to be executed |
| min_peak_memory | integer | Minimum memory peak of the statement across all DNs, in MB |

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| Name | Type | Description |
| --- | --- | --- |
| max_peak_memory | integer | Maximum memory peak of the statement across all DNs, in MB |
| spill_info | text | Statement spill information on all DNs:<br>• **None**: No data is spilled to disks on all DNs.<br>• **All**: Data is spilled to disks on all DNs.<br>• **[*a*:*b*]**: The statement has been spilled to disks on *a* of *b* DNs. |
| query | text | Statement being executed |
| node_group | text | Logical cluster of the user running the statement (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| top_mem_dn | text | Top N memory usage |

## 16.2.7.17 STATEMENT_IOSTAT_COMPLEX_RUNTIME

**STATEMENT_IOSTAT_COMPLEX_RUNTIME** displays I/O load management information about ongoing jobs executed by the current user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) IOPS is counted by ones for column store and by 10 thousands for row store.

**Table 16-96** STATEMENT_IOSTAT_COMPLEX_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| query_id | bigint | Job ID |
| mincurriops | integer | Minimum I/O of the current job across DNs |
| maxcurriops | integer | Maximum I/O of the current job across DNs |
| minpeakiops | integer | Minimum peak I/O of the current job across DNs |
| maxpeakiops | integer | Maximum peak I/O of the current job across DNs |
| io_limits | integer | **io_limits** set for the job |
| io_priority | text | **io_priority** set for the job |
| query | text | Job |
| node_group | text | Logical cluster of the user running the job (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

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| Name | Type | Description |
| --- | --- | --- |
| curr_io_limits | integer | Real-time **iolimits** value when **io_priority** is used to control I/Os. |

## 16.2.7.18 LOCAL_ACTIVE_SESSION

**LOCAL_ACTIVE_SESSION** displays samples in the **ACTIVE SESSION PROFILE** memory on the current node.

**Table 16-97** LOCAL_ACTIVE_SESSION columns

| Name | Type | Description |
| --- | --- | --- |
| sampleid | bigint | Sample ID. |
| sample_time | timestamp with time zone | Sampling time. |
| need_flush_sample | boolean | Specifies whether the sample needs to be refreshed. |
| databaseid | oid | Database ID. |
| thread_id | bigint | Thread ID. |
| sessionid | bigint | Session ID. |
| start_time | timestamp with time zone | Start time of a session. |
| event | text | Specified event name. |
| lwtid | integer | Lightweight thread ID of the current thread. |
| psessionid | bigint | Parent thread of the streaming thread. |
| tlevel | integer | Level of the streaming thread. The value corresponds to the level (ID) of the execution plan. |
| smpid | integer | Concurrent thread ID in SMP execution mode. |
| userid | oid | ID of a session user. |
| application_name | text | Name of an application. |
| client_addr | inet | IP address of a client. |
| client_hostname | text | Name of a client. |

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| Name | Type | Description |
| --- | --- | --- |
| client_port | integer | TCP port number used by a client to communicate with the backend. |
| query_id | bigint | Debug query ID. |
| unique_query_id | bigint | Unique query ID. |
| user_id | oid | User ID in the key of the unique query. |
| cn_id | integer | A CN ID on a DN indicates that the unique SQL statement comes from a CN ID in a key of the unique query on a CN. |
| unique_query | text | Standardized UniqueSQL text string. |
| locktag | text | Information of a lock that the session waits for. It can be parsed using **locktag_decode**. |
| lockmode | text | Mode of a lock that the session waits for. |
| block_sessionid | bigint | Blocks a session from obtaining the session ID of a lock if the session is waiting for the lock. |
| final_block_sessionid | bigint | ID of the blocked session at the source end. |
| wait_status | text | Provides more details about the event column. |
| global_sessionid | text | Global session ID. |
| xact_start_time | timestamp with time zone | Start time of the transaction. |
| query_start_time | timestamp with time zone | Time when the statement starts to be executed. |
| state | text | Current statement state.<br>The value can be **active**, **idle in transaction**, **fastpath function call**, **idle in transaction (aborted)**, **disabled**, or **retrying**. |

## 16.2.7.19 GLOBAL_ACTIVE_SESSION

**GLOBAL_ACTIVE_SESSION** displays a summary of samples in the **ACTIVE SESSION PROFILE** memory on all nodes.

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**Table 16-98** GLOBAL_ACTIVE_SESSION columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| sampleid | bigint | Sample ID |
| sample_time | timestamp without time zone | Sampling time |
| need_flush_sample | boolean | Specifies whether the sample needs to be refreshed. |
| databaseid | oid | Database ID |
| thread_id | bigint | Thread ID |
| sessionid | bigint | Session ID |
| start_time | timestamp without time zone | Start time of a session |
| event | text | Specified event name |
| lwtid | integer | Lightweight thread ID of the current thread |
| psessionid | bigint | Parent thread of the streaming thread |
| tlevel | integer | Level of the streaming thread. The value corresponds to the level (ID) of the execution plan. |
| smpid | integer | Concurrent thread ID in SMP execution mode |
| userid | oid | ID of a session user |
| application_name | text | Name of an application. |
| client_addr | inet | IP address of a client |
| client_hostname | text | Name of a client |
| client_port | integer | TCP port number used by a client to communicate with the backend |
| query_id | bigint | debug query id |
| unique_query_id | bigint | unique query id |
| user_id | oid | User ID in the key of the unique query |

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| Name | Type | Description |
| --- | --- | --- |
| cn_id | integer | A CN ID on a DN indicates that the unique SQL statement comes from a CN ID in a key of the unique query on a CN. |
| unique_query | text | Standardized UniqueSQL text string. |
| locktag | text | Information of a lock that the session waits for. It can be parsed using **locktag_decode**. |
| lockmode | text | Mode of a lock that the session waits for. |
| block_sessionid | bigint | Blocks a session from obtaining the session ID of a lock if the session is waiting for the lock. |
| final_block_sessionid | bigint | ID of the blocked session at the source end |
| wait_status | text | Provides more details about the event column. |
| global_sessionid | text | Global session ID |
| xact_start_time | timestamp with time zone | Start time of the transaction |
| query_start_time | timestamp with time zone | Time when the statement starts to be executed |
| state | text | Current statement state<br>The value can be **active**, **idle in transaction**, **fastpath function call**, **idle in transaction (aborted)**, **disabled**, or **retrying**. |

## 16.2.8 Transaction

### 16.2.8.1 TRANSACTIONS_RUNNING_XACTS

**TRANSACTIONS_RUNNING_XACTS** displays information about running transactions on the current node.

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**Table 16-99** TRANSACTIONS_RUNNING_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| handle | integer | Handle corresponding to the transaction in GTM |
| gxid | xid | Transaction ID |
| state | tinyint | Transaction status (**3**: prepared; **0**: starting) |
| node | text | Node name |
| xmin | xid | Minimum transaction ID on the node |
| vacuum | boolean | Whether the current transaction is lazy vacuum |
| timeline | bigint | Number of database restarts |
| prepare_xid | xid | ID of the transaction in the **prepared** state (the value is **0** if the state is not **prepared**) |
| pid | bigint | Thread ID corresponding to the transaction |
| next_xid | xid | Transaction ID sent from a CN to a DN |

## 16.2.8.2 SUMMARY_TRANSACTIONS_RUNNING_XACTS

**SUMMARY_TRANSACTIONS_RUNNING_XACTS** displays information about the running transactions on each CN in the cluster. The column content is the same as that of **transactions_running_xacts**.

**Table 16-100** SUMMARY_TRANSACTIONS_RUNNING_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| handle | integer | Handle corresponding to the transaction in GTM |
| gxid | xid | Transaction ID |
| state | tinyint | Transaction status (**3**: prepared; **0**: starting) |
| node | text | Node name |
| xmin | xid | Minimum transaction ID on the node |
| vacuum | boolean | Whether the current transaction is lazy vacuum |
| timeline | bigint | Number of database restarts |
| prepare_xid | xid | ID of the transaction in the **prepared** state (the value is **0** if the state is not **prepared**) |
| pid | bigint | Thread ID corresponding to the transaction |
| next_xid | xid | Transaction ID sent from a CN to a DN |

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### 16.2.8.3 GLOBAL_TRANSACTIONS_RUNNING_XACTS

**GLOBAL_TRANSACTIONS_RUNNING_XACTS** displays information about the running transactions on each node in the cluster.

**Table 16-101** GLOBAL_TRANSACTIONS_RUNNING_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| handle | integer | Handle corresponding to the transaction in GTM |
| gxid | xid | Transaction ID |
| state | tinyint | Transaction status (**3**: prepared; **0**: starting) |
| node | text | Node name |
| xmin | xid | Minimum transaction ID on the node |
| vacuum | boolean | Whether the current transaction is lazy vacuum |
| timeline | bigint | Number of database restarts |
| prepare_xid | xid | ID of the transaction in the **prepared** state (the value is **0** if the state is not **prepared**) |
| pid | bigint | Thread ID corresponding to the transaction |
| next_xid | xid | Transaction ID sent from a CN to a DN |

### 16.2.8.4 TRANSACTIONS_PREPARED_XACTS

**TRANSACTIONS_PREPARED_XACTS** displays information about transactions that are currently prepared for two-phase commit.

**Table 16-102** TRANSACTIONS_PREPARED_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| transaction | xid | Numeric transaction identifier of the prepared transaction |
| gid | text | Global transaction identifier that was assigned to the transaction |
| prepared | timestamp with time zone | Time at which the transaction is prepared for commit |
| owner | name | Name of the user that executes the transaction |
| database | name | Name of the database in which the transaction is executed |

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### 16.2.8.5 SUMMARY_TRANSACTIONS_PREPARED_XACTS

**SUMMARY_TRANSACTIONS_PREPARED_XACTS** displays information about the transactions that are ready for two-phase commit on each CN in the cluster.

**Table 16-103** SUMMARY_TRANSACTIONS_PREPARED_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| transaction | xid | Numeric transaction identifier of the prepared transaction |
| gid | text | Global transaction identifier that was assigned to the transaction |
| prepared | timestamp with time zone | Time at which the transaction is prepared for commit |
| owner | name | Name of the user that executes the transaction |
| database | name | Name of the database in which the transaction is executed |

### 16.2.8.6 GLOBAL_TRANSACTIONS_PREPARED_XACTS

**GLOBAL_TRANSACTIONS_PREPARED_XACTS** displays information about the transactions that are currently prepared for two-phase commit on each node.

**Table 16-104** GLOBAL_TRANSACTIONS_PREPARED_XACTS columns

| Name | Type | Description |
| --- | --- | --- |
| transaction | xid | Numeric transaction identifier of the prepared transaction |
| gid | text | Global transaction identifier that was assigned to the transaction |
| prepared | timestamp with time zone | Time at which the transaction is prepared for commit |
| owner | name | Name of the user that executes the transaction |
| database | name | Name of the database in which the transaction is executed |

## 16.2.9 Query

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### 16.2.9.1 STATEMENT

**STATEMENT** obtains information about execution statements (normalized SQL statements) on the current node. To query a view, you must have the **sysadmin** or **monitor admin** permission. You can view all statistics about normalized SQL statements received by the CN, whereas you can view only the statistics about normalized SQL statements executed on the current DN.

**Table 16-105** STATEMENT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| node_id | integer | Node ID (**node_id** in **pgxc_node**) |
| user_name | name | Username |
| user_id | oid | OID of the user |
| unique_sql_id | bigint | ID of the normalized SQL statement |
| query | text | Normalized SQL statement<br>Note: The length is controlled by **track_activity_query_size**. |
| n_calls | bigint | Number of calls |
| min_elapse_time | bigint | Minimum execution time of the SQL statement in the kernel (unit: μs) |
| max_elapse_time | bigint | Maximum execution time of the SQL statement in the kernel (unit: μs) |
| total_elapse_time | bigint | Total execution time of the SQL statement in the kernel (unit: μs) |
| n_returned_rows | bigint | Number of rows in the result set returned by the **SELECT** statement |
| n_tuples_fetched | bigint | Number of rows randomly scanned |
| n_tuples_returned | bigint | Number of rows sequentially scanned |
| n_tuples_inserted | bigint | Number of rows inserted |
| n_tuples_updated | bigint | Number of rows updated |
| n_tuples_deleted | bigint | Number of rows deleted |
| n_blocks_fetched | bigint | Number of buffer block access times |
| n_blocks_hit | bigint | Number of buffer block hits |

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| Name | Type | Description |
| --- | --- | --- |
| n_soft_parse | bigint | Number of soft parsing times. The value of **n_soft_parse** plus the value of **n_hard_parse** may be greater than the value of **n_calls** because the number of subqueries are not counted in the value of **n_calls**. |
| n_hard_parse | bigint | Number of hard parsing times. The value of **n_soft_parse** plus the value of **n_hard_parse** may be greater than the value of **n_calls** because the number of subqueries are not counted in the value of **n_calls**. |
| db_time | bigint | Valid DB time, which is accumulated if multiple threads are involved (unit: μs) |
| cpu_time | bigint | CPU time (unit: μs) |
| execution_time | bigint | Execution time in the executor (unit: μs) |
| parse_time | bigint | SQL parsing time (unit: μs) |
| plan_time | bigint | SQL plan generation time (unit: μs) |
| rewrite_time | bigint | SQL rewriting time (unit: μs) |
| pl_execution_time | bigint | Execution time of PL/pgSQL (unit: μs) |
| pl_compilation_time | bigint | Compilation time of PL/pgSQL (unit: μs) |
| data_io_time | bigint | I/O time (unit: μs) |
| net_send_info | text | Network status of messages sent through a physical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, CNs communicate with each other, CNs communicate with customer service ends, and CNs communicate with DNs through physical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |

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| Name | Type | Description |
| --- | --- | --- |
| net_recv_info | text | Network status of messages received through a physical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, CNs communicate with each other, CNs communicate with customer service ends, and CNs communicate with DNs through physical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| net_stream_send_info | text | Network status of messages sent through a logical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, DNs of different shards communicate with each other through logical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| net_stream_recv_info | text | Network status of messages received through a logical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, DNs of different shards communicate with each other through logical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| last_updated | timestamp with time zone | Last time when the statement was updated |
| sort_count | bigint | Sorting count |
| sort_time | bigint | Sorting duration (unit: μs) |
| sort_mem_used | bigint | Size of work memory used during sorting (unit: KB) |
| sort_spill_count | bigint | Count of file writing when data is flushed to disks during sorting |

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| Name | Type | Description |
| --- | --- | --- |
| sort_spill_size | bigint | File size used when data is flushed to disks during sorting (unit: KB) |
| hash_count | bigint | Hashing count |
| hash_time | bigint | Hashing duration (unit: μs) |
| hash_mem_used | bigint | Size of work memory used during hashing (unit: KB) |
| hash_spill_count | bigint | Count of file writing when data is flushed to disks during hashing |
| hash_spill_size | bigint | File size used when data is flushed to disks during hashing (unit: KB) |

## 16.2.9.2 SUMMARY_STATEMENT

**SUMMARY_STATEMENT** displays all information (including DNs) about executed statements (normalized SQL statements) on each CN.

**Table 16-106** SUMMARY_STATEMENT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| node_id | integer | Node ID (**node_id** in **pgxc_node**) |
| user_name | name | Username |
| user_id | oid | OID of the user |
| unique_sql_id | bigint | ID of the normalized SQL statement |
| query | text | Normalized SQL statement<br>Note: The length is controlled by **track_activity_query_size**. |
| n_calls | bigint | Number of calls |
| min_elapse_time | bigint | Minimum execution time of the SQL statement in the kernel (unit: μs) |
| max_elapse_time | bigint | Maximum execution time of the SQL statement in the kernel (unit: μs) |
| total_elapse_time | bigint | Total execution time of the SQL statement in the kernel (unit: μs) |
| n_returned_rows | bigint | Number of rows in the result set returned by the **SELECT** statement |

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| Name | Type | Description |
| --- | --- | --- |
| n_tuples_fetched | bigint | Number of rows randomly scanned |
| n_tuples_returned | bigint | Number of rows sequentially scanned |
| n_tuples_inserted | bigint | Number of rows inserted |
| n_tuples_updated | bigint | Number of rows updated |
| n_tuples_deleted | bigint | Number of rows deleted |
| n_blocks_fetched | bigint | Number of buffer block access times |
| n_blocks_hit | bigint | Number of buffer block hits |
| n_soft_parse | bigint | Number of soft parsing times |
| n_hard_parse | bigint | Number of hard parsing times |
| db_time | bigint | Valid DB time, which is accumulated if multiple threads are involved (unit: μs) |
| cpu_time | bigint | CPU time (unit: μs) |
| execution_time | bigint | Execution time in the executor (unit: μs) |
| parse_time | bigint | SQL parsing time (unit: μs) |
| plan_time | bigint | SQL plan generation time (unit: μs) |
| rewrite_time | bigint | SQL rewriting time (unit: μs) |
| pl_execution_time | bigint | Execution time of PL/pgSQL (unit: μs) |
| pl_compilation_time | bigint | Compilation time of PL/pgSQL (unit: μs) |
| data_io_time | bigint | I/O time (unit: μs) |
| net_send_info | text | Network status of messages sent through a physical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, CNs communicate with each other, CNs communicate with customer service ends, and CNs communicate with DNs through physical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |

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| Name | Type | Description |
| --- | --- | --- |
| net_recv_info | text | Network status of messages received through a physical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, CNs communicate with each other, CNs communicate with customer service ends, and CNs communicate with DNs through physical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| net_stream_send_info | text | Network status of messages sent through a logical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, DNs of different shards communicate with each other through logical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| net_stream_recv_info | text | Network status of messages received through a logical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, DNs of different shards communicate with each other through logical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| last_updated | timestamp with time zone | Last time when the statement was updated |
| sort_count | bigint | Sorting count |
| sort_time | bigint | Sorting duration (unit: μs) |
| sort_mem_used | bigint | Size of work memory used during sorting (unit: KB) |
| sort_spill_count | bigint | Count of file writing when data is flushed to disks during sorting |

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| Name | Type | Description |
| --- | --- | --- |
| sort_spill_size | bigint | File size used when data is flushed to disks during sorting (unit: KB) |
| hash_count | bigint | Hashing count |
| hash_time | bigint | Hashing duration (unit: μs) |
| hash_mem_used | bigint | Size of work memory used during hashing (unit: KB) |
| hash_spill_count | bigint | Count of file writing when data is flushed to disks during hashing |
| hash_spill_size | bigint | File size used when data is flushed to disks during hashing (unit: KB) |

## 16.2.9.3 STATEMENT_COUNT

**STATEMENT_COUNT** displays statistics about four types of running statements (**SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO**) as well as DDL, DML, and DCL statements on the current node of the database.

NOTE

By querying the **STATEMENT_COUNT** view, a common user can view statistics only about this user on the current node, whereas an administrator can view statistics about all users on the current node. When the cluster or node is restarted, the statistics are cleared and the counting restarts. The system counts when a node receives a query, including a query inside the cluster. For example, when a CN receives a query and distributes multiple queries to DNs, the queries are counted accordingly on the DNs.

**Table 16-107** STATEMENT_COUNT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| user_name | text | Username |
| select_count | bigint | Statistical result of the **SELECT** statement |
| update_count | bigint | Statistical result of the **UPDATE** statement |
| insert_count | bigint | Statistical result of the **INSERT** statement |
| delete_count | bigint | Statistical result of the **DELETE** statement |
| mergeinto_count | bigint | Statistical result of the **MERGE INTO** statement |
| ddl_count | bigint | Number of DDL statements |
| dml_count | bigint | Number of DML statements |

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| Name | Type | Description |
| --- | --- | --- |
| dcl_count | bigint | Number of DCL statements |
| total_select_elapse | bigint | Total response time of **SELECT** statements (unit: μs) |
| avg_select_elapse | bigint | Average response time of **SELECT** statements (unit: μs) |
| max_select_elapse | bigint | Maximum response time of **SELECT** statements (unit: μs) |
| min_select_elapse | bigint | Minimum response time of **SELECT** statements (unit: μs) |
| total_update_elapse | bigint | Total response time of **UPDATE** statements (unit: μs) |
| avg_update_elapse | bigint | Average response time of **UPDATE** statements (unit: μs) |
| max_update_elapse | bigint | Maximum response time of **UPDATE** statements (unit: μs) |
| min_update_elapse | bigint | Minimum response time of **UPDATE** statements (unit: μs) |
| total_insert_elapse | bigint | Total response time of **INSERT** statements (unit: μs) |
| avg_insert_elapse | bigint | Average response time of **INSERT** statements (unit: μs) |
| max_insert_elapse | bigint | Maximum response time of **INSERT** statements (unit: μs) |
| min_insert_elapse | bigint | Minimum response time of **INSERT** statements (unit: μs) |
| total_delete_elapse | bigint | Total response time of **DELETE** statements (unit: μs) |
| avg_delete_elapse | bigint | Average response time of **DELETE** statements (unit: μs) |
| max_delete_elapse | bigint | Maximum response time of **DELETE** statements (unit: μs) |
| min_delete_elapse | bigint | Minimum response time of **DELETE** statements (unit: μs) |

## 16.2.9.4 GLOBAL_STATEMENT_COUNT

**GLOBAL_STATEMENT_COUNT** displays statistics about four types of running statements (**SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO**) as well as DDL, DML, and DCL statements on each node of the database.

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**Table 16-108** GLOBAL_STATEMENT_COUNT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| user_name | text | Username |
| select_count | bigint | Statistical result of the **SELECT** statement |
| update_count | bigint | Statistical result of the **UPDATE** statement |
| insert_count | bigint | Statistical result of the **INSERT** statement |
| delete_count | bigint | Statistical result of the **DELETE** statement |
| mergeinto_count | bigint | Statistical result of the **MERGE INTO** statement |
| ddl_count | bigint | Number of DDL statements |
| dml_count | bigint | Number of DML statements |
| dcl_count | bigint | Number of DCL statements |
| total_select_elapse | bigint | Total response time of **SELECT** statements (unit: μs) |
| avg_select_elapse | bigint | Average response time of **SELECT** statements (unit: μs) |
| max_select_elapse | bigint | Maximum response time of **SELECT** statements (unit: μs) |
| min_select_elapse | bigint | Minimum response time of **SELECT** statements (unit: μs) |
| total_update_elapse | bigint | Total response time of **UPDATE** statements (unit: μs) |
| avg_update_elapse | bigint | Average response time of **UPDATE** statements (unit: μs) |
| max_update_elapse | bigint | Maximum response time of **UPDATE** statements (unit: μs) |
| min_update_elapse | bigint | Minimum response time of **UPDATE** statements (unit: μs) |
| total_insert_elapse | bigint | Total response time of **INSERT** statements (unit: μs) |
| avg_insert_elapse | bigint | Average response time of **INSERT** statements (unit: μs) |
| max_insert_elapse | bigint | Maximum response time of **INSERT** statements (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| min_insert_elapse | bigint | Minimum response time of **INSERT** statements (unit: μs) |
| total_delete_elapse | bigint | Total response time of **DELETE** statements (unit: μs) |
| avg_delete_elapse | bigint | Average response time of **DELETE** statements (unit: μs) |
| max_delete_elapse | bigint | Maximum response time of **DELETE** statements (unit: μs) |
| min_delete_elapse | bigint | Minimum response time of **DELETE** statements (unit: μs) |

### 16.2.9.5 SUMMARY_STATEMENT_COUNT

**SUMMARY_STATEMENT_COUNT** displays statistics about four types of running statements (**SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO**) as well as DDL, DML, and DCL statements on all nodes (CNs and DNs) of the database.

**Table 16-109** SUMMARY_STATEMENT_COUNT columns

| Name | Type | Description |
| --- | --- | --- |
| user_name | text | Username |
| select_count | numeric | Statistical result of the **SELECT** statement |
| update_count | numeric | Statistical result of the **UPDATE** statement |
| insert_count | numeric | Statistical result of the **INSERT** statement |
| delete_count | numeric | Statistical result of the **DELETE** statement |
| mergeinto_count | numeric | Statistical result of the **MERGE INTO** statement |
| ddl_count | numeric | Number of DDL statements |
| dml_count | numeric | Number of DML statements |
| dcl_count | numeric | Number of DCL statements |
| total_select_elapse | numeric | Total response time of **SELECT** statements (unit: μs) |
| avg_select_elapse | bigint | Average response time of **SELECT** statements (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| max_select_elapse | bigint | Maximum response time of **SELECT** statements (unit: μs) |
| min_select_elapse | bigint | Minimum response time of **SELECT** statements (unit: μs) |
| total_update_elapse | numeric | Total response time of **UPDATE** statements (unit: μs) |
| avg_update_elapse | bigint | Average response time of **UPDATE** statements (unit: μs) |
| max_update_elapse | bigint | Maximum response time of **UPDATE** statements (unit: μs) |
| min_update_elapse | bigint | Minimum response time of **UPDATE** statements (unit: μs) |
| total_insert_elapse | numeric | Total response time of **INSERT** statements (unit: μs) |
| avg_insert_elapse | bigint | Average response time of **INSERT** statements (unit: μs) |
| max_insert_elapse | bigint | Maximum response time of **INSERT** statements (unit: μs) |
| min_insert_elapse | bigint | Minimum response time of **INSERT** statements (unit: μs) |
| total_delete_elapse | numeric | Total response time of **DELETE** statements (unit: μs) |
| avg_delete_elapse | bigint | Average response time of **DELETE** statements (unit: μs) |
| max_delete_elapse | bigint | Maximum response time of **DELETE** statements (unit: μs) |
| min_delete_elapse | bigint | Minimum response time of **DELETE** statements (unit: μs) |

## 16.2.9.6 GLOBAL_STATEMENT_COMPLEX_HISTORY

**GLOBAL_STATEMENT_COMPLEX_HISTORY_TABLE** displays load management information about completed jobs executed on each node. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

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**Table 16-110** GLOBAL_STATEMENT_COMPLEX_HISTORY columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that this backend is connected to |
| dbname | text | Name of the database that the backend is connected to |
| schemaname | text | Schema name |
| nodename | text | Name of the CN where the statement is executed |
| username | text | Username used for connecting to the backend |
| application_name | text | Name of the application connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is null, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with this backend (**-1** if a Unix socket is used) |
| query_band | text | Job type, which is specified by the GUC parameter **query_band**. The default value is a null string. |
| block_time | bigint | Duration that the statement is blocked before being executed, including the statement parsing and optimization duration (unit: ms) |
| start_time | timestamp with time zone | Time when the statement starts to be executed |
| finish_time | timestamp with time zone | Time when the statement execution ends |
| duration | bigint | Execution time of the statement (unit: ms) |

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| Name | Type | Description |
| --- | --- | --- |
| estimate_total_time | bigint | Estimated execution time of the statement (unit: ms) |
| status | text | Final statement execution status. The value can be **finished** (normal) or **aborted** (abnormal). |
| abort_info | text | Exception information displayed if the final statement execution status is **aborted** |
| resource_pool | text | Resource pool used by the user |
| control_group | text | Cgroup used by the statement |
| estimate_memory | integer | Estimated memory used by the statement (unit: MB) |
| min_peak_memory | integer | Minimum peak memory of the statement across all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory of the statement across all DNs (unit: MB) |
| average_peak_memory | integer | Average memory usage during statement execution (unit: MB) |
| memory_skew_percent | integer | Memory usage skew of the statement among DNs |
| spill_info | text | Statement spill information on all DNs.<br>• **None**: No data is spilled to disks.<br>• **All**: Data is spilled to disks on all DNs.<br>• **[*a*:*b*]**: The statement has been spilled to disks on *a* of *b* DNs. |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_dn_time | bigint | Minimum execution time of the statement across all DNs (unit: ms) |

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| Name | Type | Description |
| --- | --- | --- |
| max_dn_time | bigint | Maximum execution time of the statement across all DNs (unit: ms) |
| average_dn_time | bigint | Average execution time of the statement across all DNs (unit: ms) |
| dntime_skew_percent | integer | Execution time skew of the statement among DNs |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs (unit: ms) |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs (unit: ms) |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs (unit: ms) |
| cpu_skew_percent | integer | CPU time skew of the statement among DNs |
| min_peak_iops | integer | Minimum peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| max_peak_iops | integer | Maximum peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| average_peak_iops | integer | Average peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| iops_skew_percent | integer | I/O skew of the statement among DNs |
| warning | text | Warning. The following warnings and warnings related to **10.3.6.1 Optimizing SQL Self-Diagnosis** are displayed:<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |
| queryid | bigint | Internal query ID used for statement execution |

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| Name | Type | Description |
| --- | --- | --- |
| query | text | Statement executed |
| query_plan | text | Execution plan of the statement |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| cpu_top1_node_name | text | Name of the node with the 1st CPU usage |
| cpu_top2_node_name | text | Name of the node with the 2nd CPU usage |
| cpu_top3_node_name | text | Name of the node with the 3rd CPU usage |
| cpu_top4_node_name | text | Name of the node with the 4th CPU usage |
| cpu_top5_node_name | text | Name of the node with the 5th CPU usage |
| mem_top1_node_name | text | Name of the node with the 1st memory usage |
| mem_top2_node_name | text | Name of the node with the 2nd memory usage |
| mem_top3_node_name | text | Name of the node with the 3rd memory usage |
| mem_top4_node_name | text | Name of the node with the 4th memory usage |
| mem_top5_node_name | text | Name of the node with the 5th memory usage |
| cpu_top1_value | bigint | 1st CPU usage |
| cpu_top2_value | bigint | 2nd CPU usage |
| cpu_top3_value | bigint | 3rd CPU usage |
| cpu_top4_value | bigint | 4th CPU usage |
| cpu_top5_value | bigint | 5th CPU usage |
| mem_top1_value | bigint | 1st memory usage |
| mem_top2_value | bigint | 2nd memory usage |
| mem_top3_value | bigint | 3rd memory usage |
| mem_top4_value | bigint | 4th memory usage |

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| Name | Type | Description |
| --- | --- | --- |
| mem_top5_value | bigint | 5th memory usage |
| top_mem_dn | text | Top N memory usage |
| top_cpu_dn | text | Top N CPU usage |

## 16.2.9.7 GLOBAL_STATEMENT_COMPLEX_HISTORY_TABLE

**GLOBAL_STATEMENT_COMPLEX_HISTORY_TABLE** displays load management information about completed jobs executed on each node. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Data is dumped from the kernel to this system catalog. If **enable_resource_record** is set to **on**, the system imports records from **16.2.9.6 GLOBAL_STATEMENT_COMPLEX_HISTORY** to this system catalog every 3 minutes. You are not advised to enable this function, because it occupies storage space and affects performance. Columns in this catalog are the same as those in **16.2.9.6 GLOBAL_STATEMENT_COMPLEX_HISTORY**.

## 16.2.9.8 GLOBAL_STATEMENT_COMPLEX_RUNTIME

**GLOBAL_STATEMENT_COMPLEX_RUNTIME** displays load management records of jobs that are being executed by the current user on each node. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 16-111** GLOBAL_STATEMENT_COMPLEX_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that this backend is connected to |
| dbname | name | Name of the database that the backend is connected to |
| schemaname | text | Schema name |
| nodename | text | Name of the CN where the statement is executed. |
| username | name | Username used for connecting to the backend. |
| application_name | text | Name of the application connected to the backend. |

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| Name | Type | Description |
| --- | --- | --- |
| client_addr | inet | IP address of the client connected to the backend. If this column is null, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with this backend (**-1** if a Unix socket is used) |
| query_band | text | Job type, which is specified by the GUC parameter **query_band**. The default value is a null string. |
| pid | bigint | Backend thread ID |
| block_time | bigint | Block time before the statement is executed (unit: ms) |
| start_time | timestamp with time zone | Time when the statement starts to be executed |
| duration | bigint | For how long the statement has been executing (unit: ms) |
| estimate_total_time | bigint | Estimated execution time of the statement (unit: ms) |
| estimate_left_time | bigint | Estimated remaining time of statement execution (unit: ms) |
| enqueue | text | Resource status in workload management. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| resource_pool | name | Resource pool used by the user |
| control_group | text | Cgroup used by the statement |
| estimate_memory | integer | Estimated memory used by the statement (unit: MB). This parameter takes effect only when **enable_dynamic_workload** is set to **on**. |
| min_peak_memory | integer | Minimum peak memory of the statement across all DNs (unit: MB) |

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| Name | Type | Description |
| --- | --- | --- |
| max_peak_memory | integer | Maximum peak memory of the statement across all DNs (unit: MB) |
| average_peak_memory | integer | Average memory usage during statement execution (unit: MB) |
| memory_skew_percent | integer | Memory usage skew of the statement among DNs |
| spill_info | text | Statement spill information on all DNs.<br>• **None**: No data is spilled to disks on all DNs.<br>• **All**: Data is spilled to disks on all DNs.<br>• **[*a*:*b*]**: The statement has been spilled to disks on *a* of *b* DNs. |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_dn_time | bigint | Minimum execution time of the statement across all DNs (unit: ms) |
| max_dn_time | bigint | Maximum execution time of the statement across all DNs (unit: ms) |
| average_dn_time | bigint | Average execution time of the statement across all DNs (unit: ms) |
| dntime_skew_percent | integer | Execution time skew of the statement among DNs |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs (unit: ms) |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs (unit: ms) |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs (unit: ms) |
| cpu_skew_percent | integer | CPU time skew of the statement among DNs |

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| Name | Type | Description |
| --- | --- | --- |
| min_peak_iops | integer | Minimum peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| max_peak_iops | integer | Maximum peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| average_peak_iops | integer | Average peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| iops_skew_percent | integer | I/O skew of the statement among DNs |
| warning | text | Warning. The following warnings and warnings related to **10.3.6.1 Optimizing SQL Self-Diagnosis** are displayed:<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |
| queryid | bigint | Internal query ID used for statement execution |
| query | text | Statement being executed |
| query_plan | text | Execution plan of the statement |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| top_cpu_dn | text | Top N CPU usage |
| top_mem_dn | text | Top N memory usage |

## 16.2.9.9 STATEMENT_RESPONSETIME_PERCENTILE

**STATEMENT_RESPONSETIME_PERCENTILE** obtains the response times of 80% and 95% SQL statements in the cluster.

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**Table 16-112** STATEMENT_RESPONSETIME_PERCENTILE columns

| Name | Type | Description |
| --- | --- | --- |
| p80 | bigint | Response time of 80% SQL statements in the cluster (unit: μs) |
| p95 | bigint | Response time of 95% SQL statements in the cluster (unit: μs) |

## 16.2.9.10 STATEMENT_COMPLEX_RUNTIME

**STATEMENT_COMPLEX_RUNTIME** displays load management information about jobs being executed by the current user on the current CN. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 16-113** STATEMENT_COMPLEX_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that this backend is connected to |
| dbname | name | Name of the database that the backend is connected to |
| schemaname | text | Schema name |
| nodename | text | Name of the CN where the statement is executed. |
| username | name | Username used for connecting to the backend |
| application_name | text | Name of the application connected to the backend |
| client_addr | inet | IP address of the client connected to the backend. If this column is null, it indicates either the client is connected via a Unix socket on the server or this is an internal process, such as autovacuum. |
| client_hostname | text | Host name of the connected client, as reported by a reverse DNS lookup of **client_addr**. This column will be non-null only for IP connections and only when **log_hostname** is enabled. |
| client_port | integer | TCP port number that the client uses for communication with this backend (**-1** if a Unix socket is used) |

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| Name | Type | Description |
| --- | --- | --- |
| query_band | text | Job type, which is specified by the GUC parameter **query_band**. The default value is a null string. |
| pid | bigint | Backend thread ID |
| block_time | bigint | Block time before the statement is executed (unit: ms) |
| start_time | timestamp with time zone | Time when the statement starts to be executed |
| duration | bigint | For how long the statement has been executing (unit: ms) |
| estimate_total_time | bigint | Estimated execution time of the statement (unit: ms) |
| estimate_left_time | bigint | Estimated remaining time of statement execution (unit: ms) |
| enqueue | text | Resource status in workload management. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| resource_pool | name | Resource pool used by the user |
| control_group | text | Cgroup used by the statement |
| estimate_memory | integer | Estimated memory used by the statement (unit: MB). This parameter takes effect only when **enable_dynamic_workload** is set to **on**. |
| min_peak_memory | integer | Minimum peak memory of the statement across all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory of the statement across all DNs (unit: MB) |
| average_peak_memory | integer | Average memory usage during statement execution (unit: MB) |
| memory_skew_percent | integer | Memory usage skew of the statement among DNs |

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| Name | Type | Description |
| --- | --- | --- |
| spill_info | text | Statement spill information on all DNs.<br>• **None**: No data is spilled to disks.<br>• **All**: Data is spilled to disks on all DNs.<br>• **[*a*:*b*]**: The statement has been spilled to disks on *a* of *b* DNs. |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_dn_time | bigint | Minimum execution time of the statement across all DNs (unit: ms) |
| max_dn_time | bigint | Maximum execution time of the statement across all DNs (unit: ms) |
| average_dn_time | bigint | Average execution time of the statement across all DNs (unit: ms) |
| dntime_skew_percent | integer | Execution time skew of the statement among DNs |
| min_cpu_time | bigint | Minimum CPU time of the statement across all DNs (unit: ms) |
| max_cpu_time | bigint | Maximum CPU time of the statement across all DNs (unit: ms) |
| total_cpu_time | bigint | Total CPU time of the statement across all DNs (unit: ms) |
| cpu_skew_percent | integer | CPU time skew of the statement among DNs |
| min_peak_iops | integer | Minimum peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| max_peak_iops | integer | Maximum peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |

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| Name | Type | Description |
| --- | --- | --- |
| average_peak_iops | integer | Average peak IOPS of the statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table. |
| iops_skew_percent | integer | I/O skew of the statement among DNs |
| warning | text | Warning. The following warnings and warnings related to **10.3.6.1 Optimizing SQL Self-Diagnosis** are displayed:<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |
| queryid | bigint | Internal query ID used for statement execution |
| query | text | Statement being executed |
| query_plan | text | Execution plan of the statement |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| top_cpu_dn | text | Top N CPU usage |
| top_mem_dn | text | Top N memory usage |

## 16.2.9.11 STATEMENT_COMPLEX_HISTORY_TABLE

**STATEMENT_COMPLEX_HISTORY_TABLE** displays load management information about completed jobs executed on the current CN. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) Data is dumped from the kernel to this system catalog. If **enable_resource_record** is set to **on**, the system imports records from **15.3.83 GS_WLM_SESSION_HISTORY** to this system catalog every 3 minutes. You are not advised to enable this function, because it occupies storage space and affects performance. Columns in this catalog are the same as those in **Table 15-190**.

## 16.2.9.12 STATEMENT_COMPLEX_HISTORY

**STATEMENT_COMPLEX_HISTORY** displays load management information about completed jobs executed on all CNs. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The data in this view is

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obtained from **15.2.33 GS_WLM_SESSION_QUERY_INFO_ALL**. Columns in this view are the same as those in **Table 15-190**.

## 16.2.9.13 STATEMENT_WLMSTAT_COMPLEX_RUNTIME

**STATEMENT_WLMSTAT_COMPLEX_RUNTIME** displays load management information about ongoing jobs executed by the current user. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 16-114** STATEMENT_WLMSTAT_COMPLEX_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| datid | oid | OID of the database that this backend is connected to |
| datname | name | Name of the database that the backend is connected to |
| threadid | bigint | Backend thread ID |
| processid | integer | PID of the backend thread |
| usesysid | oid | User OID for logging in to the backend |
| appname | text | Name of the application connected to the backend |
| usename | name | Name of the user logged in to the backend |
| priority | bigint | Priority of Cgroup where the statement is located |
| attribute | text | Attributes of the statement:<br>• **Ordinary**: default attribute of a statement before it is parsed by the database<br>• **Simple**: simple statements<br>• **Complicated**: complicated statements<br>• **Internal**: internal statement of the database |
| block_time | bigint | Pending duration of the statement by now, in seconds |
| elapsed_time | bigint | Actual execution duration of the statement by now, in seconds |
| total_cpu_time | bigint | Total CPU usage duration of the statement on the DN in the last period, in seconds |

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| Name | Type | Description |
| --- | --- | --- |
| cpu_skew_percent | integer | CPU usage skew percentage of the statement on the DN in the last period |
| statement_mem | integer | **statement_mem** used for executing the statement (reserved column) |
| active_points | integer | Number of concurrently active points occupied by the statement in the resource pool |
| dop_value | integer | DOP value obtained by the statement from the resource pool |
| control_group | text | Cgroup currently used by the statement |
| status | text | Status of the statement, including:<br>• **pending**: waiting to be executed<br>• **running**: being executed<br>• **finished**: finished normally (If **enqueue** is set to **StoredProc** or **Transaction**, this state indicates that only a part of jobs in the statement has been executed. This state persists until the finish of this statement.)<br>• **aborted**: terminated unexpectedly<br>• **active**: normal status except for those above<br>• **unknown**: unknown status |
| enqueue | text | Queuing status of the statement, including:<br>• **Global**: queuing in the global queue<br>• **Respool**: queuing in the resource pool queue<br>• **CentralQueue**: queuing on the CCN<br>• **Transaction**: being in a transaction block<br>• **StoredProc**: being in a stored procedure<br>• **None**: not in the queue<br>• **Forced None**: being forcibly executed (transaction block statement or stored procedure statement are) because the statement waiting time exceeds the specified value |

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| Name | Type | Description |
| --- | --- | --- |
| resource_pool | name | Current resource pool where the statements are located |
| query | text | Latest query at the backend. If **state** is **active**, this column shows the executing query. In all other states, it shows the last query that was executed. |
| is_plana | boolean | Whether a statement occupies the resources of other logical clusters in logical cluster mode. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The default value is **f** (does not occupy). |
| node_group | text | Logical cluster of the user running the statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

## 16.2.9.14 GS_SLOW_QUERY_INFO (Discarded)

**GS_SLOW_QUERY_INFO** displays the slow query information that has been dumped on the current node. Data is dumped from the kernel to this system catalog. If **enable_resource_record** is set to **on**, the system imports the query information from the kernel to **GS_WLM_SESSION_QUERY_INFO_ALL** every 3 minutes. This operation occupies storage space and affects performance. You can check **GS_SLOW_QUERY_INFO** to view the slow query information that has been dumped. This view has been discarded in this version.

**Table 16-115** GS_SLOW_QUERY_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| dbname | text | Database name |
| schemaname | text | Schema name |
| nodename | text | Node name |
| username | text | Username |
| queryid | bigint | Normalization ID |
| query | text | Query statement |
| start_time | timestamp with time zone | Execution start time |
| finish_time | timestamp with time zone | Execution end time |

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| Name | Type | Description |
| --- | --- | --- |
| duration | bigint | Execution duration (unit: ms) |
| query_plan | text | Plan inforation |
| n_returned_rows | bigint | Number of rows in the result set returned by the **SELECT** statement |
| n_tuples_fetched | bigint | Number of rows randomly scanned |
| n_tuples_returned | bigint | Number of rows sequentially scanned |
| n_tuples_inserted | bigint | Number of rows inserted |
| n_tuples_updated | bigint | Number of rows updated |
| n_tuples_deleted | bigint | Number of rows deleted |
| n_blocks_fetched | bigint | Number of cache loading times |
| n_blocks_hit | bigint | Cache hits |
| db_time | bigint | Valid DB time, which is accumulated if multiple threads are involved (unit: μs) |
| cpu_time | bigint | CPU time (unit: μs) |
| execution_time | bigint | Execution time in the executor (unit: μs) |
| parse_time | bigint | SQL parsing time (unit: μs) |
| plan_time | bigint | SQL plan generation time (unit: μs) |
| rewrite_time | bigint | SQL rewriting time (unit: μs) |
| pl_execution_time | bigint | Execution time of PL/pgSQL (unit: μs) |
| pl_compilation_time | bigint | Compilation time of PL/pgSQL (unit: μs) |
| net_send_time | bigint | Network time (unit: μs) |
| data_io_time | bigint | I/O time (unit: μs) |

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## 16.2.9.15 GS_SLOW_QUERY_HISTORY (Discarded)

**GS_SLOW_QUERY_HISTORY** displays the slow query information that is not dumped on the current node. For details, see **18.9.15 GS_SLOW_QUERY_INFO**. Only the **system admin** and **monitor admin** users have the permission to query this view. This view is discarded in this version.

## 16.2.9.16 GLOBAL_SLOW_QUERY_HISTORY (Discarded)

**GS_SLOW_QUERY_HISTORY** displays the slow query information that is not dumped on all nodes. This view is discarded in this version. For details, see **18.9.15 GS_SLOW_QUERY_INFO**.

## 16.2.9.17 GLOBAL_SLOW_QUERY_INFO (Discarded)

**GS_SLOW_QUERY_HISTORY** displays the slow query information that has been dumped on all nodes. This view is discarded in this version. For details, see **18.9.15 GS_SLOW_QUERY_INFO**.

## 16.2.9.18 STATEMENT_HISTORY

**STATEMENT_HISTORY** displays information about execution statements on the current node. To query a view, you must have the **sysadmin** or **monitor admin** permission. The result can be queried only in the system database but cannot be queried in the user database.

**Table 16-116** STATEMENT_HISTORY columns

| Name | Type | Description |
| --- | --- | --- |
| dbname | name | Database name. |
| schemaname | name | Schema name. |
| origin_node | integer | Node name. |
| user_name | name | Username. |
| application_name | text | Name of the application that sends a request. |
| client_addr | text | IP address of the client that sends a request. |
| client_port | integer | Port number of the client that sends a request. |
| unique_query_id | bigint | ID of the normalized SQL statement. |
| debug_query_id | bigint | ID of the unique SQL statement. |
| query | text | Normalized SQL (available only on CNs). |
| start_time | timestamp with time zone | Time when a statement starts. |

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| Name | Type | Description |
| --- | --- | --- |
| finish_time | timestamp with time zone | Time when a statement ends. |
| slow_sql_threshold | bigint | Standard for slow SQL statement execution. |
| transaction_id | bigint | Transaction ID. |
| thread_id | bigint | ID of an execution thread. |
| session_id | bigint | Session ID of a user. |
| n_soft_parse | bigint | Number of soft parsing times. The value of **n_soft_parse** plus the value of **n_hard_parse** may be greater than the value of **n_calls** because the number of subqueries is not counted in the value of **n_calls**. |
| n_hard_parse | bigint | Number of hard parsing times. The value of **n_soft_parse** plus the value of **n_hard_parse** may be greater than the value of **n_calls** because the number of subqueries is not counted in the value of **n_calls**. |
| query_plan | text | Statement execution plan. |
| n_returned_rows | bigint | Number of rows in the result set returned by the **SELECT** statement. |
| n_tuples_fetched | bigint | Number of rows randomly scanned. |
| n_tuples_returned | bigint | Number of rows sequentially scanned. |
| n_tuples_inserted | bigint | Number of rows inserted. |
| n_tuples_updated | bigint | Number of rows updated. |
| n_tuples_deleted | bigint | Number of rows deleted. |
| n_blocks_fetched | bigint | Number of buffer block access times. |
| n_blocks_hit | bigint | Number of buffer block hits. |
| db_time | bigint | Valid DB time, which is accumulated if multiple threads are involved (unit: μs) |
| cpu_time | bigint | CPU time (unit: μs). |

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| Name | Type | Description |
| --- | --- | --- |
| execution_time | bigint | Execution time in the executor (unit: μs). |
| parse_time | bigint | SQL parsing time (unit: μs) |
| plan_time | bigint | SQL plan generation time (unit: μs). |
| rewrite_time | bigint | SQL rewriting time (unit: μs). |
| pl_execution_time | bigint | Execution time of PL/pgSQL (unit: μs). |
| pl_compilation_time | bigint | Compilation time of PL/pgSQL (unit: μs) |
| data_io_time | bigint | I/O time (unit: μs). |
| net_send_info | text | Network status of messages sent through a physical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, CNs communicate with each other, CNs communicate with customer service ends, and CNs communicate with DNs through physical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system. Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| net_recv_info | text | Network status of messages received through a physical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, CNs communicate with each other, CNs communicate with customer service ends, and CNs communicate with DNs through physical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system. Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| net_stream_send_info | text | Network status of messages sent through a logical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, DNs of different shards communicate with each other through logical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |

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| Name | Type | Description |
| --- | --- | --- |
| net_stream_recv_info | text | Network status of messages received through a logical connection, including the time (unit: μs), number of calls, and throughput (unit: byte). In a distributed database, DNs of different shards communicate with each other through logical connections. This column can be used to analyze the network overhead of SQL statements in a distributed system.<br>Example: {"time":xxx, "n_calls":xxx, "size":xxx}. |
| lock_count | bigint | Number of locks. |
| lock_time | bigint | Time required for locking. |
| lock_wait_count | bigint | Number of lock waits. |
| lock_wait_time | bigint | Time required for lock waiting. |
| lock_max_count | bigint | Maximum number of locks. |
| lwlock_count | bigint | Number of lightweight locks (reserved). |
| lwlock_wait_count | bigint | Number of lightweight lock waits. |
| lwlock_time | bigint | Time required for lightweight locking (reserved). |
| lwlock_wait_time | bigint | Time required for lightweight lock waiting. |
| details | bytea | List of statement lock events, which are recorded in chronological order. The number of records is affected by the **track_stmt_details_size** parameter. This column is binary and needs to be read using the parsing function **pg_catalog.statement_detail_decode**. For details, see **12.5.26.12 Other Functions**.<br>Events include:<br>Start locking.<br>Complete locking.<br>Start lock waiting.<br>Complete lock waiting.<br>Start unlocking.<br>Complete unlocking.<br>Start lightweight lock waiting.<br>Complete lightweight lock waiting. |

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| Name | Type | Description |
| --- | --- | --- |
| is_slow_sql | boolean | Whether the SQL statement is a slow SQL statement. |
| trace_id | text | Driver-specific trace ID, which is associated with an application request. |
| advise | text | Risks which may cause slow SQL statements. (Multiple risks may exist at the same time.)<br>• **Cast Function Cause Index Miss.**: Index matching may fail due to implicit conversion.<br>• **Limit too much rows.**: The SQL statement execution may slow down due to a large **limit** value.<br>• **Proleakproof of function is false.**: The **proleakproof** of the function is set to **false**. In this case, the function does not use statistics when generating a plan due to data leakage risks. As a result, the accuracy of the generated plan is affected and the SQL statement execution may slow down. |

# 16.2.10 Cache and I/O

## 16.2.10.1 STATIO_USER_TABLES

**STATIO_USER_TABLES** displays I/O status information about all user relationship tables in the namespace.

**Table 16-117** STATIO_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |
| heap_blks_hit | bigint | Number of cache hits in the table |

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| Name | Type | Description |
| --- | --- | --- |
| idx_blks_read | bigint | Number of disk blocks read from indexes in the table |
| idx_blks_hit | bigint | Number of cache hits in indexes in the table |
| toast_blks_read | bigint | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in TOAST tables (if any) in the table |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer hits in the TOAST table index (if any) in the table |

## 16.2.10.2 SUMMARY_STATIO_USER_TABLES

**SUMMARY_STATIO_USER_TABLES** displays I/O status information about all user relationship tables in namespaces in the cluster.

**Table 16-118** SUMMARY_STATIO_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | numeric | Number of disk blocks read from the table |
| heap_blks_hit | numeric | Number of cache hits in the table |
| idx_blks_read | numeric | Number of disk blocks read from indexes in the table |
| idx_blks_hit | numeric | Number of cache hits in indexes in the table |
| toast_blks_read | numeric | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | numeric | Number of buffer hits in TOAST tables (if any) in the table |
| tidx_blks_read | numeric | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | numeric | Number of buffer hits in the TOAST table index (if any) in the table |

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## 16.2.10.3 GLOBAL_STATIO_USER_TABLES

**GLOBAL_STATIO_USER_TABLES** displays I/O status information about all user relationship tables in namespaces on each node.

**Table 16-119** GLOBAL_STATIO_USER_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |
| heap_blks_hit | bigint | Number of cache hits in the table |
| idx_blks_read | bigint | Number of disk blocks read from indexes in the table |
| idx_blks_hit | bigint | Number of cache hits in indexes in the table |
| toast_blks_read | bigint | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in TOAST tables (if any) in the table |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer hits in the TOAST table index (if any) in the table |

## 16.2.10.4 STATIO_USER_INDEXES

**STATIO_USER_INDEXES** displays I/O status information about all user relationship table indexes in namespaces on the current node.

**Table 16-120** STATIO_USER_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |

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| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |
| idx_blks_read | bigint | Number of disk blocks read from the index |
| idx_blks_hit | bigint | Number of cache hits in the index |

## 16.2.10.5 SUMMARY_STATIO_USER_INDEXES

**SUMMARY_STATIO_USER_INDEXES** displays I/O status information about all user relationship table indexes in namespaces in the cluster.

**Table 16-121** SUMMARY_STATIO_USER_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |
| idx_blks_read | numeric | Number of disk blocks read from the index |
| idx_blks_hit | numeric | Number of cache hits in the index |

## 16.2.10.6 GLOBAL_STATIO_USER_INDEXES

**GLOBAL_STATIO_USER_INDEXES** displays I/O status information about all user relationship table indexes in namespaces on each node.

**Table 16-122** GLOBAL_STATIO_USER_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |

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| Name | Type | Description |
| --- | --- | --- |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |
| idx_blks_read | numeric | Number of disk blocks read from the index |
| idx_blks_hit | numeric | Number of cache hits in the index |

## 16.2.10.7 STATIO_USER_SEQUENCES

**STATIO_USER_SEQUENCE** displays I/O status information about all user-defined sequences in namespaces on the current node.

**Table 16-123** STATIO_USER_SEQUENCE columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the sequence |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Number of cache hits in the sequence |

## 16.2.10.8 SUMMARY_STATIO_USER_SEQUENCES

**SUMMARY_STATIO_USER_SEQUENCES** displays I/O status information about all user-defined sequences in namespaces in the cluster.

**Table 16-124** SUMMARY_STATIO_USER_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | numeric | Number of disk blocks read from the sequence |
| blks_hit | numeric | Number of cache hits in the sequence |

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## 16.2.10.9 GLOBAL_STATIO_USER_SEQUENCES

**GLOBAL_STATIO_USER_SEQUENCES** displays I/O status information about all user-defined sequences in namespaces on each node.

**Table 16-125** GLOBAL_STATIO_USER_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the sequence |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Number of cache hits in the sequence |

## 16.2.10.10 STATIO_SYS_TABLES

**PG_STATIO_SYS_TABLES** displays I/O status information about all system catalogs in the current namespace.

**Table 16-126** STATIO_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |
| heap_blks_hit | bigint | Number of cache hits in the table |
| idx_blks_read | bigint | Number of disk blocks read from indexes in the table |
| idx_blks_hit | bigint | Number of cache hits in indexes in the table |
| toast_blks_read | bigint | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in TOAST tables (if any) in the table |

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| Name | Type | Description |
| --- | --- | --- |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer hits in the TOAST table index (if any) in the table |

## 16.2.10.11 SUMMARY_STATIO_SYS_TABLES

**SUMMARY_STATIO_SYS_TABLES** displays I/O status information about all system catalogs in namespaces in the cluster.

**Table 16-127** SUMMARY_STATIO_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | numeric | Number of disk blocks read from the table |
| heap_blks_hit | numeric | Number of cache hits in the table |
| idx_blks_read | numeric | Number of disk blocks read from indexes in the table |
| idx_blks_hit | numeric | Number of cache hits in indexes in the table |
| toast_blks_read | numeric | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | numeric | Number of buffer hits in TOAST tables (if any) in the table |
| tidx_blks_read | numeric | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | numeric | Number of buffer hits in the TOAST table index (if any) in the table |

## 16.2.10.12 GLOBAL_STATIO_SYS_TABLES

**GLOBAL_STATIO_SYS_TABLES** displays I/O status information about all system catalogs in namespaces on each node.

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**Table 16-128** GLOBAL_STATIO_SYS_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |
| heap_blks_hit | bigint | Number of cache hits in the table |
| idx_blks_read | bigint | Number of disk blocks read from indexes in the table |
| idx_blks_hit | bigint | Number of cache hits in indexes in the table |
| toast_blks_read | bigint | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in TOAST tables (if any) in the table |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer hits in the TOAST table index (if any) in the table |

## 16.2.10.13 STATIO_SYS_INDEXES

**STATIO_SYS_INDEXES** displays the I/O status information about all system catalog indexes in the current namespace.

**Table 16-129** STATIO_SYS_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |

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| Name | Type | Description |
| --- | --- | --- |
| idx_blks_read | bigint | Number of disk blocks read from the index |
| idx_blks_hit | bigint | Number of cache hits in the index |

## 16.2.10.14 SUMMARY_STATIO_SYS_INDEXES

**SUMMARY_STATIO_SYS_INDEXES** displays I/O status information about all system catalog indexes in namespaces in the cluster.

**Table 16-130** SUMMARY_STATIO_SYS_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |
| idx_blks_read | numeric | Number of disk blocks read from the index |
| idx_blks_hit | numeric | Number of cache hits in the index |

## 16.2.10.15 GLOBAL_STATIO_SYS_INDEXES

**GLOBAL_STATIO_SYS_INDEXES** displays I/O status information about all system catalog indexes in namespaces on each node.

**Table 16-131** GLOBAL_STATIO_SYS_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |
| idx_blks_read | numeric | Number of disk blocks read from the index |

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| Name | Type | Description |
| --- | --- | --- |
| idx_blks_hit | numeric | Number of cache hits in the index |

## 16.2.10.16 STATIO_SYS_SEQUENCES

**STATIO_SYS_SEQUENCES** displays the I/O status information about all the system sequences in the current namespace.

**Table 16-132** STATIO_SYS_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the sequence |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Number of cache hits in the sequence |

## 16.2.10.17 SUMMARY_STATIO_SYS_SEQUENCES

**SUMMARY_STATIO_SYS_SEQUENCES** displays I/O status information about all system sequences in namespaces in the cluster.

**Table 16-133** SUMMARY_STATIO_SYS_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | numeric | Number of disk blocks read from the sequence |
| blks_hit | numeric | Number of cache hits in the sequence |

## 16.2.10.18 GLOBAL_STATIO_SYS_SEQUENCES

**GLOBAL_STATIO_SYS_SEQUENCES** displays I/O status information about all system sequences in namespaces on each node.

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**Table 16-134** GLOBAL_STATIO_SYS_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the sequence |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Number of cache hits in the sequence |

## 16.2.10.19 STATIO_ALL_TABLES

**STATIO_ALL_TABLES** contains I/O statistics about a row of each table (including TOAST tables) in databases.

**Table 16-135** STATIO_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |
| heap_blks_hit | bigint | Number of cache hits in the table |
| idx_blks_read | bigint | Number of disk blocks read from indexes in the table |
| idx_blks_hit | bigint | Number of cache hits in indexes in the table |
| toast_blks_read | bigint | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in TOAST tables (if any) in the table |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer hits in the TOAST table index (if any) in the table |

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## 16.2.10.20 SUMMARY_STATIO_ALL_TABLES

**SUMMARY_STATIO_ALL_TABLES** contains I/O statistics about each table (including TOAST tables) in databases in the cluster.

**Table 16-136** SUMMARY_STATIO_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | numeric | Number of disk blocks read from the table |
| heap_blks_hit | numeric | Number of cache hits in the table |
| idx_blks_read | numeric | Number of disk blocks read from indexes in the table |
| idx_blks_hit | numeric | Number of cache hits in indexes in the table |
| toast_blks_read | numeric | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | numeric | Number of buffer hits in TOAST tables (if any) in the table |
| tidx_blks_read | numeric | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | numeric | Number of buffer hits in the TOAST table index (if any) in the table |

## 16.2.10.21 GLOBAL_STATIO_ALL_TABLES

**GLOBAL_STATIO_ALL_TABLES** contains I/O statistics about each table (including TOAST tables) in databases on each node.

**Table 16-137** GLOBAL_STATIO_ALL_TABLES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | Table OID |
| schemaname | name | Name of the schema that the table is in |
| relname | name | Table name |
| heap_blks_read | bigint | Number of disk blocks read from the table |

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| Name | Type | Description |
| --- | --- | --- |
| heap_blks_hit | bigint | Number of cache hits in the table |
| idx_blks_read | bigint | Number of disk blocks read from indexes in the table |
| idx_blks_hit | bigint | Number of cache hits in indexes in the table |
| toast_blks_read | bigint | Number of disk blocks read from TOAST tables (if any) in the table |
| toast_blks_hit | bigint | Number of buffer hits in TOAST tables (if any) in the table |
| tidx_blks_read | bigint | Number of disk blocks read from the TOAST tables index (if any) in the table |
| tidx_blks_hit | bigint | Number of buffer hits in the TOAST table index (if any) in the table |

## 16.2.10.22 STATIO_ALL_INDEXES

**STATIO_ALL_INDEXES** contains one row for each index in the current database, showing I/O statistics about specific indexes.

**Table 16-138** STATIO_ALL_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |
| idx_blks_read | bigint | Number of disk blocks read from the index |
| idx_blks_hit | bigint | Number of cache hits in the index |

## 16.2.10.23 SUMMARY_STATIO_ALL_INDEXES

**SUMMARY_.STATIO_ALL_INDEXES** contains I/O statistics about each index row in databases in the cluster.

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**Table 16-139** SUMMARY_STATIO_ALL_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |
| idx_blks_read | numeric | Number of disk blocks read from the index |
| idx_blks_hit | numeric | Number of cache hits in the index |

## 16.2.10.24 GLOBAL_STATIO_ALL_INDEXES

**GLOBAL_STATIO_ALL_INDEXES** contains I/O statistics about one row of each index in databases on each node.

**Table 16-140** GLOBAL_STATIO_ALL_INDEXES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the table that the index is created for |
| indexrelid | oid | OID of the index |
| schemaname | name | Name of the schema that the index is in |
| relname | name | Name of the table that the index is created for |
| indexrelname | name | Index name |
| idx_blks_read | numeric | Number of disk blocks read from the index |
| idx_blks_hit | numeric | Number of cache hits in the index |

## 16.2.10.25 STATIO_ALL_SEQUENCES

**STATIO_ALL_SEQUENCES** contains one row for each sequence in the current database, showing I/O statistics about specific sequences.

**Table 16-141** STATIO_ALL_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | OID of the sequence |

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| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Number of cache hits in the sequence |

## 16.2.10.26 SUMMARY_STATIO_ALL_SEQUENCES

**SUMMARY_STATIO_ALL_SEQUENCES** contains I/O statistics about one row of each sequence in databases in the cluster.

**Table 16-142** SUMMARY_STATIO_ALL_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | numeric | Number of disk blocks read from the sequence |
| blks_hit | numeric | Number of cache hits in the sequence |

## 16.2.10.27 GLOBAL_STATIO_ALL_SEQUENCES

**GLOBAL_STATIO_ALL_SEQUENCES** contains I/O statistics about one row of each sequence in databases on each node.

**Table 16-143** GLOBAL_STATIO_ALL_SEQUENCES columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| relid | oid | OID of the sequence |
| schemaname | name | Name of the schema that the sequence is in |
| relname | name | Sequence name |
| blks_read | bigint | Number of disk blocks read from the sequence |
| blks_hit | bigint | Number of cache hits in the sequence |

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### 16.2.10.28 GLOBAL_STAT_DB_CU

**GLOBAL_STAT_DB_CU** displays CU hits on each node in each database in the cluster. You can clear it using **gs_stat_reset()**.

**Table 16-144** GLOBAL_STAT_DB_CU columns

| Name | Type | Description |
| --- | --- | --- |
| node_name1 | text | Node name |
| db_name | text | Database name |
| mem_hit | bigint | Number of memory hits |
| hdd_sync_read | bigint | Number of hard disk synchronous reads |
| hdd_asyn_read | bigint | Number of hard disk asynchronous reads |

### 16.2.10.29 GLOBAL_STAT_SESSION_CU

**GLOBAL_STAT_SESSION_CU** displays CU hits of running sessions on each node in the cluster. This data about a session is cleared when you exit this session After the cluster is restarted, the statistics are also cleared.

**Table 16-145** GLOBAL_STAT_SESSION_CU columns

| Name | Type | Description |
| --- | --- | --- |
| node_name1 | text | Node name |
| mem_hit | integer | Number of memory hits |
| hdd_sync_read | integer | Number of hard disk synchronous reads |
| hdd_asyn_read | integer | Number of hard disk asynchronous reads |

## 16.2.11 Communication Library

### 16.2.11.1 COMM_DELAY

**COMM_DELAY** displays the TCP proxy communications library status for a single DN.

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**Table 16-146** COMM_DELAY columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| remote_name | text | Name of the peer node |
| remote_host | text | IP address of the peer node |
| stream_num | integer | Number of logical stream connections used by the current physical connection |
| min_delay | integer | Minimum delay of the current physical connection within 1 minute (unit: μs)<br>**NOTE**<br>A negative result is invalid. Wait until the delay status is updated and query again. |
| average | integer | Average delay of the current physical connection within 1 minute (unit: μs) |
| max_delay | integer | Maximum delay of the current physical connection within 1 minute (unit: μs) |

## 16.2.11.2 GLOBAL_COMM_DELAY

**GLOBAL_COMM_DELAY** displays the TCP proxy communications library status for all the DNs.

**Table 16-147** GLOBAL_COMM_DELAY columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| remote_name | text | Name of the peer node |
| remote_host | text | IP address of the peer node |
| stream_num | integer | Number of logical stream connections used by the current physical connection |
| min_delay | integer | Minimum delay of the current physical connection within 1 minute (unit: μs)<br>**NOTE**<br>A negative result is invalid. Wait until the delay status is updated and query again. |
| average | integer | Average delay of the current physical connection within 1 minute (unit: μs) |

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| Name | Type | Description |
| --- | --- | --- |
| max_delay | integer | Maximum delay of the current physical connection within 1 minute (unit: μs) |

## 16.2.11.3 COMM_RECV_STREAM

**COMM_RECV_STREAM** displays the receiving stream status of all TCP proxy communications libraries on a single DN.

**Table 16-148** COMM_RECV_STREAM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| local_tid | bigint | ID of the thread using this stream |
| remote_name | text | Name of the peer node |
| remote_tid | bigint | Peer thread ID |
| idx | integer | Peer DN ID in the local DN |
| sid | integer | Stream ID in the physical connection |
| tcp_sock | integer | TCP socket used in the stream |
| state | text | Stream status |
| query_id | bigint | **debug_query_id** corresponding to the stream |
| pn_id | integer | **plan_node_id** of the query executed by the stream |
| send_smp | integer | **smpid** of the sender of the query executed by the stream |
| recv_smp | integer | **smpid** of the receiver of the query executed by the stream |
| recv_bytes | bigint | Total data volume received by the stream (unit: byte) |
| time | bigint | Current lifecycle service duration of the stream (unit: ms) |
| speed | bigint | Average receiving rate of the stream (unit: byte/s) |
| quota | bigint | Current communication quota value of the stream (unit: byte) |
| buff_usize | bigint | Current size of the data cache of the stream (unit: byte) |

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## 16.2.11.4 GLOBAL_COMM_RECV_STREAM

**GLOBAL_COMM_RECV_STREAM** displays the receiving stream status of all TCP proxy communications libraries on all the DNs.

**Table 16-149** GLOBAL_COMM_RECV_STREAM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| local_tid | bigint | ID of the thread using this stream |
| remote_name | text | Name of the peer node |
| remote_tid | bigint | Peer thread ID |
| idx | integer | Peer DN ID in the local DN |
| sid | integer | Stream ID in the physical connection |
| tcp_sock | integer | TCP socket used in the stream |
| state | text | Stream status |
| query_id | bigint | **debug_query_id** corresponding to the stream |
| pn_id | integer | **plan_node_id** of the query executed by the stream |
| send_smp | integer | **smpid** of the sender of the query executed by the stream |
| recv_smp | integer | **smpid** of the receiver of the query executed by the stream |
| recv_bytes | bigint | Total data volume received by the stream (unit: byte) |
| time | bigint | Current lifecycle service duration of the stream (unit: ms) |
| speed | bigint | Average receiving rate of the stream (unit: byte/s) |
| quota | bigint | Current communication quota value of the stream (unit: byte) |
| buff_usize | bigint | Current size of the data cache of the stream (unit: byte) |

## 16.2.11.5 COMM_SEND_STREAM

**COMM_SEND_STREAM** displays the sending stream status of all TCP proxy communications libraries on a single DN.

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**Table 16-150** COMM_SEND_STREAM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| local_tid | bigint | ID of the thread using this stream |
| remote_name | text | Name of the peer node |
| remote_tid | bigint | Peer thread ID |
| idx | integer | Peer DN ID in the local DN |
| sid | integer | Stream ID in the physical connection |
| tcp_sock | integer | TCP socket used in the stream |
| state | text | Stream status |
| query_id | bigint | **debug_query_id** corresponding to the stream |
| pn_id | integer | **plan_node_id** of the query executed by the stream |
| send_smp | integer | **smpid** of the sender of the query executed by the stream |
| recv_smp | integer | **smpid** of the receiver of the query executed by the stream |
| send_bytes | bigint | Total data volume sent by the stream (unit: byte) |
| time | bigint | Current lifecycle service duration of the stream (unit: ms) |
| speed | bigint | Average sending rate of the stream (unit: byte/s) |
| quota | bigint | Current communication quota value of the stream (unit: byte) |
| wait_quota | bigint | Extra time generated when the stream waits for the quota value (unit: ms) |

## 16.2.11.6 GLOBAL_COMM_SEND_STREAM

**GLOBAL_COMM_SEND_STREAM** displays the sending stream status of all TCP proxy communications libraries on all the DNs.

**Table 16-151** GLOBAL_COMM_SEND_STREAM columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| local_tid | bigint | ID of the thread using this stream |

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| Name | Type | Description |
| --- | --- | --- |
| remote_name | text | Name of the peer node |
| remote_tid | bigint | Peer thread ID |
| idx | integer | Peer DN ID in the local DN |
| sid | integer | Stream ID in the physical connection |
| tcp_sock | integer | TCP socket used in the stream |
| state | text | Stream status |
| query_id | bigint | **debug_query_id** corresponding to the stream |
| pn_id | integer | **plan_node_id** of the query executed by the stream |
| send_smp | integer | **smpid** of the sender of the query executed by the stream |
| recv_smp | integer | **smpid** of the receiver of the query executed by the stream |
| send_bytes | bigint | Total data volume sent by the stream (unit: byte) |
| time | bigint | Current lifecycle service duration of the stream (unit: ms) |
| speed | bigint | Average sending rate of the stream (unit: byte/s) |
| quota | bigint | Current communication quota value of the stream (unit: byte) |
| wait_quota | bigint | Extra time generated when the stream waits for the quota value (unit: ms) |

## 16.2.11.7 COMM_STATUS

**COMM_STATUS** displays the TCP proxy communications library status on a single DN.

**Table 16-152** COMM_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| rxpck_rate | integer | Receiving rate of the communication library on the node, in byte/s |
| txpck_rate | integer | Sending rate of the communication library on the node, in byte/s |

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| Name | Type | Description |
| --- | --- | --- |
| rxkbyte_rate | bigint | Receiving rate of the communication library on the node, in kbyte/s |
| txkbyte_rate | bigint | Sending rate of the communication library on the node, in kbyte/s |
| buffer | bigint | Size of the buffer of the Cmailbox |
| memkbyte_libcomm | bigint | Communication memory size of the **libcomm** process, in bytes |
| memkbyte_libpq | bigint | Communication memory size of the **libpq** process, in bytes |
| used_pm | integer | Real-time usage of the **postmaster** thread |
| used_sflow | integer | Real-time usage of the **gs_sender_flow_controller** thread |
| used_rflow | integer | Real-time usage of the **gs_receiver_flow_controller** thread |
| used_rloop | integer | Highest real-time usage among multiple **gs_receivers_loop** threads |
| stream | integer | Total number of used logical connections. |

## 16.2.11.8 GLOBAL_COMM_STATUS

**GLOBAL_COMM_STATUS** displays the TCP proxy communications library status on all the DNs.

**Table 16-153** GLOBAL_COMM_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| rxpck_rate | integer | Receiving rate of the communication library on the node, in byte/s |
| txpck_rate | integer | Sending rate of the communication library on the node, in byte/s |
| rxkbyte_rate | bigint | Receiving rate of the communication library on the node, in kbyte/s |
| txkbyte_rate | bigint | Sending rate of the communication library on the node, in kbyte/s |
| buffer | bigint | Size of the buffer of the Cmailbox |

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| Name | Type | Description |
| --- | --- | --- |
| memkbyte_libcomm | bigint | Communication memory size of the **libcomm** process, in bytes |
| memkbyte_libpq | bigint | Communication memory size of the **libpq** process, in bytes |
| used_pm | integer | Real-time usage of the **postmaster** thread |
| used_sflow | integer | Real-time usage of the **gs_sender_flow_controller** thread |
| used_rflow | integer | Real-time usage of the **gs_receiver_flow_controller** thread |
| used_rloop | integer | Highest real-time usage among multiple **gs_receivers_loop** threads |
| stream | integer | Total number of used logical connections. |

# 16.2.12 Utility

## 16.2.12.1 REPLICATION_STAT

**REPLICATION_STAT** describes information about log synchronization status, such as the locations where the sender sends logs and where the receiver receives logs.

**Table 16-154** REPLICATION_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| pid | bigint | Process ID of the thread |
| usesysid | oid | User system ID |
| usename | name | Username |
| application_name | text | Program name |
| client_addr | inet | Client address |
| client_hostname | text | Client name |
| client_port | integer | Port of the client |
| backend_start | timestamp with time zone | Start time of the program |
| state | text | Log replication state (catch-up or consistent streaming) |
| sender_sent_location | text | Location where the sender sends logs |

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| Name | Type | Description |
| --- | --- | --- |
| receiver_write_location | text | Location where the receiver writes logs |
| receiver_flush_location | text | Location where the receiver flushes logs |
| receiver_replay_location | text | Location where the receiver replays logs |
| sync_priority | integer | Priority of synchronous duplication (**0** indicates asynchronization.) |
| sync_state | text | Synchronization status (asynchronous duplication, synchronous duplication, or potential synchronization) |

## 16.2.12.2 GLOBAL_REPLICATION_STAT

**GLOBAL_REPLICATION_STAT** displays information about log synchronization status on each node, such as the locations where the sender sends logs and where the receiver receives logs.

**Table 16-155** GLOBAL_REPLICATION_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| pid | bigint | Process ID of the thread |
| usesysid | oid | User system ID |
| usename | name | Username |
| application_name | text | Program name |
| client_addr | inet | Client address |
| client_hostname | text | Client name |
| client_port | integer | Port of the client |
| backend_start | timestamp with time zone | Start time of the program |
| state | text | Log replication state (catch-up or consistent streaming) |
| sender_sent_location | text | Location where the sender sends logs |
| receiver_write_location | text | Location where the receiver writes logs |

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| Name | Type | Description |
| --- | --- | --- |
| receiver_flush_location | text | Location where the receiver flushes logs |
| receiver_replay_location | text | Location where the receiver replays logs |
| sync_priority | integer | Priority of synchronous duplication (**0** indicates asynchronization.) |
| sync_state | text | Synchronization state:<br>• Asynchronous replication<br>• Synchronous replication<br>• Potential synchronization |

## 16.2.12.3 REPLICATION_SLOTS

**REPLICATION_SLOTS** displays replication slot information.

**Table 16-156** REPLICATION_SLOTS columns

| Name | Type | Description |
| --- | --- | --- |
| slot_name | text | Replication slot name. |
| plugin | text | Name of the output plug-in corresponding to the logical replication slot. |
| slot_type | text | Replication slot type.<br>• **physical**: physical replication slot.<br>• **logical**: logical replication slot. |
| datoid | oid | OID of the database where the replication slot resides. |
| database | name | Name of the database where the replication slot resides. |
| active | boolean | Determines whether the replication slot is activated.<br>• **t** (true): yes<br>• **f** (false): no |
| xmin | xid | XID of the earliest transaction that the database must reserve for the replication slot. |
| catalog_xmin | xid | XID of the earliest system catalog-involved transaction that the database must reserve for the logical replication slot. |

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| Name | Type | Description |
| --- | --- | --- |
| restart_lsn | text | Physical location of the earliest Xlog required by the replication slot. |
| dummy_standby | boolean | Determines whether the peer end connected to the replication slot is a secondary node.<br>• **t** (true): yes<br>• **f** (false): no |

## 16.2.12.4 GLOBAL_REPLICATION_SLOTS

**GLOBAL_REPLICATION_SLOTS** displays information about replicated slots on each node in the cluster.

**Table 16-157** GLOBAL_REPLICATION_SLOTS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| slot_name | text | Replication slot name. |
| plugin | text | Name of the output plug-in corresponding to the logical replication slot. |
| slot_type | text | Replication slot type.<br>• **physical**: physical replication slot.<br>• **logical**: logical replication slot. |
| datoid | oid | OID of the database where the replication slot resides. |
| database | name | Name of the database where the replication slot resides. |
| active | boolean | Determines whether the replication slot is activated.<br>• **t** (true): yes<br>• **f** (false): no |
| x_min | xid | XID of the earliest transaction that the database must reserve for the replication slot. |
| catalog_xmin | xid | XID of the earliest system catalog-involved transaction that the database must reserve for the logical replication slot. |
| restart_lsn | text | Physical location of the earliest Xlog required by the replication slot. |

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| Name | Type | Description |
| --- | --- | --- |
| dummy_standby | boolean | Determines whether the peer end connected to the replication slot is a secondary node.<br>• **t** (true): yes<br>• **f** (false): no |

## 16.2.12.5 BGWRITER_STAT

**BGWRITER_STAT** displays statistics about the background writer process's activities.

**Table 16-158** BGWRITER_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| checkpoints_timed | bigint | Number of scheduled checkpoints that have been performed |
| checkpoints_req | bigint | Number of requested checkpoints that have been performed |
| checkpoint_write_time | double precision | Total time that has been spent in the portion of checkpoint processing where files are written to disk (unit: ms) |
| checkpoint_sync_time | double precision | Total time that has been spent in the portion of checkpoint processing where files are synchronized to disk (unit: ms) |
| buffers_checkpoint | bigint | Number of buffers written during checkpoints |
| buffers_clean | bigint | Number of buffers written by the background writer |
| maxwritten_clean | bigint | Number of times the background writer stopped a cleaning scan because it had written too many buffers |
| buffers_backend | bigint | Number of buffers written directly by the backend |
| buffers_backend_fsync | bigint | Number of times the backend had to execute its own fsync call (normally the background writer handles those even when the backend does its own write) |
| buffers_alloc | bigint | Number of buffers allocated |
| stats_reset | timestamp with time zone | Time at which these statistics were last reset |

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## 16.2.12.6 GLOBAL_BGWRITER_STAT

**GLOBAL_BGWRITER_STAT** displays statistics about the background writer process's activities on each node.

**Table 16-159** GLOBAL_BGWRITER_STAT columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| checkpoints_timed | bigint | Number of scheduled checkpoints that have been performed |
| checkpoints_req | bigint | Number of requested checkpoints that have been performed |
| checkpoint_write_time | double precision | Total time that has been spent in the portion of checkpoint processing where files are written to disk (unit: ms) |
| checkpoint_sync_time | double precision | Total time that has been spent in the portion of checkpoint processing where files are synchronized to disk (unit: ms) |
| buffers_checkpoint | bigint | Number of buffers written during checkpoints |
| buffers_clean | bigint | Number of buffers written by the background writer |
| maxwritten_clean | bigint | Number of times the background writer stopped a cleaning scan because it had written too many buffers |
| buffers_backend | bigint | Number of buffers written directly by a backend |
| buffers_backend_fsync | bigint | Number of times the backend had to execute its own fsync call (normally the background writer handles those even when the backend does its own write) |
| buffers_alloc | bigint | Number of buffers allocated |
| stats_reset | timestamp with time zone | Time at which these statistics were last reset |

## 16.2.12.7 POOLER_STATUS

**POOLER_STATUS** is used to query the cache connection status of the pooler module on the local CN.

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**Table 16-160** POOLER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| database | text | Database name |
| user_name | text | Username |
| tid | bigint | In non-thread pool logic, this parameter indicates the ID of the thread connected to the CN. In thread pool logic, this parameter indicates the ID of the session connected to the CN. |
| node_oid | bigint | OID of the node connected |
| node_name | name | Name of the node connected |
| in_use | boolean | Whether the connection is currently used.<br>• **t** (true): The connection is in use.<br>• **f** (false): The connection is not in use. |
| node_port | integer | Port number of the node connected |
| fdsock | bigint | Port file descriptor |
| remote_pid | bigint | Thread ID of the remote node connected |
| session_params | text | Session parameter |
| used_count | bigint | Number of reuse times of a connection |
| idx | bigint | Logical connection ID of the connected instance node |
| streamid | bigint | Stream ID corresponding to each logical connection |

## 16.2.12.8 GLOBAL_COMM_CHECK_CONNECTION_STATUS

**GLOBAL_COMM_CHECK_CONNECTION_STATUS** displays the connection status of all CNs and all active nodes (CNs and primary DNs). The permission control is inherited from the **DBE_PERF** schema.

**Table 16-161** GLOBAL_COMM_CHECK_CONNECTION_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |

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| Name | Type | Description |
| --- | --- | --- |
| remote_name | text | Name of the peer instance |
| remote_host | text | IP address of the peer instance |
| remote_port | integer | Port number of the peer instance |
| is_connected | boolean | Detection result of the connection between the current instance and the peer instance<br>• **t** (true) indicates that the connection is normal.<br>• **f** (false) indicates that the connection is abnormal. |
| no_error_occur | boolean | Pooler connection result between the current instance and the peer instance<br>• **t** (true) indicates that the pooler connection is normal.<br>• **f** (false) indicates that the pooler connection is abnormal. |

## 16.2.12.9 GLOBAL_CKPT_STATUS

**GLOBAL_CKPT_STATUS** displays the information about checkpoints and flushing pages of all instances in the cluster.

**Table 16-162** GLOBAL_CKPT_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| ckpt_redo_point | test | Checkpoint of the current instance |
| ckpt_clog_flush_num | bigint | Number of Clog flushing pages from the startup time to the current time |
| ckpt_csnlog_flush_num | bigint | Number of CSN log flushing pages from the startup time to the current time |
| ckpt_multixact_flush_num | bigint | Number of MultiXact flushing pages from the startup time to the current time |
| ckpt_predicate_flush_num | bigint | Number of predicate flushing pages from the startup time to the current time |

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| Name | Type | Description |
| --- | --- | --- |
| ckpt_twophase_flush_num | bigint | Number of two-phase flushing pages from the startup time to the current time |

## 16.2.12.10 GLOBAL_DOUBLE_WRITE_STATUS

**GLOBAL_DOUBLE_WRITE_STATUS** displays the information about doublewrite files of all instances in the entire cluster.

**Table 16-163** GLOBAL_DOUBLE_WRITE_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| curr_dwn | bigint | Sequence number of the doublewrite file |
| curr_start_page | bigint | Start page for restoring the doublewrite file |
| file_trunc_num | bigint | Number of times that the doublewrite file is reused |
| file_reset_num | bigint | Number of reset times after the doublewrite file is full |
| total_writes | bigint | Total number of I/Os of the doublewrite file |
| low_threshold_writes | bigint | Number of I/Os for writing the doublewrite files with low efficiency (the number of I/O flushing pages at a time is less than 16.) |
| high_threshold_writes | bigint | Number of I/Os for writing the doublewrite files with high efficiency (the number of I/O flushing pages at a time is more than 421.) |
| total_pages | bigint | Total number of pages that are flushed to the doublewrite file area |
| low_threshold_pages | bigint | Number of pages that are flushed with low efficiency |
| high_threshold_pages | bigint | Number of pages that are flushed with high efficiency |
| file_id | bigint | ID of the current doublewrite file |

## 16.2.12.11 GLOBAL_PAGEWRITER_STATUS

**GLOBAL_PAGEWRITER_STATUS** displays the information about checkpoints and flushing pages of all instances in the cluster.

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**Table 16-164** GLOBAL_PAGEWRITER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| pgwr_actual_flush_total_num | bigint | Total number of dirty pages flushed from the startup time to the current time |
| pgwr_last_flush_num | integer | Number of dirty pages flushed in the previous batch |
| remain_dirty_page_num | bigint | Estimated number of dirty pages that are not flushed |
| queue_head_page_rec_lsn | text | **recovery_lsn** of the first dirty page in the dirty page queue of the current instance |
| queue_rec_lsn | text | **recovery_lsn** of the dirty page queue of the current instance |
| current_xlog_insert_lsn | text | Write position of Xlogs in the current instance |
| ckpt_redo_point | text | Checkpoint of the current instance |

## 16.2.12.12 GLOBAL_POOLER_STATUS

**GLOBAL_POOLER_STATUS** is used to query the cache connection status of the pooler modules on all CNs.

**Table 16-165** GLOBAL_POOLER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| source_node_name | name | Source node name |
| database | text | Database name |
| user_name | text | Username |
| tid | bigint | In non-thread pool logic, this parameter indicates the ID of the thread connected to the CN. In thread pool logic, this parameter indicates the ID of the session connected to the CN. |
| node_oid | bigint | OID of the node connected |
| node_name | name | Name of the node connected |
| in_use | boolean | Whether the connection is currently used.<br>• **t** (true): The connection is in use.<br>• **f** (false): The connection is not in use. |

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| Name | Type | Description |
| --- | --- | --- |
| fdsock | bigint | Port file descriptor |
| remote_pid | bigint | Thread ID of the remote node connected |
| session_params | text | Session parameter |

## 16.2.12.13 GLOBAL_RECORD_RESET_TIME

**GLOBAL_RECORD_RESET_TIME** is used to reset the time of restarts, switchovers, and database deletions.

**Table 16-166** GLOBAL_RECORD_RESET_TIME columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| reset_time | timestamp with time zone | Time to be reset |

## 16.2.12.14 GLOBAL_REDO_STATUS

**GLOBAL_REDO_STATUS** displays the replaying of logs about instances in the cluster.

**Table 16-167** GLOBAL_REDO_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| redo_start_ptr | bigint | Start point for replaying the instance logs |
| redo_start_time | bigint | Start time (UTC) when the instance logs are replayed |
| redo_done_time | bigint | End time (UTC) when the instance logs are replayed |
| curr_time | bigint | Current time (UTC) of the instance |
| min_recovery_point | bigint | Position of the minimum consistency point for the instance logs |
| read_ptr | bigint | Position for reading the instance logs |
| last_replayed_read_ptr | bigint | Position for replaying the instance logs |

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| Name | Type | Description |
| --- | --- | --- |
| recovery_done_ptr | bigint | Replay position after the instance is started |
| read_xlog_io_counter | bigint | Number of I/Os when the instance reads and replays logs |
| read_xlog_io_total_dur | bigint | Total I/O latency when the instance reads and replays logs |
| read_data_io_counter | bigint | Number of data page I/O reads during replay in the instance |
| read_data_io_total_dur | bigint | Total I/O latency of data page reads during replay in the instance |
| write_data_io_counter | bigint | Number of data page I/O writes during replay in the instance |
| write_data_io_total_dur | bigint | Total I/O latency of data page writes during replay in the instance |
| process_pending_counter | bigint | Number of synchronization times of log distribution threads during replay in the instance |
| process_pending_total_dur | bigint | Total synchronization latency of log distribution threads during replay in the instance |
| apply_counter | bigint | Number of synchronization times of replay threads during replay in the instance |
| apply_total_dur | bigint | Total synchronization latency of replay threads during replay in the instance |
| speed | bigint | Log replay rate of the current instance. The value is updated every time when a 256 MB log is replayed. The unit is byte/s.<br>In a cluster environment, you are advised to run the **cm_ctl query -rv** command to obtain a more accurate replay speed of the standby node. For details about the **cm_ctl** command, see "Tools Used in the System > cm_ctl" in the *Tool Reference*. |
| local_max_ptr | bigint | Maximum number of replay logs received by the local host after the instance is started |
| primary_flush_ptr | bigint | Log point where the host flushes logs to a disk |
| worker_info | text | Replay thread information of the instance. If concurrent replay is not enabled, the value is **NULL**. |

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## 16.2.12.15 GLOBAL_RECOVERY_STATUS

**GLOBAL_RECOVERY_STATUS** displays log flow control information about the primary and standby nodes.

**Table 16-168** GLOBAL_RECOVERY_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name (including the primary and standby nodes) |
| standby_node_name | text | Name of the standby node |
| source_ip | text | IP address of the primary node |
| source_port | integer | Port number of the primary node |
| dest_ip | text | IP address of the standby node |
| dest_port | integer | Port number of the standby node |
| current_rto | bigint | Current log flow control time of the standby node (unit: s) |
| target_rto | bigint | Expected flow control time of the standby node specified by the corresponding GUC parameter (unit: s) |
| current_sleep_time | bigint | Sleep time required to achieve the expected flow control time (unit: μs) |

## 16.2.12.16 CLASS_VITAL_INFO

**CLASS_VITAL_INFO** is used to check whether the OIDs of the same table or index are consistent for WDR snapshots.

**Table 16-169** CLASS_VITAL_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| relid | oid | Table OID |
| schemaname | name | Schema name |
| relname | name | Table name |

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| Name | Type | Description |
| --- | --- | --- |
| relkind | "char" | Object type. Its value can be:<br>• **r**: ordinary table<br>• **t**: TOAST table<br>• **i**: index |

## 16.2.12.17 USER_LOGIN

**USER_LOGIN** records the number of user logins and logouts.

**Table 16-170** USER_LOGIN columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| user_name | text | Username |
| user_id | integer | User OID (Its value is the same as that of **oid** in **pg_authid**.) |
| login_counter | bigint | Number of logins |
| logout_counter | bigint | Number of logouts |

## 16.2.12.18 SUMMARY_USER_LOGIN

**SUMMARY_USER_LOGIN** records information about user logins and logouts on all CNs.

**Table 16-171** SUMMARY_USER_LOGIN columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| user_name | text | Username |
| user_id | integer | User OID (Its value is the same as that of **oid** in **pg_authid**.) |
| login_counter | bigint | Number of logins |
| logout_counter | bigint | Number of logouts |

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## 16.2.12.19 GLOBAL_GET_BGWRITER_STATUS

**GLOBAL_GET_BGWRITER_STATUS** displays the information about pages flushed by the bgwriter threads of all instances in the entire cluster, number of pages in the candidate buffer chain, and buffer eviction information.

**Table 16-172** GLOBAL_GET_BGWRITER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name |
| bgwr_actual_flush_total_num | bigint | Total number of dirty pages flushed by the bgwriter thread from the startup time to the current time |
| bgwr_last_flush_num | integer | Number of dirty pages flushed by the bgwriter thread in the previous batch |
| candidate_slots | integer | Number of pages in the current candidate buffer chain. |
| get_buffer_from_list | bigint | Number of times that pages are obtained from the candidate buffer chain during buffer eviction. |
| get_buffer_clock_sweep | bigint | Number of times that pages are obtained from the original eviction solution during buffer eviction. |

## 16.2.12.20 GLOBAL_SINGLE_FLUSH_DW_STATUS

The GLOBAL_SINGLE_FLUSH_DW_STATUS view displays the information about the eliminated dual-write file on a single page of all instances in the entire cluster. The information before the slash (/) is the page refresh information of the first version of the dual-write file, and that after the slash (/) is the page refresh information of the second version of the dual-write file.

**Table 16-173** GLOBAL_SINGLE_FLUSH_DW_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Instance name. |
| curr_dwn | text | Sequence number of the doublewrite file. |
| curr_start_page | text | Start position of the current doublewrite file. |
| total_writes | text | Total number of data write pages in the current doublewrite file. |
| file_trunc_num | text | Number of times that the doublewrite file is reused. |

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| Name | Type | Description |
| --- | --- | --- |
| file_reset_num | text | Number of reset times after the doublewrite file is full. |

### 16.2.12.21 GLOBAL_CANDIDATE_STATUS

**GLOBAL_CANDIDATE_STATUS** displays the number of candidate buffers and buffer eviction information of all instances in the database.

**Table 16-174** GLOBAL_GET_BGWRITER_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| candidate_slots | integer | Number of pages in the candidate buffer chain of the current normal buffer pool |
| get_buf_from_list | bigint | Number of times that pages are obtained from the candidate buffer chain during buffer eviction in the current normal buffer pool |
| get_buf_clock_sweep | bigint | Number of times that pages are obtained from the original eviction solution during buffer eviction in the current normal buffer pool |
| seg_candidate_slots | integer | Number of pages in the candidate buffer chain of the current segment buffer pool |
| seg_get_buf_from_list | bigint | Number of times that pages are obtained from the candidate buffer chain during buffer eviction in the current segment buffer pool |
| seg_get_buf_clock_sweep | bigint | Number of times that pages are obtained from the original eviction solution during buffer eviction in the current segment buffer pool |

## 16.2.13 Lock

### 16.2.13.1 LOCKS

**LOCKS** displays information about locks held by each open transaction.

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**Table 16-175** LOCKS columns

| Name | Type | Description |
| --- | --- | --- |
| locktype | text | Type of the locked object: **relation**, **extend**, **page**, **tuple**, **transactionid**, **virtualxid**, **object**, **userlock**, or **advisory** |
| database | oid | OID of the database in which the locked object exists.<br>• The OID is **0** if the object is a shared object.<br>• The OID is **NULL** if the object is a transaction ID. |
| relation | oid | OID of the relationship targeted by the lock. The value is **NULL** if the object is not a relationship or part of a relationship. |
| page | integer | Page number targeted by the lock within the relationship. The value is **NULL** if the object is not a relationship page or row page. |
| tuple | smallint | Row number targeted by the lock within the page. The value is **NULL** if the object is not a row. |
| bucket | integer | Hash bucket number |
| virtualxid | text | Virtual ID of the transaction targeted by the lock. The value is **NULL** if the object is not a virtual transaction ID. |
| transactionid | xid | ID of the transaction targeted by the lock. The value is **NULL** if the object is not a transaction ID. |
| classid | oid | OID of the system catalog that contains the object. The value is **NULL** if the object is not a general database object. |
| objid | oid | OID of the locked object within its system catalog. The value is **NULL** if the object is not a general database object. |
| objsubid | smallint | Column number for a column in the table. The value is **0** if the object is some other object type. The value is **NULL** if the object is not a general database object. |
| virtualtransaction | text | Virtual ID of the transaction holding or awaiting this lock |
| pid | bigint | Logical ID of the server thread holding or awaiting this lock. The value is **NULL** if the lock is held by a prepared transaction. |

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| Name | Type | Description |
| --- | --- | --- |
| sessionid | bigint | ID of the session holding or awaiting this lock The value is **NULL** if the lock is held by a prepared transaction. |
| mode | text | Lock mode held or desired by this thread |
| granted | boolean | • The value is **TRUE** if the lock is a held lock.<br>• The value is **FALSE** if the lock is an awaited lock. |
| fastpath | boolean | The value is **TRUE** if the lock is obtained through **fast-path**, and is **FALSE** if the lock is obtained through the main lock table. |
| locktag | text | Information about the lock that the session waits for. It can be parsed using the **locktag_decode()** function. |
| global_sessionid | text | Global session ID |

## 16.2.13.2 GLOBAL_LOCKS

**GLOBAL_LOCKS** displays information about locks held by open transactions on each node.

**Table 16-176** GLOBAL_LOCKS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | name | Node name |
| locktype | text | Type of the locked object: **relation**, **extend**, **page**, **tuple**, **transactionid**, **virtualxid**, **object**, **userlock**, or **advisory** |
| database | oid | OID of the database in which the locked object exists.<br>• The OID is **0** if the object is a shared object.<br>• The OID is **NULL** if the object is a transaction ID. |
| relation | oid | OID of the relationship targeted by the lock. The value is **NULL** if the object is not a relationship or part of a relationship. |
| page | integer | Page number targeted by the lock within the relationship. The value is **NULL** if the object is not a relationship page or row page. |

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| Name | Type | Description |
| --- | --- | --- |
| tuple | smallint | Row number targeted by the lock within the page. The value is **NULL** if the object is not a row. |
| bucket | integer | Hash bucket ID |
| virtualxid | text | Virtual ID of the transaction targeted by the lock. The value is **NULL** if the object is not a virtual transaction ID. |
| transactionid | xid | ID of the transaction targeted by the lock. The value is **NULL** if the object is not a transaction ID. |
| classid | oid | OID of the system catalog that contains the object. The value is **NULL** if the object is not a general database object. |
| objid | oid | OID of the locked object within its system catalog. The value is **NULL** if the object is not a general database object. |
| objsubid | smallint | Column number for a column in the table. The value is **0** if the object is some other object type. The value is **NULL** if the object is not a general database object. |
| virtualtransaction | text | Virtual ID of the transaction holding or awaiting this lock |
| pid | bigint | Logical ID of the server thread holding or awaiting this lock. The value is **NULL** if the lock is held by a prepared transaction. |
| sessionid | bigint | ID of the session holding or awaiting this lock The value is **NULL** if the lock is held by a prepared transaction. |
| global_sessionid | text | Global session ID |
| mode | text | Lock mode held or desired by this thread |
| granted | boolean | • The value is **TRUE** if the lock is a held lock.<br>• The value is **FALSE** if the lock is an awaited lock. |
| fastpath | boolean | The value is **TRUE** if the lock is obtained through **fast-path**, and is **FALSE** if the lock is obtained through the main lock table. |
| locktag | text | Information about the lock that the session waits for. It can be parsed using the **locktag_decode()** function. |

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# 16.2.14 Wait Event

## 16.2.14.1 WAIT_EVENTS

**WAIT_EVENTS** displays statistics about wait events on the current node. For key events in the kernel, see **Table 16-180**. Alternatively, view the list of all events in the system in the **wait_event_info** view. For details about the impact of each transaction lock on services, see **12.14.142 LOCK**.

**Table 16-177** WAIT_EVENTS columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |
| type | text | Event type |
| event | text | Event name |
| wait | bigint | Number of waiting times |
| failed_wait | bigint | Number of waiting failures |
| total_wait_time | bigint | Total waiting time (unit: μs) |
| avg_wait_time | bigint | Average waiting time (unit: μs) |
| max_wait_time | bigint | Maximum waiting time (unit: μs) |
| min_wait_time | bigint | Minimum waiting time (unit: μs) |
| last_updated | timestamp with time zone | Last time when the event was updated |

## 16.2.14.2 GLOBAL_WAIT_EVENTS

**GLOBAL_WAIT_EVENTS** displays statistics about wait events on each node. To query a view, you must have the **sysadmin** or **monitor admin** permission.

**Table 16-178** GLOBAL_WAIT_EVENTS columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Node name |
| type | text | Event type |
| event | text | Event name |
| wait | bigint | Number of waiting times |
| failed_wait | bigint | Number of waiting failures |

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| Name | Type | Description |
| --- | --- | --- |
| total_wait_time | bigint | Total waiting time (unit: μs) |
| avg_wait_time | bigint | Average waiting time (unit: μs) |
| max_wait_time | bigint | Maximum waiting time (unit: μs) |
| min_wait_time | bigint | Minimum waiting time (unit: μs) |
| last_updated | timestamp with time zone | Last time when the event was updated |

### 16.2.14.3 WAIT_EVENT_INFO

**WAIT_EVENT_INFO** displays the details about wait events.

**Table 16-179** WAIT_EVENT_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| module | text | Name of the module an event belongs to |
| type | text | Event type |
| event | text | Event name |

**Table 16-180** Wait event information list

| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Lock | Wait event | acquire lock | Waits for locking until the locking succeeds or times out. |
| SharedMemory | LWLock event | ShmemIndexLock | Used to protect the primary index table, a hash table, in shared memory. |
| Shared buffer | LWLock event | BufMappingLock | Used to protect operations on a shared-buffer mapping table. |
| Lmgr | LWLock event | LockMgrLock | Used to protect the information about a common lock structure. |
| LWLock | Wait event | acquire lwlock | Waits for a lightweight lock. |
| I/O | Wait event | wait io | Waits for I/O completion. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| COMM | Wait event | wait cmd | Waits for finishing reading network communication packets. |
| COMM | Wait event | wait pooler get conn | Waits for pooler to obtain connections. |
| COMM | Wait event | wait pooler abort conn | Waits for pooler to terminate connections. |
| COMM | Wait event | wait pooler clean conn | Waits for pooler to clear connections. |
| COMM | Wait event | get conn | Obtains connections to other nodes. |
| COMM | Wait event | set cmd | Waits for running the **SET**, **RESET**, or **TRANSACTION BLOCK LEVEL** statement on the connection. |
| COMM | Wait event | cancel query | Cancels the SQL statement that is being executed through a connection. |
| COMM | Wait event | stop query | Stops the query that is being executed through a connection. |
| COMM | Wait event | wait node | Waits for receiving data through the connection to a node. |
| COMM | Wait event | flush data | Waits for sending data to other nodes in the network. |
| COMM | Wait event | stream get conn | Waits for establishing connections to consumer nodes when the stream flow is initialized. |
| COMM | Wait event | wait producer ready | Waits for every producer to get ready when the stream flow is initialized. |
| Stream | Wait event | synchronize quit | Waiting for the threads in the stream thread group to quit when the stream plan ends |
| Stream | Wait event | wait stream group destroy | Waiting for destroying the stream node group when the stream plan ends |
| Transaction | Wait event | wait transaction sync | Waits for transaction synchronization. |
| Transaction | Wait event | wait data sync | Waits for the completion of data page synchronization to the standby node. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Transaction | Wait event | wait data sync queue | Waits for putting the data pages that are in the row storage or the CU in the column storage into the synchronization queue. |
| Transaction | LWLock event | OidGenLock | Used to prevent different threads from generating the same OID. |
| Transaction | LWLock event | XidGenLock | Used to prevent two transactions from obtaining the same transaction ID. |
| Transaction | LWLock event | ProcArrayLock | Used to prevent concurrent access to or concurrent modification on ProcArray shared arrays. |
| Transaction | LWLock event | SubtransControlLock | Used to prevent concurrent access to or concurrent modification on the sub-transaction control data structure. |
| Transaction | LWLock event | MultiXactGenLock | Used to allocate a unique MultiXact ID in serial mode. |
| Transaction | LWLock event | TwoPhaseStateLock | Used to prevent concurrent access to or concurrent modification on two-phase information sharing arrays. |
| Transaction | LWLock event | SerializableXactHashLock | Used to prevent concurrent read/write or concurrent write/write on a sharing structure for serializable transactions. |
| Transaction | LWLock event | SerializableFinishedListLock | Used to prevent concurrent read/write or concurrent write/write on a shared linked list for completed serial transactions. |
| Transaction | LWLock event | SerializablePredicateLockListLock | Used to protect a linked list of serializable transactions that have locks. |
| Transaction | LWLock event | PredicateLockMgrLock | Used to protect the information about a lock structure that has serializable transactions. |
| Transaction | LWLock event | OldSerXid SLRU lwlock | Used to protect SLRU buffers of old transaction IDs. |
| Transaction | LWLock event | OldSerXidLock | Used to protect a structure that records serializable transactions that have conflicts. |
| Transaction | Lock event | transactionid | Adds a lock to a transaction ID. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Transaction | Lock event | virtualxid | Adds a lock to a virtual transaction ID. |
| Checkpoint | LWLock event | CheckpointLock | Used to prevent multi-checkpoint concurrent execution. |
| Checkpoint | LWLock event | CheckpointerCommLock | Used to send file flush requests to a checkpointer. The request structure needs to be inserted to a request queue in serial mode. |
| Analyze | LWLock event | AutoanalyzeLock | Used to obtain and release resources related to a task that allows for autoanalyze execution. |
| Vacuum | LWLock event | BtreeVacuumLock | Used to prevent **VACUUM** from clearing pages that are being used by B-tree indexes. |
| Vacuum | LWLock event | AutovacuumLock | Used to access the autovacuum worker array in serial mode. |
| Vacuum | LWLock event | AutovacuumScheduleLock | Used to distribute tables requiring **VACUUM** in serial mode. |
| Auto vacuum | LWLock event | AutovacuumLock | Used to protect the autovacuum shared memory structure. |
| Auto vacuum | LWLock event | AutovacuumScheduleLock | Used to protect the information about autovacuum workers. |
| Auto analyze | LWLock event | AutoanalyzeLock | Used to protect the *autoAnalyzeFreeProcess* variable and ensure that no more than 10 autoanalyze threads are running at the same time. |
| WAL | Wait event | wait wal sync | Waits for the completion of WAL synchronization from the specified LSN to the standby node. |
| WAL | I/O event | WALBootstrapSync | Flushes an initialized WAL file to a disk during database initialization. |
| WAL | I/O event | WALBootstrapWrite | Writes an initialized WAL file during database initialization. |
| WAL | I/O event | WALCopyRead | Read operation generated when an existing WAL file is read for replication after archiving and restoration. |
| WAL | I/O event | WALCopySync | Flushes a replicated WAL file to a disk after archiving and restoration. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| WAL | I/O event | WALCopyWrite | Write operation generated when an existing WAL file is read for replication after archiving and restoration. |
| WAL | I/O event | WALInitSync | Flushes a newly initialized WAL file to a disk during log reclaiming or writing. |
| WAL | I/O event | WALInitWrite | Initializes a newly created WAL file to **0** during log reclaiming or writing. |
| WAL | I/O event | WALRead | Reads data from Xlogs during redo operations on two-phase files. |
| WAL | I/O event | WALSyncMethodAssign | Flushes all open WAL files to a disk. |
| WAL | I/O event | WALWrite | Writes a WAL file. |
| WAL | I/O event | LOGCTRL_SLEEP | Collects statistics on the number of stream control times and the sleep time of log stream control. |
| WAL | LWLock event | RcvWriteLock | Used to prevent concurrent call of **WalDataRcvWrite**. |
| WAL | LWLock event | WALBufMappingLock | An exclusive (X) lock needs to be added when the next page of an Xlog buffer is initialized. |
| WAL | LWLock event | WALInsertLock | Used to prevent multiple programs from writing data to the same Xlog buffer at the same time. |
| WAL | LWLock event | WALWriteLock | Used to prevent concurrent WAL write. |
| Relation | LWLock event | SInvalReadLock | Used to prevent concurrent execution with invalid message deletion. |
| Relation | LWLock event | SinvalWriteLock | Used to prevent concurrent execution with invalid message write and deletion. |
| Relation | LWLock event | RelCacheInitLock | Used to add a lock before any operations are performed on the **init** file when messages are invalid. |
| Relation | LWLock event | TablespaceCreateLock | Used to check whether a tablespace already exists. |
| Relation | LWLock event | RelfilenodeReuseLock | Used to prevent the link to a reused column attribute file from being canceled by mistake. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Relation | Lock event | relation | Adds a lock to a table. |
| Relation | Lock event | extend | Adds a lock to a table being scaled out. |
| Relation | Lock event | partition | Adds a lock to a partitioned table. |
| Relation | Lock event | partition_seq | Adds a lock to a partition of a partitioned table. |
| WLM | Wait event | wait active statement | Waits for active statements. |
| WLM | Wait event | wait memory | Waits for free memory. |
| DDL/DCL | Wait event | create index | Waits for the completion of index creation. |
| DDL/DCL | Wait event | analyze | Waits for analysis completion. |
| DDL/DCL | Wait event | vacuum | Waits for the completion of the **VACUUM** operation. |
| DDL/DCL | LWLock event | DelayDDLLock | Used to prevent concurrent DDL operations. |
| DDL/DCL | Wait event | vacuum full | Waits for the completion of the **VACUUM FULL** operation. |
| Executor | Wait event | Sort | Waits for the completion of tuple sorting. |
| Executor | Wait event | Sort - write file | Writes sorted data to a file temporarily since the memory is limited during merge sort. |
| Executor | Wait event | Material | Waits for tuple materialization. |
| Executor | Wait event | Material - write file | Waits for writing a materialized tuple to a file. |
| Executor | Wait event | HashJoin - build hash | Waits until a hash table is created when a hash join is executed. |
| Executor | Wait event | HashJoin - write file | Waits for writing the hash result of a tuple to a disk when a hash join is executed. |
| Executor | Wait event | HashAgg - build hash | Waits until a hash table is created when a hash aggregate is executed. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Executor | Wait event | HashAgg - write file | Waits for writing the hash result of a tuple to a disk when a hash aggregate is executed. |
| Executor | Wait event | HashSetop - build hash | Waits until a hash table is created when an OP operation is performed using the hash algorithm. |
| Executor | Wait event | HashSetop - write file | Waits for writing the hash result of a tuple to a disk when an OP operation is performed using the hash algorithm. |
| Executor | Wait event | wait sync consumer next step | Waits for the stream consumer to perform the next step. |
| Executor | Wait event | wait sync producer next step | Waits for the stream producer to perform the next step. |
| GTM | Wait event | gtm connect | Waits for connecting to GTM. |
| GTM | Wait event | gtm reset xmin | Waits for GTM to reset the minimum transaction ID. |
| GTM | Wait event | gtm get xmin | Waits for obtaining the minimum transaction ID from GTM. |
| GTM | Wait event | gtm get gxid | Waits for obtaining the global transaction ID from GTM during transaction startup. |
| GTM | Wait event | gtm get csn | Waits for obtaining the CSN from GTM during transaction startup. |
| GTM | Wait event | gtm get snapshot | Waits for obtaining snapshots from GTM during transaction startup. |
| GTM | Wait event | gtm begin trans | Waits for GTM to start a transaction. |
| GTM | Wait event | gtm commit trans | Waits for GTM to commit a transaction. |
| GTM | Wait event | gtm rollback trans | Waits for GTM to roll back transactions. |
| GTM | Wait event | gtm start preprare trans | Waits for GTM to complete the first phase during two-phase commit. |
| GTM | Wait event | gtm prepare trans | Waits for GTM to complete the second phase during two-phase commit. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| GTM | Wait event | gtm open sequence | Waits for GTM to create a sequence. |
| GTM | Wait event | gtm close sequence | Waits for GTM to complete the **ALTER SEQUENCE** operation. |
| GTM | Wait event | gtm set sequence val | Waits for GTM to set a sequence value. |
| GTM | Wait event | gtm drop sequence | Waits for GTM to delete a sequence. |
| GTM | Wait event | gtm rename sequence | Waits for GTM to rename a sequence. |
| GTM | LWLock event | GTMHostInfoLock | Used to protect GTM information. |
| Temp File | I/O event | BufFileRead | Reads data from a temporary file to a specified buffer. |
| Temp File | I/O event | BufFileWrite | Writes the content of a specified buffer to a temporary file. |
| Pg_control | I/O event | ControlFileRead | Reads the **pg_control** file, mainly during database startup, checkpoint execution, and primary/standby verification. |
| Pg_control | I/O event | ControlFileSync | Flushes the **pg_control** file to a disk, mainly during database initialization. |
| Pg_control | I/O event | ControlFileSyncUpdate | Flushes the **pg_control** file to a disk, mainly during database startup, checkpoint execution, and primary/standby verification. |
| Pg_control | I/O event | ControlFileWrite | Writes the **pg_control** file, mainly during database initialization. |
| Pg_control | I/O event | ControlFileWriteUpdate | Updates the **pg_control** file, mainly during database startup, checkpoint execution, and primary/standby verification. |
| Pg_control | LWLock event | ControlFileLock | Used to prevent concurrent read/write or concurrent write/write on the **pg_control** file. |
| File operation | I/O event | CopyFileRead | Reads a file during file copying. |
| File operation | I/O event | CopyFileWrite | Writes a file during file copying. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| File operation | I/O event | DataFileExtend | Writes a file during file extension. |
| Table data file | I/O event | DataFileImmediateSync | Flushes a table data file to a disk immediately. |
| Table data file | I/O event | DataFilePrefetch | Reads a table data file asynchronously. |
| Table data file | I/O event | DataFileRead | Reads a table data file synchronously. |
| Table data file | I/O event | DataFileSync | Synchronizes a table data file to a disk. |
| Table data file | I/O event | DataFileTruncate | Truncates a table data file. |
| Table data file | I/O event | DataFileWrite | Writes a table data file. |
| Table data file | LWLock event | SyncScanLock | Used to determine the start position of a **relfilenode** during heap scanning. |
| Table data file | LWLock event | RelationMappingLock | Used to wait for the mapping file between system catalogs and storage locations to be updated. |
| metadata | LWLock event | MetaCacheSweepLock | Used to add a lock when metadata is cyclically washed out. |
| postmaster.pid | I/O event | LockFileAddToDataDirRead | Reads the **postmaster.pid** file. |
| postmaster.pid | I/O event | LockFileAddToDataDirSync | Flushes the **postmaster.pid** file to a disk. |
| postmaster.pid | I/O event | LockFileAddToDataDirWrite | Writes PID information into the **postmaster.pid** file. |
| Pid File | I/O event | LockFileCreateRead | Reads the LockFile file **%s.lock**. |
| Pid File | I/O event | LockFileCreateSync | Flushes the LockFile file **%s.lock** to a disk. |
| Pid File | I/O event | LockFileCreateWRITE | Writes PID information into the LockFile file **%s.lock**. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| System catalog mapping file | I/O event | RelationMapRead | Reads the mapping file between system catalogs and storage locations. |
| System catalog mapping file | I/O event | RelationMapSync | Flushes the mapping file between system catalogs and storage locations to a disk. |
| System catalog mapping file | I/O event | RelationMapWrite | Writes the mapping file between system catalogs and storage locations. |
| Streaming replication | I/O event | ReplicationSlotRead | Reads a stream replication slot file during a restart. |
| Streaming replication | I/O event | ReplicationSlotRestoreSync | Flushes a stream replication slot file to a disk. |
| Streaming replication | I/O event | ReplicationSlotSync | Flushes a temporary stream replication slot file to a disk during checkpoint execution. |
| Streaming replication | I/O event | ReplicationSlotWrite | Writes a temporary stream replication slot file during checkpoint execution. |
| Streaming replication | LWLock event | ReplicationSlotAllocationLock | Used to allocate a replication slot. |
| Streaming replication | LWLock event | ReplicationSlotControlLock | Used to detect replication slot name conflicts and identify replication slots that can be allocated. |
| Clog | I/O event | SLRUFlushSync | Flushes the **pg_clog** file to a disk, mainly during checkpoint execution and database shutdown. |
| Clog | I/O event | SLRURead | Reads the **pg_clog** file. |
| Clog | I/O event | SLRUSync | Writes dirty pages into the **pg_clog** file, and flushes the file to a disk, mainly during checkpoint execution and database shutdown. |
| Clog | I/O event | SLRUWrite | Writes the **pg_clog** file. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Clog | LWLock event | CLogControlLock | Used to prevent concurrent access to or concurrent modification on the Clog control data structure. |
| Clog | LWLock event | MultiXactOffsetControlLock | Used to prevent concurrent read/write or concurrent write/write on **pg_multixact/offset**. |
| Clog | LWLock event | MultiXactMemberControlLock | Used to prevent concurrent read/write or concurrent write/write on **pg_multixact/members**. |
| timelinehistory | I/O event | TimelineHistoryRead | Reads the **timelinehistory** file, during database startup. |
| timelinehistory | I/O event | TimelineHistorySync | Flushes the **timelinehistory** file to a disk, during database startup. |
| timelinehistory | I/O event | TimelineHistoryWrite | Writes the **timelinehistory** file. |
| pg_twophase | I/O event | TwophaseFileRead | Reads the **pg_twophase** file, mainly during two-phase transaction commit and restoration. |
| pg_twophase | I/O event | TwophaseFileSync | Flushes the **pg_twophase** file to a disk, mainly during two-phase transaction commit and restoration. |
| pg_twophase | I/O event | TwophaseFileWrite | Writes the **pg_twophase** file, mainly during two-phase transaction commit and restoration. |
| Cluster | LWLock event | NodeTableLock | Used to protect a shared structure that stores CNs and DNs information. |
| Concurrency | LWLock event | PoolerLock | Used to prevent two threads from simultaneously obtaining the same connection from a connection pool. |
| Concurrency | LWLock event | AsyncCtlLock | Used to prevent concurrent access to or concurrent modification on the sharing notification status. |
| Concurrency | LWLock event | AsyncQueueLock | Used to prevent concurrent access to or concurrent modification on the sharing notification queue. |
| Double write | I/O event | DoubleWriteFileWrite | Writes pages to a doublewrite file during the doublewrite process. |
| Double write | I/O event | DoubleWriteFileRead | Reads a doublewrite file during restoration for a halfwrite. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Statistics file | LWLock event | FileStatLock | Used to protect a data structure that stores statistics file information. |
| Master-slave replication | LWLock event | SyncRepLock | Used to protect Xlog synchronization information during primary/standby replication. |
| Master-slave replication | LWLock event | ReplicationSlotAllocationLock | Used to add a lock when a primary server allocates stream replication slots during primary/standby replication. |
| Master-slave replication | LWLock event | ReplicationSlotControlLock | Used to prevent concurrent update of stream replication slot status during primary/standby replication. |
| Master-slave replication | LWLock event | LsnXlogChkFileLock | Used to serially update the Xlog flush points for primary and standby servers recorded in a specific structure. |
| Master-slave replication | LWLock event | DataSyncRepLock | Used to protect data page synchronization information during primary/standby replication. |
| Column store | LWLock event | CStoreColspaceCacheLock | Used to add a lock when CU space is allocated for a column-store table. |
| Column store | LWLock event | CacheSlotMappingLock | Used to protect global CU cache information. |
| Column store | LWLock event | CStoreCUCacheSweepLock | Used to add a lock when CU caches used by a column-store table are cyclically washed out. |
| Column store | Lock event | cstore_freespace | Adds a lock to idle column-store space. |
| Speed up the cluster | LWLock event | dummyServerInfoCacheLock | Used to protect a global hash table where the information about cluster connections is cached. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Speed up the cluster | LWLock event | RPNumberLock | Used by a DN on a cluster to count the number of threads for a task where plans are being executed. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) |
| Speed up the cluster | LWLock event | ClusterRPLock | Used by a cluster to control concurrent access on cluster load data maintained in a CCN of the cluster. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) |
| Speed up the cluster | LWLock event | SearchServerLibLock | Used to add a lock on the file read operation when a specific dynamic library is initially loaded in GPU-accelerated scenarios. |
| Resource manage | LWLock event | ResourcePoolHashLock | Used to prevent concurrent access to or concurrent modification on a resource pool table, a hash table. |
| Resource manage | LWLock event | WorkloadStatHashLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains SQL requests from the CN side. |
| Resource manage | LWLock event | WorkloadIoStatHashLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains I/O information of the current DN. |
| Resource manage | LWLock event | WorkloadCGroupHashLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains Cgroup information. |
| Resource manage | LWLock event | WorkloadUserInfoLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains user information about load management. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |
| Resource manage | LWLock event | WorkloadRecordLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains requests received by CNs during adaptive memory management. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| Resource manage | LWLock event | WorkloadIOUtilLock | Used to protect a structure that records **iostat** and CPU load information. |
| Resource manage | LWLock event | WorkloadNodeGroupLock | Used to prevent concurrent access to or concurrent modification on a hash table that contains node group information in memory. |
| OBS | LWLock event | OBSGetPathLock | Used to prevent concurrent read/write or concurrent write/write on an OBS path. |
| OBS | LWLock event | OBSRuntimeLock | Used to obtain environment variables, for example, *GASSHOME*. |
| LLVM | LWLock event | LLVMDumpIRLock | Used to export the assembly language for dynamically generating functions. The current feature is a lab feature. Contact Huawei technical support before using it. |
| LLVM | LWLock event | LLVMParseIRLock | Used to compile and parse a finished IR function from the IR file at the start position of a query. The current feature is a lab feature. Contact Huawei technical support before using it. |
| MPP is compatible with ORACLE scheduled task function | LWLock event | JobShmemLock | Used to protect global variables in the shared memory that is periodically read during a scheduled task where MPP is compatible with Oracle. |
| Operator history information statistics | LWLock event | OperatorRealTLock | Used to prevent concurrent access to or concurrent modification on a global structure that contains real-time data at the operator level. |
| Operator history information statistics | LWLock event | OperatorHistLock | Used to prevent concurrent access to or concurrent modification on a global structure that contains historical data at the operator level. |
| query history information statistics | LWLock event | SessionRealTLock | Used to prevent concurrent access to or concurrent modification on a global structure that contains real-time data at the query level. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| query history information statistics | LWLock event | SessionHistLock | Used to prevent concurrent access to or concurrent modification on a global structure that contains historical data at the query level. |
| query history information statistics | LWLock event | WaitCountHashLock | Used to protect a shared structure in user statement counting scenarios. |
| barrier | LWLock event | BarrierLock | Used to ensure that only one thread is creating a barrier at a time. |
| CSN | LWLock event | CSNBufMappingLock | Used to protect CSN pages. |
| instrumentation | LWLock event | UniqueSQLMappingLock | Used to protect a unique SQL hash table. |
| instrumentation | LWLock event | InstrUserLock | Used to protect a user hash table. |
| instrumentation | LWLock event | PercentileLock | Used to protect global percentile buffers. |
| instrumentation | LWLock event | InstrWorkloadLock | Used to protect a workload transaction hash table. |
| Pgproc | LWLock event | Pgproc lwlock | Used to protect the PGPROC structure. |
| Async buffer | LWLock event | AsyncCtlLock | Used to protect asynchronization buffers. |
| MultiXact | LWLock event | MultiXactOffset lwlock | Used to protect SLRU buffers of a MultiXact offset. |
| MultiXact | LWLock event | MultiXactMemberlwlock | Used to protect SLRU buffer of a MultiXact member. |
| CBM | LWLock event | CBMParseXlogLock | Used to protect the lock used when CBM parses Xlogs. |
| BadBlock | LWLock event | BadBlockStatHashLock | Used to protect the hash table **global_bad_block_stat**. |
| Page | Lock event | page | Adds a lock to a table page. |
| Tuple | Lock event | tuple | Adds a lock to a tuple on a page. |

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| Module Category | Event Category | Event | Description |
| --- | --- | --- | --- |
| object | Lock event | object | Adds a lock to an object. |
| user | Lock event | userlock | Adds a lock to a user. |
| advisor | Lock event | advisory | Adds an advisory lock. |
| ODBC | LWLock event | ExtensionConnectorLibLock | Adds a lock when a specific dynamic library is loaded or uninstalled in ODBC connection initialization scenarios. |

# 16.2.15 Configuration

## 16.2.15.1 CONFIG_SETTINGS

**CONFIG_SETTINGS** displays information about parameters of the running database.

**Table 16-181** CONFIG_SETTINGS columns

| Name | Type | Description |
| --- | --- | --- |
| name | text | Parameter name |
| setting | text | Current parameter value |
| unit | text | Implicit unit of the parameter |
| category | text | Logical group of the parameter |
| short_desc | text | Brief description of the parameter |
| extra_desc | text | Detailed description of the parameter |
| context | text | Context required to set the parameter value, including **internal**, **postmaster**, **sighup**, **backend**, **superuser**, and **user** |
| vartype | text | Parameter type, including **bool**, **enum**, **integer**, **real**, or **string** |
| source | text | Method of assigning the parameter value |
| min_val | text | Maximum value of the parameter. If the parameter type is not numeric, the value of this column is **null**. |

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| Name | Type | Description |
| --- | --- | --- |
| max_val | text | Minimum value of the parameter. If the parameter type is not numeric, the value of this column is **null**. |
| enumvals | text[] | Valid values of an enum parameter. If the parameter type is not enum, the value of this column is **null**. |
| boot_val | text | Default parameter value used upon the database startup |
| reset_val | text | Default parameter value used upon the database reset |
| sourcefile | text | Configuration file used to set parameter values. If parameter values are not configured using the configuration file, the value of this column is **null**. |
| sourceline | integer | Row number in the configuration file for setting parameter values. If parameter values are not configured using the configuration file, the value of this column is **null**. |

## 16.2.15.2 GLOBAL_CONFIG_SETTINGS

**GLOBAL_CONFIG_SETTINGS** displays information about parameters of running databases on each node.

**Table 16-182** GLOBAL_CONFIG_SETTINGS columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name |
| name | text | Parameter name |
| setting | text | Current parameter value |
| unit | text | Implicit unit of the parameter |
| category | text | Logical group of the parameter |
| short_desc | text | Brief description of the parameter |
| extra_desc | text | Detailed description of the parameter |
| context | text | Context required to set the parameter value, including **internal**, **postmaster**, **sighup**, **backend**, **superuser**, and **user** |
| vartype | text | Parameter type, including **bool**, **enum**, **integer**, **real**, or **string** |

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| Name | Type | Description |
| --- | --- | --- |
| source | text | Method of assigning the parameter value |
| min_val | text | Maximum value of the parameter. If the parameter type is not numeric, the value of this column is **null**. |
| max_val | text | Minimum value of the parameter. If the parameter type is not numeric, the value of this column is **null**. |
| enumvals | text[] | Valid values of an enum parameter. If the parameter type is not enum, the value of this column is **null**. |
| boot_val | text | Default parameter value used upon the database startup |
| reset_val | text | Default parameter value used upon the database reset |
| sourcefile | text | Configuration file used to set parameter values. If parameter values are not configured using the configuration file, the value of this column is **null**. |
| sourceline | integer | Row number in the configuration file for setting parameter values. If parameter values are not configured using the configuration file, the value of this column is **null**. |

# 16.2.16 Operator

## 16.2.16.1 OPERATOR_EC_HISTORY

**OPERATOR_EC_HISTORY** displays records of operators in Extension Connector jobs that have been executed by the current user on the current CN. The records in this view are cleared every 3 minutes. The current feature is a lab feature. Contact Huawei technical support before using it.

- If the GUC parameter **enable_resource_record** is set to **on**, the records in the view are dumped to the system catalog **15.2.30 GS_WLM_EC_OPERATOR_INFO** and deleted from the view every 3 minutes.
- If **enable_resource_record** is set to **off**, records are retained in the view for 3 minutes and then deleted. Columns in this view are the same as those in **15.2.30 GS_WLM_EC_OPERATOR_INFO**.

## 16.2.16.2 OPERATOR_EC_HISTORY_TABLE

**OPERATOR_EC_HISTORY_TABLE** records information about operators of Extension Connector jobs that have been executed. If **enable_resource_record** is set to **on**, the system imports records from **15.3.78**

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GS_WLM_EC_OPERATOR_HISTORY to this system catalog every 3 minutes. This operation occupies storage space and affects performance. The current feature is a lab feature. Contact Huawei technical support before using it.

**Table 16-183** OPERATOR_EC_HISTORY_TABLE columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for Extension Connector statement execution |
| plan_node_id | integer | Plan node ID of the execution plan of an Extension Connector operator |
| start_time | timestamp with time zone | Time when the Extension Connector operator starts to process the first data record |
| duration | bigint | Total execution time of the Extension Connector operator (unit: ms) |
| tuple_processed | bigint | Number of elements returned by the Extension Connector operator |
| min_peak_memory | integer | Minimum peak memory used by the Extension Connector operator on all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory used by the Extension Connector operator on all DNs (unit: MB) |
| average_peak_memory | integer | Average peak memory used by the Extension Connector operator on all DNs (unit: MB) |
| ec_status | text | Status of the Extension Connector job |
| ec_execute_datanode | text | Name of the DN executing the Extension Connector job |
| ec_dsn | text | DSN used by the Extension Connector job |
| ec_username | text | Username used by the Extension Connector job to access a remote cluster. This parameter is null if the remote cluster type is SPARK. |
| ec_query | text | Statement sent by the Extension Connector job to a remote cluster |
| ec_libodbc_type | text | Type of the unixODBC driver used by the Extension Connector job |

## 16.2.16.3 OPERATOR_EC_RUNTIME

**OPERATOR_EC_RUNTIME** displays information about operators of the Extension Connector jobs that are being executed by the current user. The current feature is a lab feature. Contact Huawei technical support before using it.

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**Table 16-184** OPERATOR_EC_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for Extension Connector statement execution |
| plan_node_id | integer | Plan node ID of the execution plan of an Extension Connector operator |
| start_time | timestamp with time zone | Time when the Extension Connector operator starts to process the first data record |
| ec_status | text | Status of the Extension Connector job |
| ec_execute_datanode | text | Name of the DN executing the Extension Connector job |
| ec_dsn | text | DSN used by the Extension Connector job |
| ec_username | text | Username used by the Extension Connector job to access a remote cluster. This parameter is null if the remote cluster type is SPARK. |
| ec_query | text | Statement sent by the Extension Connector job to a remote cluster |
| ec_libodbc_type | text | Type of the unixODBC driver used by the Extension Connector job |
| ec_fetch_count | bigint | Number of data records processed by the Extension Connector job |

## 16.2.16.4 OPERATOR_HISTORY_TABLE

**OPERATOR_HISTORY_TABLE** displays records about operators of completed jobs. Data is dumped from the kernel to this system catalog. If **enable_resource_record** is set to **on**, the system imports records from **15.3.79 GS_WLM_OPERATOR_HISTORY** to this system catalog every 3 minutes. You are not advised to enable this function, because it occupies storage space and affects performance.

**Table 16-185** OPERATOR_HISTORY_TABLE columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for statement execution |
| pid | bigint | Backend thread ID |
| plan_node_id | integer | Plan node ID of the execution plan of a query |

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| Name | Type | Description |
| --- | --- | --- |
| plan_node_name | text | Name of the operator corresponding to the plan node ID |
| start_time | timestamp with time zone | Time when the operator starts to process the first data record |
| duration | bigint | Total execution time of the operator (unit: ms) |
| query_dop | integer | DOP of the operator |
| estimated_rows | bigint | Number of rows estimated by the optimizer |
| tuple_processed | bigint | Number of elements returned by the operator |
| min_peak_memory | integer | Minimum peak memory used by the operator on all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory used by the operator on all DNs (unit: MB) |
| average_peak_memory | integer | Average peak memory used by the operator on all DNs (unit: MB) |
| memory_skew_percent | integer | Memory usage skew of the operator among DNs |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_cpu_time | bigint | Minimum execution time of the operator on all DNs (unit: ms) |
| max_cpu_time | bigint | Maximum execution time of the operator on all DNs (unit: ms) |
| total_cpu_time | bigint | Total execution time of the operator on all DNs (unit: ms) |
| cpu_skew_percent | integer | Skew of the execution time among DNs |

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| Name | Type | Description |
| --- | --- | --- |
| warning | text | Warning. The following warnings are displayed:<br>• Sort/SetOp/HashAgg/HashJoin spill<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |

## 16.2.16.5 OPERATOR_HISTORY

**OPERATOR_HISTORY** displays information about operators of the jobs that are executed by the current user on the current CN. Data in the kernel is cleared every 3 minutes. If the GUC parameter **enable_resource_record** is set to **on**, the records in the view are dumped to the system catalog **15.2.32 GS_WLM_OPERATOR_INFO** every 3 minutes and deleted from the view. If **enable_resource_record** is set to **off**, records are retained in the view for 3 minutes and then deleted. Columns in this view are the same as those in **Table 15-29**.

## 16.2.16.6 OPERATOR_RUNTIME

**OPERATOR_RUNTIME** displays information about operators of the jobs that are being executed by the current user.

**Table 16-186** OPERATOR_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for statement execution |
| pid | bigint | Backend thread ID |
| plan_node_id | integer | Plan node ID of the execution plan of a query |
| plan_node_name | text | Name of the operator corresponding to the plan node ID |
| start_time | timestamp with time zone | Time when the operator starts to process the first data record |
| duration | bigint | Total execution time of the operator (unit: ms) |
| status | text | Execution status of the current operator. Its value can be **finished** or **running**. |
| query_dop | integer | DOP of the operator |

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| Name | Type | Description |
| --- | --- | --- |
| estimated_rows | bigint | Number of rows estimated by the optimizer |
| tuple_processed | bigint | Number of elements returned by the operator |
| min_peak_memory | integer | Minimum peak memory used by the operator on all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory used by the operator on all DNs (unit: MB) |
| average_peak_memory | integer | Average peak memory used by the operator on all DNs (unit: MB) |
| memory_skew_percent | integer | Memory usage skew of the operator among DNs |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_cpu_time | bigint | Minimum execution time of the operator on all DNs (unit: ms) |
| max_cpu_time | bigint | Maximum execution time of the operator on all DNs (unit: ms) |
| total_cpu_time | bigint | Total execution time of the operator on all DNs (unit: ms) |
| cpu_skew_percent | integer | Skew of the execution time among DNs |
| warning | text | Warning. The following warnings are displayed:<br>● Sort/SetOp/HashAgg/HashJoin spill<br>● Spill file size large than 256MB<br>● Broadcast size large than 100MB<br>● Early spill<br>● Spill times is greater than 3<br>● Spill on memory adaptive<br>● Hash table conflict |

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## 16.2.16.7 GLOBAL_OPERATOR_EC_HISTORY

**GLOBAL_OPERATOR_EC_HISTORY** is used to query recorded information about operators of Extension Connector jobs that have been executed. The current feature is a lab feature. Contact Huawei technical support before using it.

**Table 16-187** GLOBAL_OPERATOR_EC_HISTORY columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for Extension Connector statement execution |
| plan_node_id | integer | Plan node ID of the execution plan of an Extension Connector operator |
| start_time | timestamp with time zone | Time when the Extension Connector operator starts to process the first data record |
| duration | bigint | Total execution time of the Extension Connector operator (unit: ms) |
| tuple_processed | bigint | Number of elements returned by the Extension Connector operator |
| min_peak_memory | integer | Minimum peak memory used by the Extension Connector operator on all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory used by the Extension Connector operator on all DNs (unit: MB) |
| average_peak_memory | integer | Average peak memory used by the Extension Connector operator on all DNs (unit: MB) |
| ec_status | text | Status of the Extension Connector job |
| ec_execute_datanode | text | Name of the DN executing the Extension Connector job |
| ec_dsn | text | DSN used by the Extension Connector job |
| ec_username | text | Username used by the Extension Connector job to access a remote cluster. This parameter is null if the remote cluster type is SPARK. |
| ec_query | text | Statement sent by the Extension Connector job to a remote cluster |
| ec_libodbc_type | text | Type of the unixODBC driver used by the Extension Connector job |

## 16.2.16.8 GLOBAL_OPERATOR_EC_HISTORY_TABLE

**GLOBAL_OPERATOR_EC_HISTORY_TABLE** is used to query recorded information about operators of Extension Connector jobs that have been executed. If the GUC

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parameter **enable_resource_record** is set to **on**, the records in **15.3.78 GS_WLM_EC_OPERATOR_HISTORY** are imported to the system catalog **GS_WLM_EC_OPERATOR_INFO** every 3 minutes.
**GLOBAL_OPERATOR_EC_HISTORY_TABLE** is an aggregation view for querying the system catalog **GS_WLM_EC_OPERATOR_INFO** among all CNs. Columns in this view are the same as those in **Table 16-187**. The current feature is a lab feature. Contact Huawei technical support before using it.

## 16.2.16.9 GLOBAL_OPERATOR_EC_RUNTIME

**GLOBAL_OPERATOR_EC_RUNTIME** displays information about operators of the Extension Connector jobs that are being globally executed by the current user. The current feature is a lab feature. Contact Huawei technical support before using it.

**Table 16-188** GLOBAL_OPERATOR_EC_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for Extension Connector statement execution |
| plan_node_id | integer | Plan node ID of the execution plan of an Extension Connector operator |
| start_time | timestamp with time zone | Time when the Extension Connector operator starts to process the first data record |
| ec_status | text | Status of the Extension Connector job |
| ec_execute_datanode | text | Name of the DN executing the Extension Connector job |
| ec_dsn | text | DSN used by the Extension Connector job |
| ec_username | text | Username used by the Extension Connector job to access a remote cluster. This parameter is null if the remote cluster type is SPARK. |
| ec_query | text | Statement sent by the Extension Connector job to a remote cluster |
| ec_libodbc_type | text | Type of the unixODBC driver used by the Extension Connector job |
| ec_fetch_count | bigint | Number of data records processed by the Extension Connector job |

## 16.2.16.10 GLOBAL_OPERATOR_HISTORY

**GLOBAL_OPERATOR_HISTORY** displays the records about operators after jobs are executed by the current user on all CNs.

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**Table 16-189** GLOBAL_OPERATOR_HISTORY columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for statement execution |
| pid | bigint | Backend thread ID |
| plan_node_id | integer | Plan node ID of the execution plan of a query |
| plan_node_name | text | Name of the operator corresponding to the plan node ID |
| start_time | timestamp with time zone | Time when the operator starts to process the first data record |
| duration | bigint | Total execution time of the operator (unit: ms) |
| query_dop | integer | DOP of the operator |
| estimated_rows | bigint | Number of rows estimated by the optimizer |
| tuple_processed | bigint | Number of elements returned by the operator |
| min_peak_memory | integer | Minimum peak memory used by the operator on all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory used by the operator on all DNs (unit: MB) |
| average_peak_memory | integer | Average peak memory used by the operator on all DNs (unit: MB) |
| memory_skew_percent | integer | Memory usage skew of the operator among DNs |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_cpu_time | bigint | Minimum execution time of the operator on all DNs (unit: ms) |
| max_cpu_time | bigint | Maximum execution time of the operator on all DNs (unit: ms) |

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| Name | Type | Description |
| --- | --- | --- |
| total_cpu_time | bigint | Total execution time of the operator on all DNs (unit: ms) |
| cpu_skew_percent | integer | Skew of the execution time among DNs |
| warning | text | Warning. The following warnings are displayed:<br>1. Sort/SetOp/HashAgg/HashJoin spill<br>2. Spill file size large than 256MB<br>3. Broadcast size large than 100MB<br>4. Early spill<br>5. Spill times is greater than 3<br>6. Spill on memory adaptive<br>7. Hash table conflict |

## 16.2.16.11 GLOBAL_OPERATOR_HISTORY_TABLE

**GLOBAL_OPERATOR_HISTORY_TABLE** displays the records about operators of completed jobs on all CNs. Data is dumped from the kernel to the system catalog **GS_WLM_OPERATOR_INFO**. If the GUC parameter **enable_resource_record** is set to **on**, the records in **15.3.79 GS_WLM_OPERATOR_HISTORY** are imported to the system catalog **GS_WLM_OPERATOR_INFO** every 3 minutes. It is an aggregation view for querying the system catalog **GS_WLM_OPERATOR_INFO** on all CNs. Columns in this view are the same as those in **Table 16-189**.

## 16.2.16.12 GLOBAL_OPERATOR_RUNTIME

**GLOBAL_OPERATOR_RUNTIME** displays information about operators of the jobs that are being executed by the current user on all CNs.

**Table 16-190** GLOBAL_OPERATOR_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| queryid | bigint | Internal query ID used for statement execution |
| pid | bigint | Backend thread ID |
| plan_node_id | integer | Plan node ID of the execution plan of a query |
| plan_node_name | text | Name of the operator corresponding to the plan node ID |
| start_time | timestamp with time zone | Time when the operator starts to process the first data record |
| duration | bigint | Total execution time of the operator (unit: ms) |

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| Name | Type | Description |
| --- | --- | --- |
| status | text | Execution status of the current operator. Its value can be **finished** or **running**. |
| query_dop | integer | DOP of the operator |
| estimated_rows | bigint | Number of rows estimated by the optimizer |
| tuple_processed | bigint | Number of elements returned by the operator |
| min_peak_memory | integer | Minimum peak memory used by the operator on all DNs (unit: MB) |
| max_peak_memory | integer | Maximum peak memory used by the operator on all DNs (unit: MB) |
| average_peak_memory | integer | Average peak memory used by the operator on all DNs (unit: MB) |
| memory_skew_percent | integer | Memory usage skew of the operator among DNs |
| min_spill_size | integer | Minimum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| max_spill_size | integer | Maximum spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| average_spill_size | integer | Average spilled data among all DNs when a spill occurs (unit: MB; default value: **0**) |
| spill_skew_percent | integer | DN spill skew when a spill occurs |
| min_cpu_time | bigint | Minimum execution time of the operator on all DNs (unit: ms) |
| max_cpu_time | bigint | Maximum execution time of the operator on all DNs (unit: ms) |
| total_cpu_time | bigint | Total execution time of the operator on all DNs (unit: ms) |
| cpu_skew_percent | integer | Skew of the execution time among DNs |

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| Name | Type | Description |
| --- | --- | --- |
| warning | text | Warning. The following warnings are displayed:<br>• Sort/SetOp/HashAgg/HashJoin spill<br>• Spill file size large than 256MB<br>• Broadcast size large than 100MB<br>• Early spill<br>• Spill times is greater than 3<br>• Spill on memory adaptive<br>• Hash table conflict |

# 16.2.17 Workload Manager

## 16.2.17.1 WLM_CGROUP_CONFIG

**WLM_CGROUP_CONFIG** displays information about a Cgroup for a job that is being executed.

**Table 16-191** WLM_CGROUP_CONFIG columns

| Name | Type | Description |
| --- | --- | --- |
| cgoup_name | text | Cgroup name |
| priority | integer | Job priority |
| usage_pecent | integer | Percentage of resources used by the Cgroup |
| shares | bigint | CPU quota allocated to the Cgroup |
| cpuacct | bigint | Allocated CPU quota |
| cpuset | text | Allocated CPU cores |
| relpath | text | Relative path of the Cgroup |
| valid | text | Whether the Cgroup is valid |
| node_group | text | Logical cluster name (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

## 16.2.17.2 WLM_CLUSTER_RESOURCE_RUNTIME

**WLM_CLUSTER_RESOURCE_RUNTIME** displays a DN resource summary.

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**Table 16-192** WLM_CLUSTER_RESOURCE_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| min_mem_util | integer | Minimum memory usage of a DN |
| max_mem_util | integer | Maximum memory usage of a DN |
| min_cpu_util | integer | Minimum CPU usage of a DN |
| max_cpu_util | integer | Maximum CPU usage of a DN |
| min_io_util | integer | Minimum I/O usage of a DN |
| max_io_util | integer | Maximum I/O usage of a DN |
| used_mem_rate | integer | Maximum memory usage of a physical node |

## 16.2.17.3 WLM_CONTROLGROUP_CONFIG

**WLM_CONTROLGROUP_CONFIG** displays information about all Cgroups in the current database.

**Table 16-193** WLM_CONTROLGROUP_CONFIG columns

| Name | Type | Description |
| --- | --- | --- |
| name | text | Cgroup name |
| type | text | Cgroup type |
| gid | bigint | Cgroup ID |
| classgid | bigint | ID of the Class Cgroup to which a Workload Cgroup belongs |
| class | text | Class Cgroup |
| workload | text | Workload Cgroup |
| shares | bigint | CPU quota allocated to a Cgroup |
| limits | bigint | Limit of CPUs allocated to a Cgroup |
| wdlevel | bigint | Workload Cgroup level |
| cpucores | text | Usage of CPU cores in a Cgroup |

## 16.2.17.4 WLM_CONTROLGROUP_NG_CONFIG

**WLM_CONTROLGROUP_NG_CONFIG** displays information about Cgroups of all logical clusters in the current database. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

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**Table 16-194** WLM_CONTROLGROUP_NG_CONFIG columns

| Name | Type | Description |
| --- | --- | --- |
| name | text | Cgroup name |
| type | text | Cgroup type |
| gid | bigint | Cgroup ID |
| classgid | bigint | ID of the Class Cgroup to which a Workload Cgroup belongs |
| class | text | Class Cgroup |
| workload | text | Workload Cgroup |
| shares | bigint | CPU quota allocated to a Cgroup |
| limits | bigint | Limit of CPUs allocated to a Cgroup |
| wdlevel | bigint | Workload Cgroup level |
| cpucores | text | Usage of CPU cores in a Cgroup |
| nodegroup | text | Name of a logical cluster |
| group_kind | text | Node group type. Its value can be **i**, **n**, **v**, or **e**.<br>• **i**: installation node group<br>• **n**: node group in a common non-logical cluster<br>• **v**: node group in a logical cluster<br>• **e**: elastic cluster |

## 16.2.17.5 WLM_RESOURCEPOOL_RUNTIME

**WLM_RESOURCEPOOL_RUNTIME** displays statistics about a resource pool.

**Table 16-195** WLM_RESOURCEPOOL_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| rpoid | oid | OID of the resource pool |
| respool | name | Name of the resource pool |
| control_group | name | Cgroup associated with the resource pool |
| parentid | oid | OID of the parent resource pool |
| ref_count | integer | Number of jobs associated with the resource pool |

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| Name | Type | Description |
| --- | --- | --- |
| active_points | integer | Number of used points in the resource pool |
| running_count | integer | Number of jobs running in the resource pool |
| waiting_count | integer | Number of jobs queuing in the resource pool |
| io_limits | integer | IOPS upper limit of the resource pool |
| io_priority | integer | I/O priority of the resource pool |

## 16.2.17.6 WLM_USER_RESOURCE_CONFIG

**WLM_USER_RESOURCE_CONFIG** displays the resource configuration information of a user.

**Table 16-196** WLM_USER_RESOURCE_CONFIG columns

| Name | Type | Description |
| --- | --- | --- |
| userid | oid | OID of the user |
| username | name | Username |
| sysadmin | boolean | Whether the user has the **sysadmin** permission |
| rpoid | oid | OID of the resource pool |
| respool | name | Name of the resource pool |
| parentid | oid | OID of the parent user |
| totalspace | bigint | Size of the occupied space |
| spacelimit | bigint | Upper limit of the space size |
| childcount | integer | Number of child users |
| childlist | texto | Child user list |

## 16.2.17.7 WLM_USER_RESOURCE_RUNTIME

**WLM_USER_RESOURCE_RUNTIME** displays resource usage of all users. Only administrators can query this view. This view is valid only when the GUC parameter **use_workload_manager** is set to **on**.

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**Table 16-197** WLM_USER_RESOURCE_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| username | name | Username |
| used_memory | integer | Size of the memory being used (unit: MB) |
| total_memory | integer | Available memory (unit: MB) The value **0** indicates that the available memory is not limited and depends on the maximum memory available in the database. |
| used_cpu | integer | Number of CPU cores in use |
| total_cpu | integer | Total number of CPU cores of the Cgroup associated with the user on the node |
| used_space | bigint | Used storage space (unit: KB) |
| total_space | bigint | Available storage space (unit: KB). The value **-1** indicates that the space is not limited. |
| used_temp_space | bigint | Used temporary space (reserved column; unit: KB) |
| total_temp_space | bigint | Available temporary space (reserved column; unit: KB). The value **-1** indicates that the maximum temporary storage space is not limited. |
| used_spill_space | bigint | Used space for storing spilled data (reserved column; unit: KB) |
| total_spill_space | bigint | Available space for storing spilled data (reserved column; unit: KB). The value **-1** indicates that the maximum space for storing spilled data is not limited. |

## 16.2.17.8 WLM_WORKLOAD_HISTORY_INFO

**WLM_WORKLOAD_HISTORY_INFO** displays information about workload management after a job is complete or the exception has been handled. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 16-198** WLM_WORKLOAD_HISTORY_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| statement | text | Statement executed for exception handling |

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| Name | Type | Description |
| --- | --- | --- |
| block_time | bigint | Block time before the statement is executed |
| elapsed_time | bigint | Elapsed time when the statement is executed |
| total_cpu_time | bigint | Total time used by the CPU on the DN when the statement is executed for exception handling |
| qualification_time | bigint | Period when the statement checks the skew |
| cpu_skew_percent | integer | CPU usage skew on the DN when the statement is executed for exception handling |
| control_group | text | Cgroup used when the statement is executed for exception handling |
| status | text | Statement status after statement are executed for exception handling, including:<br>• **pending**: waiting to be executed<br>• **running**: being executed<br>• **finished**: finished normally<br>• **abort**: terminated unexpectedly |
| action | text | Actions when statements are executed for exception handling, including:<br>• **abort**: terminating the operation.<br>• **adjust**: executing the Cgroup adjustment operations. Currently, you can only perform the demotion operation.<br>• **finish**: finished normally |

## 16.2.17.9 WLM_WORKLOAD_RUNTIME

**WLM_WORKLOAD_RUNTIME** displays the status of job executed by the current user on CNs.

**Table 16-199** WLM_WORKLOAD_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Name of the CN where a job is executed |
| thread_id | bigint | Backend thread ID |

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| Name | Type | Description |
| --- | --- | --- |
| processid | integer | PID of the backend thread |
| time_stamp | bigint | Time when the statement starts to be executed |
| username | name | Name of the user logged in to the backend |
| memory | integer | Memory required by the statement |
| active_points | integer | Number of resources consumed by the statement in the resource pool |
| max_points | integer | Number of resources consumed by the statement in the resource pool |
| priority | integer | Job priority |
| resource_pool | text | Resource pool to which the job belongs |
| status | text | Job execution status. Its value can be:<br>● **pending**: blocked status<br>● **running**: running status<br>● **finished**: final status<br>● **aborted**: termination status<br>● **unknown**: unknown status |
| control_group | text | Cgroups used by the job |
| enqueue | text | Queue that the job is in. Its value can be:<br>● **GLOBAL**: global queue<br>● **RESPOOL**: resource pool queue<br>● **ACTIVE**: not in a queue |
| query | text | Statement being executed |
| node_group | text | Logical cluster name (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

## 16.2.17.10 GLOBAL_WLM_WORKLOAD_RUNTIME

**GLOBAL_WAL_WORKLOAD_RUNTIME** displays the status of jobs executed by the current user on CNs. This view is accessible only to users with system administrator permissions.

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**Table 16-200** GLOBAL_WAL_WORKLOAD_RUNTIME columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Name of the CN where the job is executed |
| thread_id | bigint | Backend thread ID |
| processid | integer | LWP ID of the thread |
| time_stamp | bigint | Time when the statement starts to be executed |
| username | name | Name of the user logged in to the backend |
| memory | integer | Memory required by the statement |
| active_points | integer | Number of resources consumed by the statement in the resource pool |
| max_points | integer | Maximum number of resources in the resource pool |
| priority | integer | Job priority |
| resource_pool | text | Resource pool to which the job belongs |
| status | text | Job execution status. Its value can be:<br>• **pending**: blocked status<br>• **running**: running status<br>• **finished**: final status<br>• **aborted**: termination status<br>• **unknown**: unknown status |
| control_group | name | Cgroups used by the job |
| enqueue | text | Queue that the job is in. Its value can be:<br>• **GLOBAL**: global queue<br>• **RESPOOL**: resource pool queue<br>• **ACTIVE**: not in a queue |
| query | text | Statement being executed |
| node_group | text | Name of the logical cluster (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) |

## 16.2.17.11 LOCAL_IO_WAIT_INFO

Returns the real-time statistics of I/O control on the current node.

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**Table 16-201** LOCAL_IO_WAIT_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name. |
| device_name | text | Name of the data disk mounted to the node. |
| read_per_second | float | Number of read completions per second. |
| write_per_second | float | Number of write completions per second. |
| write_ratio | float | Ratio of the disk write I/Os to the total I/Os. |
| io_util | float | Percentage of the I/O time to the total CPU time per second. |
| total_io_util | integer | Level of the CPU time occupied by the last three I/Os. The value ranges from 0 to 6. |
| tick_count | integer | Interval for updating disk I/O information. The value is fixed to 1 second. The value is cleared each time before data is read. |
| io_wait_list_len | integer | Size of the I/O request thread wait queue. If the value is **0**, no I/O is under control. |

## 16.2.17.12 GLOBAL_IO_WAIT_INFO

Returns the real-time statistics of I/O control on all nodes.

**Table 16-202** GLOBAL_IO_WAIT_INFO columns

| Name | Type | Description |
| --- | --- | --- |
| node_name | text | Node name. |
| device_name | text | Name of the data disk mounted to the node. |
| read_per_second | float | Number of read completions per second. |
| write_per_second | float | Number of write completions per second. |
| write_ratio | float | Ratio of the disk write I/Os to the total I/Os. |
| io_util | float | Percentage of the I/O time to the total CPU time per second. |
| total_io_util | integer | Level of the CPU time occupied by the last three I/Os. The value ranges from 0 to 6. |

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| Name | Type | Description |
| --- | --- | --- |
| tick_count | integer | Interval for updating disk I/O information. The value is fixed to 1 second. The value is cleared each time before data is read. |
| io_wait_list_len | integer | Size of the I/O request thread wait queue. If the value is **0**, no I/O is under control. |

## 16.2.18 Global Plan Cache

### 16.2.18.1 LOCAL_PLANCACHE_STATUS

**LOCAL_PLANCACHE_STATUS** displays the status of the GPC plan cache on the current node. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 16-203** LOCAL_PLANCACHE_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Name of the node that the plan cache belongs to |
| query | text | Text of query statements |
| refcount | integer | Number of times that the plan cache is referenced |
| valid | bool | Whether the plan cache is valid |
| databaseid | oid | ID of the database that the plan cache belongs to |
| schema_name | text | Schema that the plan cache belongs to |
| params_num | integer | Number of parameters |
| func_id | oid | OID of the stored procedure where the plan cache is located. If the plancache does not belong to the stored procedure, the value is **0**. |

### 16.2.18.2 GLOBAL_PLANCACHE_STATUS

**GLOBAL_PLANCACHE_STATUS** displays the status of GPC plan caches on all nodes. For details about the columns, see **16.2.18.1 LOCAL_PLANCACHE_STATUS**. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

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### 16.2.18.3 LOCAL_PREPARE_STATEMENT_STATUS (Discarded)

**LOCAL_PREPARE_STATEMENT_STATUS** displays the information about prepare statements corresponding to the GPC plan cache on the current node. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

**Table 16-204** LOCAL_PREPARE_STATEMENT_STATUS columns

| Name | Type | Description |
| --- | --- | --- |
| nodename | text | Name of the node that the statement belongs to |
| cn_sess_id | bigint | Session ID of the CN that the statement is sent from |
| cn_node_id | integer | Node ID of the CN that the statement is sent from |
| cn_time_line | integer | Number of restart times of the CN that the statement is sent from |
| statement_name | text | Statement name |
| refcount | integer | Number of times that the corresponding plan cache is referenced |
| is_shared | bool | Whether the corresponding plan cache is shared |
| query | text | Corresponding query statement. |

### 16.2.18.4 GLOBAL_PREPARE_STATEMENT_STATUS (Discarded)

**GLOBAL_PREPARE_STATEMENT_STATUS** displays the information about prepare statements corresponding to GPC plan caches on all nodes. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) For details about the columns, see **16.2.18.3 LOCAL_PREPARE_STATEMENT_STATUS (Discarded)**.

## 16.2.19 RTO & RPO

### 16.2.19.1 global_rto_status

Displays log flow control information about the primary and standby nodes (except the current node and DNs).

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**Table 16-205** global_rto_status columns

| Parameter | Type | Description |
| --- | --- | --- |
| node_name | text | Node name (including the primary and standby nodes) |
| rto_info | text | Flow control information, including the current log flow control time (unit: second) of the standby server, the expected flow control time (unit: second) specified by the GUC parameter, and the primary server sleep time (unit: μs) required to reach the expectation |

## 16.2.19.2 global_streaming_hadr_rto_and_rpo_stat

**global_streaming_hadr_rto_and_rpo_stat** displays the log flow control information about the primary and standby clusters for streaming DR. (This view can be used only on the CN in the primary cluster and cannot obtain statistics from the DN or standby cluster.)

**Table 16-206** Parameters

| Parameter | Type | Description |
| --- | --- | --- |
| hadr_sender_node_name | text | Name of the first standby node of the primary and standby clusters. |
| hadr_receiver_node_name | text | Name of the first standby node in the standby cluster. |
| current_rto | int | Flow control information, that is, log RTO time of the current primary and standby clusters (unit: second). |
| target_rto | int | Flow control information, that is, RTO time between the target primary and standby clusters (unit: second) |
| current_rpo | int | Flow control information, that is, log RPO time of the current primary and standby clusters (unit: second) |
| target_rpo | int | Flow control information, that is, RPO time between the target primary and standby clusters (unit: second). |
| rto_sleep_time | int | RTO flow control information, that is, expected sleep time (unit: μs) required by WAL sender on the host to reach the specified RTO |
| rpo_sleep_time | int | RPO flow control information, that is, expected sleep time (unit: μs) required by xlogInsert on the host to reach the specified RPO. |

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# 16.3 WDR Snapshot Schema

After the WDR snapshot function is enabled (the **enable_wdr_snapshot** parameter is set to **on**), objects are created in the snapshot schema in the **postgres** database of the **pg_default** tablespace to persist WDR snapshot data. By default, the initial user or monitor administrator can access objects in the snapshot schema.

You can set the parameter **wdr_snapshot_retention_days** to automatically manage the snapshot lifecycle.

## 16.3.1 Original Information of WDR Snapshots

### 16.3.1.1 SNAPSHOT.SNAPSHOT

**SNAPSHOT** records the index information, start time, and end time of WDR snapshots stored in the current system. Only the initial user or monitor administrator has the permission to view the information. The result can be queried only in the system database but cannot be queried in the user database. After the WDR snapshot function is enabled (the parameter **enable_wdr_snapshot** is set to **on**), the table is created.

**Table 16-207** SNAPSHOT attributes

| Name | Type | Description | Example |
| --- | --- | --- | --- |
| snapshot_id | bigint | WDR snapshot ID | 1 |
| start_ts | timestamp | Start time of a WDR snapshot | 2019-12-28 17:11:27.423742+08 |
| end_ts | timestamp | End time of a WDR snapshot | 2019-12-28 17:11:43.67726+08 |

### 16.3.1.2 SNAPSHOT.TABLES_SNAP_TIMESTAMP

**TABLES_SNAP_TIMESTAMP** records the start time and end time of data collection, as well as corresponding databases, and table objects for all stored WDR snapshots. Only the initialization user or monitor administrator has the permission to view the table. After the WDR snapshot function is enabled (the parameter **enable_wdr_snapshot** is set to **on**), the table is created.

**Table 16-208** TABLES_SNAP_TIMESTAMP attributes

| Name | Type | Description | Example |
| --- | --- | --- | --- |
| snapshot_id | bigint | WDR snapshot ID | 1 |

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| Name | Type | Description | Example |
| --- | --- | --- | --- |
| db_name | text | Database corresponding to a WDR snapshot | tpcc1000 |
| tablename | text | Table corresponding to a WDR snapshot | snap_xc_statio_all_indexes |
| start_ts | timestamp | Start time of a WDR snapshot | 2019-12-28 17:11:27.425849+08 |
| end_ts | timestamp | End time of a WDR snapshot | 2019-12-28 17:11:27.707398+08 |

#### 16.3.1.3 SNAP_SEQ

**SNAP_SEQ** is an ascending sequence, which provides IDs for WDR snapshots.

## 16.3.2 WDR Snapshot Data Table

The naming rule of a WDR snapshot data table is **snap**_*{source data table}*.

WDR snapshot data tables come from all views in **16.2 DBE_PERF Schema**.

NOTE

The initial user or monitoring administrator has the permission to view the WDR snapshot data table.

## 16.3.3 Performance Report Generated Based on WDR Snapshots

Performance reports are generated based on the summary and statistics of WDR snapshot data tables. By default, the initial user or monitoring administrator can generate reports.

### Prerequisites

The number of WDR snapshots is greater than or equal to 2.

### Procedure

**Step 1** Run the following command to create a report file:

```
touch  /home/om/wdrTestNode.html
```

**Step 2** Run the following command to connect to the **postgres** database.

```
gsql -d postgres -p [Port number] -r
```

**Step 3** Run the following command to query the generated snapshot and obtain **snapshot_id**:

```
select * from snapshot.snapshot;
```

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**Step 4** (Optional) Run the following command on the CCN to manually create a snapshot. If only one snapshot exists in the database or you want to view the monitoring data of the database in the current period, manually create a snapshot. This command is only available to users with the **sysadmin** permission.

```
select create_wdr_snapshot();
```

NOTE

Run the **cm_ctl query -Cdvi** command. In the command output, the information under **Central Coordinator State** is the CCN information.

**Step 5** Generate a performance report.

1. Run the following command to generate a formatted performance report file:

   ```
   \a \t \o /home/om/wdrTestNode.html
   ```

   The parameters in the preceding command are described as follows:

   - **\a**: switches the unaligned mode.
   - **\t**: switches the information and row count footer of the output column name.
   - **\o**: specifies that all the query results are sent to the server file.
   - *Server file path*: indicates the path for storing the generated performance report file. The user must have the read and write permissions on the path.

2. Run the following command to write the queried information to the performance report:

   ```
   select generate_wdr_report(begin_snap_id bigint, end_snap_id bigint, report_type cstring, report_scope cstring, node_name cstring);
   ```

   The description of the parameters in the preceding command is as follows:

**Table 16-209** Parameters of the generate_wdr_report function

| Parameter | Description | Value Range |
| --- | --- | --- |
| begin_snap_id | ID of a snapshot when a query starts, which is specified by **snapshot_id** in the **snapshot.snaoshot** table. | - |
| end_snap_id | ID of a snapshot when a query ends. By default, the value of **end_snap_id** is greater than that of **begin_snap_id table** (**snapshot_id** in the **snapshot.snaoshot** table). | - |

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| Parameter | Description | Value Range |
| --- | --- | --- |
| report_type | Type of the generated report. The value can be **summary**, **detail**, or **all**. | – **summary**: Summary data<br>– **detail**: Detailed data<br>– **all**: summary data and detailed data |
| report_scope | Range of the generated report. The value can be **cluster** or **node**. | – **cluster**: database-level information<br>– **node**: node-level information |
| node_name | When **report_scope** is set to **node**, set this parameter to the name of the corresponding node. (You can run the **select * from pg_node_env;** command to query the node name.)<br>If **report_scope** is set to **cluster**, this parameter can be omitted, left blank, or set to **NULL**. | – **node**: a node name in GaussDB<br>– **cluster**: This value is omitted, left blank or set to **NULL**. |

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**CAUTION**

The two snapshots used to generate the report should meet the following conditions:

- No node is restarted between two snapshots.
- No primary/standby switchover is performed between two snapshots.
- Performance indicators cannot be reset between two snapshots.
- No drop database operation is performed between two snapshots.
- If a negative value exists in the generated WDR, it indicates that the indicator cannot reflect the performance of the database.
- The time required for generating a report depends on the amount of performance data in the performance snapshot. Generally, a report can be generated in minutes. If the report cannot be generated within 5 minutes, collect the statistics **12.14.40 ANALYZE | ANALYSE** about the tables in the snapshot schema (considering the **snap_global_statio_all_tables** and **snap_global_statio_all_indexes** tables first), and then generate the report again. Alternatively, set **set statement_timeout** to ***** to terminate report generation.
- When generating a report, ensure that the character set of the client is the same as that of openGauss. You can run **set client_encoding to *** to set the character set of the client.

3. Disable the output options and format the output.

```
\o \a \t
```

**Step 6** **View the WDR** in **/home/om/** as required.

**----End**

## Examples

```
-- Create a report file.
touch  /home/om/wdrTestNode.html

-- Connect to the database.
gsql -d postgres -p [Port number] -r

-- Query the snapshots that have been generated.
openGauss=# select * from snapshot.snapshot;
 snapshot_id |          start_ts          |          end_ts
-------------+----------------------------+----------------------------
           1 | 2020-09-07 10:20:36.763244+08 | 2020-09-07 10:20:42.166511+08
           2 | 2020-09-07 10:21:13.416352+08 | 2020-09-07 10:21:19.470911+08
(2 rows)

-- Generate the formatted performance report wdrTestNode.html.
openGauss=# \a \t \o /home/om/wdrTestNode.html
Output format is unaligned.
Showing only tuples.

-- Write data into the performance report wdrTestNode.html.
openGauss=# select generate_wdr_report(1, 2, 'all', 'node', 'dn_6001_6002_6003');

-- Close the performance report wdrTestNode.html.
openGauss=# \o

-- Generate the formatted performance report wdrTestCluster.html.
openGauss=# \o /home/om/wdrTestCluster.html
```

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```
-- Write data into the performance report wdrTestCluster.html.
openGauss=# select generate_wdr_report(1, 2, 'all', 'cluster');

-- Close the performance report wdrTestCluster.html.
openGauss=# \o \a \t
Output format is aligned.
Tuples only is off.
```

## 16.3.4 WDRs

The following table describes the main contents of WDR reports.

**Table 16-210** Content of WDRs

| Item | Description |
| --- | --- |
| **Database Stat** | • Database performance statistics: transactions, read and write operations, row activities, write conflicts, and deadlocks<br>• Cluster-wide report, which can be viewed only in cluster mode |
| **Load Profile** | • Cluster performance statistics: CPU time, DB time, logical or physical read operation, I/O performance, login and logout, load strength, and load performance<br>• Cluster-wide report, which can be viewed only in cluster mode |
| **Instance Efficiency Percentages** | • Cluster-level or node-level cache hit ratio<br>• Cluster- or node-wide report, which can be viewed in cluster or node mode |
| **Top 10 Events by Total Wait Time** | • Most time-consuming event<br>• Node-wide report, which can be viewed in node mode |
| **Wait Classes by Total Wait Time** | • Category of the wait time that is most time-consuming<br>• Node-wide report, which can be viewed in node mode |
| **Host CPU** | • CPU usage of the host<br>• Node-wide report, which can be viewed in node mode |
| **IO Profile** | • I/O usage in the cluster or node dimension.<br>• Cluster- or node-wide report, which can be viewed in cluster or node mode |
| **Memory Statistics** | • Kernel memory usage distribution<br>• Node-wide report, which can be viewed in node mode |
| **Time Model** | • Time distribution information about the statements on a node<br>• Node-wide report, which can be viewed in node mode |

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| Item | Description |
| --- | --- |
| SQL Statistics | • SQL statement performance statistics: end-to-end time, row activities, cache hit, CPU consumption, and time consumption<br>• Cluster- or node-wide report, which can be viewed in cluster or node mode |
| Wait Events | • Statistics on wait events at the node level<br>• Node-wide report, which can be viewed in node mode |
| Cache IO Stats | • I/O statistics on user tables and indexes<br>• Cluster- or node-wide report, which can be viewed in cluster or node mode |
| Utility status | • Status information about the replication slot and background checkpoint<br>• Node-wide report, which can be viewed in node mode |
| Object stats | • Performance statistics in the index and table dimensions<br>• Cluster- or node-wide report, which can be viewed in cluster or node mode |
| Configuration settings | • Node configuration<br>• Node-wide report, which can be viewed in node mode |
| SQL Detail | • SQL statement text details<br>• Cluster- or node-wide report, which can be viewed in cluster or node mode |

### 16.3.4.1 Database Stat

The following table describes columns in the Database Stat report.

**Table 16-211** Columns in the Database Stat report

| Column | Description |
| --- | --- |
| DB Name | Database name |
| Backends | Number of backends connected to this database |
| Xact Commit | Number of transactions in this database that have been committed |
| Xact Rollback | Number of transactions in this database that have been rolled back |
| Blks Read | Number of disk blocks read in this database |
| Blks Hit | Number of times that disk blocks have been found in the cache |

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| Column | Description |
| --- | --- |
| Tuple Returned | Number of rows sequentially scanned |
| Tuple Fetched | Number of rows randomly scanned |
| Tuple Inserted | Number of rows inserted by queries in this database |
| Tuple Updated | Number of rows updated by queries in this database |
| Tup Deleted | Number of rows deleted by queries in this database |
| Conflicts | Number of queries canceled due to conflicts |
| Temp Files | Number of temporary files created by queries in this database |
| Temp Bytes | Total amount of data written to temporary files by queries in this database |
| Deadlocks | Number of deadlocks detected in this database |
| Blk Read Time | Time spent reading data file blocks by backends in this database (unit: ms) |
| Blk Write Time | Time spent reading data file blocks by backends in this database (unit: ms) |
| Stats Reset | Time at which the current statistics were reset |

### 16.3.4.2 Load Profile

The following table lists metrics in the Load Profile report.

**Table 16-212** Metrics in the Load Profile report

| Metric | Description |
| --- | --- |
| DB Time(us) | Total elapsed time of a job |
| CPU Time(us) | Total CPU time used for job running |
| Redo size(blocks) | Size of the generated WAL (blocks) |
| Logical read (blocks) | Number of logical reads for a table or an index (number of blocks) |
| Physical read (blocks) | Number of physical reads for a table or an index (number of blocks) |
| Physical write (blocks) | Number of physical writes (blocks) on a table or an index |

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| Metric | Description |
| --- | --- |
| Read IO requests | Number of reads for a table or an index |
| Write IO requests | Number of writes for a table or an index |
| Read IO (MB) | Size of reads for a table or an index (in MB) |
| Write IO (MB) | Size of writes for a table or an index (in MB) |
| Logons | Number of logins |
| Executes (SQL) | Number of times SQL statements are executed |
| Rollbacks | Number of rolled-back transactions |
| Transactions | Number of transactions |
| SQL response time P95(us) | Response time of 95% SQL statements |
| SQL response time P80(us) | Response time of 80% SQL statements |

### 16.3.4.3 Instance Efficiency Percentages

The following table lists metrics in the Instance Efficiency Percentages report.

**Table 16-213** Metrics in the Instance Efficiency Percentages report

| Metric | Description |
| --- | --- |
| Buffer Hit % | Hit ratio of the buffer pool |

### 16.3.4.4 Top 10 Events by Total Wait Time

The following table lists columns in the Top 10 Events by Total Wait Time report.

**Table 16-214** Columns in the Top 10 Events by Total Wait Time report

| Column | Description |
| --- | --- |
| Event | Name of a wait event |
| Waits | Number of wait times |
| Total Wait Time(us) | Total wait time, in microseconds |
| Avg Wait Time(us) | Average wait time, in microseconds |

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| Column | Description |
| --- | --- |
| Tpye | Wait event type |

### 16.3.4.5 Wait Classes by Total Wait Time

The following table lists columns in the Wait Classes by Total Wait Time report.

**Table 16-215** Columns in the Wait Classes by Total Wait Time report

| Column | Description |
| --- | --- |
| Tpye | Wait events are classified as follows:<br>• STATUS<br>• LWLOCK_EVENT<br>• LOCK_EVENT<br>• IO_EVENT |
| Waits | Number of wait times |
| Total Wait Time(us) | Total wait time, in microseconds |
| Avg Wait Time(us) | Average wait time, in microseconds |

### 16.3.4.6 Host CPU

The following table describes columns in the Host CPU report.

**Table 16-216** Columns in the Host CPU report

| Column | Description |
| --- | --- |
| Cpus | Number of CPUs |
| Cores | Number of CPU cores |
| Sockets | Number of CPU sockets |
| Load Average Begin | Average load of the start snapshot |
| Load Average End | Average load of the end snapshot |
| %User | Percentage of CPU time occupied when the system is running in user mode |

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| Column | Description |
| --- | --- |
| %System | Percentage of CPU time occupied when the system is running in kernel mode |
| %WIO | Percentage of CPU time occupied when the system is running in wait I/O mode |
| %Idle | Percentage of CPU time occupied when the system is running in idle mode |

### 16.3.4.7 IO Profile

The following table lists metrics in the IO Profile report.

**Table 16-217** Metrics in the IO Profile report

| Metric | Description |
| --- | --- |
| Database requests | Number of database I/O times |
| Database (MB) | Database I/O data volume |
| Database (blocks) | Number of database I/O data blocks |
| Redo requests | Number of redo I/O times |
| Redo (MB) | Redo I/O data volume |

### 16.3.4.8 Memory Statistics

The following table lists metrics in the Memory Statistics report.

**Table 16-218** Metrics in the Memory Statistics report

| Metric | Description |
| --- | --- |
| shared_used_memory | Size of the used shared memory, in MB |
| max_shared_memory | Size of the maximum shared memory, in MB |
| process_used_memory | Size of the used process memory, in MB |
| max_process_memory | Size of the maximum process memory, in MB |

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### 16.3.4.9 Time Model

The following table describes metrics in the Time Model report.

**Table 16-219** Metrics in the Time Model report

| Name | Description |
| --- | --- |
| DB_TIME | Total end-to-end wall time consumed by all threads (unit: μs) |
| EXECUTION_TIME | Total time consumed on the executor (unit: μs) |
| PL_EXECUTION_TIME | Total time consumed for executing PL/SQL statements (unit: μs) |
| CPU_TIME | Total CPU time consumed by all threads (unit: μs) |
| PLAN_TIME | Total time consumed for generating an execution plan (unit: μs) |
| REWRITE_TIME | Total time consumed for rewriting queries (unit: μs) |
| PL_COMPILATION_TIME | Total time consumed for compiling SQL statements (unit: μs) |
| PARSE_TIME | Total time consumed for parsing SQL statements (unit: μs) |
| NET_SEND_TIME | Total time consumed for sending data over the network (unit: μs) |
| DATA_IO_TIME | Total time consumed for reading and writing data (unit: μs) |

### 16.3.4.10 SQL Statistics

The following table describes columns in the SQL Statistics report.

**Table 16-220** Columns in the SQL Statistics report

| Column | Description |
| --- | --- |
| Unique SQL Id | ID of the normalized SQL statement. |
| Node Name | Node name. |
| User Name | Username. |

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| Column | Description |
| --- | --- |
| Tuples Read | Number of tuples that are read. |
| Calls | Number of calls. |
| Min Elapse Time(us) | Minimum execution time (unit: us). |
| Max Elapse Time(us) | Maximum execution time (unit: us). |
| Total Elapse Time(us) | Total execution time (unit: us). |
| Avg Elapse Time(us) | Average execution time (unit: us). |
| Returned Rows | Number of rows returned by SELECT. |
| Tuples Affected | Number of rows affected by INSERT, UPDATE, and DELETE. |
| Logical Read | Number of logical reads on the buffer. |
| Physical Read | Number of physical reads on the buffer. |
| CPU Time(us) | CPU time (unit: us). |
| Data IO Time(us) | Time spent on I/O (unit: us). |
| Sort Count | Number of sorting execution times. |
| Sort Time(us) | Sorting execution time (unit: us). |
| Sort Mem Used(KB) | Size of work memory used during sorting (unit: KB). |
| Sort Spill Count | Number of file writes when data is flushed to disks during sorting. |
| Sort Spill Size(KB) | File size used when data is flushed to disks during sorting (unit: KB). |
| Hash Count | Number of hashing execution times. |
| Hash Time(us) | Hashing execution time (unit: us). |
| Hash Mem Used(KB) | Size of work memory used during hashing (unit: KB). |

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| Column | Description |
| --- | --- |
| Hash Spill Count | Number of file writes when data is flushed to disks during hashing. |
| Hash Spill Size(KB) | File size used when data is flushed to disks during hashing (unit: KB). |
| SQL Text | Normalized SQL character string. |

## 16.3.4.11 Wait Events

The following table describes columns in the Wait Events report.

**Table 16-221** Columns in the Wait Events report

| Column | Description |
| --- | --- |
| Type | Wait events are classified as follows:<br>• STATUS<br>• LWLOCK_EVENT<br>• LOCK_EVENT<br>• IO_EVENT |
| Event | Name of a wait event |
| Total Wait Time (us) | Total wait time (unit: us) |
| Waits | Total number of wait times |
| Failed Waits | Number of wait failures |
| Avg Wait Time (us) | Average wait time (unit: us) |
| Max Wait Time (us) | Maximum wait time (unit: us) |

## 16.3.4.12 Cache IO Stats

The Cache IO Stats report consists of two tables, namely, **User table IO activity** and **User index IO activity**. Columns in the tables are described as follows:

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## User table IO activity

**Table 16-222** Columns in the User table IO activity table

| Column | Description |
| --- | --- |
| DB Name | Database name |
| Schema Name | Schema name |
| Table Name | Table name |
| %Heap Blks Hit Ratio | Buffer pool hit ratio of the table |
| Heap Blks Read | Number of disk blocks read from the table |
| Heap Blks Hit | Number of cache hits in the table |
| Idx Blks Read | Number of disk blocks read from all indexes in the table |
| Idx Blks Hit | Number of cache hits of all indexes in the table |
| Toast Blks Read | Number of disk blocks read from the TOAST table (if any) in the table |
| Toast Blks Hit | Number of buffer hits in the TOAST table (if any) in the table |
| Tidx Blks Read | Number of disk blocks read from the TOAST table index (if any) in the table |
| Tidx Blks Hit | Number of buffer hits in the TOAST table index (if any) in the table |

## User index IO activity

**Table 16-223** Columns in the User index IO activity table

| Column | Description |
| --- | --- |
| DB Name | Database name |
| Schema Name | Schema name |
| Table Name | Table name |

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| Column | Description |
| --- | --- |
| Index Name | Index name |
| %Idx Blks Hit Ratio | Index hit ratio |
| Idx Blks Read | Number of disk blocks read from all indexes |
| Idx Blks Hit | Number of cache hits of all indexes |

### 16.3.4.13 Utility status

The Utility status report consists of two tables, namely, **Replication slot** and **Replication stat**. Columns in the tables are described as follows:

## Replication slot

**Table 16-224** Columns in the Replication slot table

| Column | Description |
| --- | --- |
| Slot Name | Replication node name |
| Slot Type | Type of the replication node |
| DB Name | Name of the database on the replication node |
| Active | Replication node status |
| Xmin | Transaction ID of the replication node |
| Restart Lsn | Xlog file information on the replication node |
| Dummy Standby | Replication node as a dummy standby |

## Replication stat

**Table 16-225** Columns in the Replication stat table

| Column | Description |
| --- | --- |
| Thread Id | PID of the thread |
| Usesys Id | User system ID |
| Usename | Username |
| Application Name | Application name |

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| Column | Description |
| --- | --- |
| Client Addr | Client address |
| Client Hostname | Client host name |
| Client Port | Client port |
| Backend Start | Start time of an application |
| State | Log replication status |
| Sender Sent Location | Location where the sender sends logs |
| Receiver Write Location | Location where the receiver writes logs |
| Receiver Flush Location | Location where the receiver flushes logs |
| Receiver Replay Location | Location where the receiver replays logs |
| Sync Priority | Synchronization priority |
| Sync State | Synchronization status |

## 16.3.4.14 Object stats

The Object stats report consists of three tables, namely, **User Tables stats**, **User index stats**, and **Bad lock stats**. Columns in the tables are described as follows:

## User Tables stats

**Table 16-226** Columns in the User Tables stats table

| Column | Description |
| --- | --- |
| DB Name | Database name |
| Schema | Schema name |
| Relname | Relation name |
| Seq Scan | Number of sequential scans initiated in the table |
| Seq Tup Read | Number of live rows fetched by sequential scans |
| Index Scan | Number of index scans initiated in the table |
| Index Tup Fetch | Number of live rows fetched by index scans |
| Tuple Insert | Number of rows inserted |

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| Column | Description |
| --- | --- |
| Tuple Update | Number of rows updated |
| Tuple Delete | Number of rows deleted |
| Tuple Hot Update | Number of rows HOT updated (with no separate index updated) |
| Live Tuple | Estimated number of live rows |
| Dead Tuple | Estimated number of dead rows |
| Last Vacuum | Last time at which the table was manually vacuumed (not counting **VACUUM FULL**) |
| Last Autovacuum | Last time at which the table was vacuumed by the autovacuum daemon |
| Last Analyze | Last time at which the table was manually analyzed |
| Last Autoanalyze | Last time at which the table was analyzed by the autovacuum daemon |
| Vacuum Count | Number of times the table has been manually vacuumed (not counting **VACUUM FULL**) |
| Autovacuum Count | Number of times the table has been vacuumed by the autovacuum daemon |
| Analyze Count | Number of times the table has been manually analyzed |
| Autoanalyze Count | Number of times the table has been analyzed by the autovacuum daemon |

## User index stats

**Table 16-227** Columns in the User index stats table

| Column | Description |
| --- | --- |
| DB Name | Database name |
| Schema | Schema name |
| Relname | Relation name |
| Index Relname | Index name |
| Index Scan | Number of index scans initiated on the index |
| Index Tuple Read | Number of index entries returned by scans on the index |

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| Column | Description |
| --- | --- |
| Index Tuple Fetch | Number of table rows fetched by simple index scans by using the index |

## Bad lock stats

**Table 16-228** Columns in the Bad lock stats table

| Column | Description |
| --- | --- |
| DB Id | Database OID |
| Tablespace Id | Tablespace OID |
| Relfilenode | File object ID |
| Fork Number | File type |
| Error Count | Number of failures |
| First Time | First occurrence time |
| Last Time | Last occurrence time |

## 16.3.4.15 Configuration settings

The following table describes columns in the Configuration settings report.

**Table 16-229** Columns in the Configuration settings report

| Column | Description |
| --- | --- |
| Name | GUC parameter name |
| Abstract | GUC parameter description |
| Type | Data type |
| Curent Value | Current value |
| Min Value | Valid minimum value |
| Max Value | Valid maximum value |
| Category | GUC parameter type |
| Enum Values | All enumerated values |
| Default Value | Default parameter value used upon the database startup |

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| Column | Description |
| --- | --- |
| Reset Value | Default parameter value used upon the database reset |

## 16.3.4.16 SQL Detail

The following table describes columns in the SQL Detail report.

**Table 16-230** Columns in the SQL Detail report

| Column | Description |
| --- | --- |
| Unique SQL Id | ID of the normalized SQL statement |
| User Name | Username |
| Node Name | Node name. This column is not displayed in node mode. |
| SQL Text | Normalized SQL text |

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# 17 GTM Mode

To meet different concurrency and consistency requirements, GaussDB provides GTM-Lite and GTM-Free modes. The main difference between GTM-Lite and GTM-Free lies in the pressure of the central transaction management node GTM and the transaction processing process. In GTM-Lite mode, the pressure on the central transaction processing node is reduced, the transaction processing process is further optimized, and the GTM performance and concurrency bottleneck are reduced. In this way, the transaction processing capability is improved to a great extent while ensuring consistency. In GTM-Free mode, the central transaction management node does not participate in transaction management, eliminating the single point of failure and achieving higher transaction processing performance. However, in terms of consistency, all transactions can be completed to ensure external read consistency. Strong consistency read of distributed transactions is not supported. Transaction consistency that depends on query results, such as insert into **select * from**, is not supported.

The current version does not support the switchover between the two modes. You are advised to use the default GTM mode during installation. The GTM mode can remain unchanged before and after the upgrade.

The related GUC parameters include **enable_gtm_free** and **gtm_option**. You can run the **show** statement in gsql to query the current GTM mode.

```
SHOW enable_gtm_free;
SHOW gtm_option;
```

The method of determining the mode is as follows:

- GTM-Lite mode: **enable_gtm_free=off** and **gtm_option=1**
- GTM-Free mode: **enable_gtm_free=on** or **gtm_option=2**

In GTM-Lite mode, GaussDB supports strong consistency and complete syntaxes for distributed transactions. In GTM-Free mode, eventual consistent execution and concurrency control are used for distributed transactions. Therefore, the usage scenarios and methods of some syntaxes are restricted. If the restricted syntaxes are required due to service requirements, refactoring is required based on the understanding of the eventual consistent behavior. The involved restricted syntaxes and refactoring suggestions are as follows:

1. General principle: Specify a proper distribution key (by using **DISTRIBUTE BY**) for all user tables.

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- You are advised to distribute data evenly.
- You are advised to use the join condition in a query as the distribution key to ensure that the join query does not cause data flow between DNs.
- You are advised to select the primary key of the table as the distribution key.

2. SELECT:
   - During table query, the **WHERE** condition must contain the equivalent query condition of all distribution keys.
   - Do not use subqueries in the **SELECT** target columns. Otherwise, the plan may fail to be pushed down to DNs for execution, affecting the execution performance.
3. DML:

   By default, cross-node transactions are not supported. If the executed DML statement contains cross-node transactions, an error is reported. There are two scenarios:

   a. If a user statement is split into multiple independent statements in the database, the error message "INSERT/UPDATE/DELETE/MERGE contains multiple remote queries under GTM-free mode Unsupport DML two phase commit under gtm free mode. modify your SQL to generate light-proxy or fast-query-shipping plan" is displayed. In this case, you need to modify the statement to execute it on a single node.

      An example is as follows:

      insert into t select * from b where b.c = xx;

      Assume that the distribution keys of the **t** and **b** tables are different, and the **WHERE** condition filters out only one data record. If **enable_stream_operator** is disabled, the preceding query is split into two independent statements and executed in serial mode. First, run **select * from b where b.c = xx** to extract data from a DN to the target record. Then, run the **insert into t** statement to deliver the extracted target record to another DN to complete the insertion. In GTM-Free mode, the preceding error is reported when such a statement is executed. Similar errors may also be reported for **create table as select * from** and **DELETE**, **JOIN**, and **INSERT** statements with subqueries.

      Refactoring solution: Before statement execution, add the **set enable_stream_operator=on** command to enable the streaming operator so that service statements can be pushed down for execution.

   b. If a user statement is executed on multiple nodes in the database, the error message "Your SQL needs more than one datanode to be involved in" will be displayed. In this case, you are advised to modify the statement so that it can be executed on a single node.

      An example is as follows:

      insert into t values(3,3),(1,1);

      If (3,3) and (1,1) are distributed on different DNs, the execution of the preceding statement involves two DNs. In GTM-Free mode, the preceding error is reported when such a statement is executed.

      Refactoring method: If the preceding statement needs to be executed on multiple nodes, add a hint to the statement to prevent errors. The hint is as follows:

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insert /*+ multinode */ into t values(3,3),(1,1);

There are similar constraints on the **DELETE** and **UPDATE** statements. You are advised to add the equivalent filtering condition of the distribution key to the **WHERE** condition in the **DELETE** and **UPDATE** statements.

4. It is recommended that **application_type** be set to **perfect_sharding_type** in the JDBC connection string in the development phase. In this way, errors are reported for all SQL statements for cross-node read and write operations, prompting developers to optimize statements as soon as possible.

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# 18 Materialized View

A materialized view is a special physical table, which is relative to a common view. A common view is a virtual table and has many application limitations. Any query on a view is actually converted into a query on an SQL statement, and performance is not actually improved. The materialized view actually stores the results of the statements executed by the SQL statement, and is used to cache the results.

## 18.1 Full Materialized View

### 18.1.1 Overview

Full materialized views can be fully refreshed only. The syntax for creating a full materialized view is the same as the CREATE TABLE AS syntax. You cannot specify a NodeGroup to create a full materialized view.

### 18.1.2 Usage

#### Syntax

- Create a full materialized view.
  ```
  CREATE MATERIALIZED VIEW [ view_name ] AS { query_block };
  ```
- Fully refresh a materialized view.
  ```
  REFRESH MATERIALIZED VIEW [ view_name ];
  ```
- Delete a materialized view.
  ```
  DROP MATERIALIZED VIEW [ view_name ];
  ```
- Query a materialized view.
  ```
  SELECT * FROM [ view_name ];
  ```

#### Examples

```
-- Prepare data.
CREATE TABLE t1(c1 int, c2 int);
INSERT INTO t1 VALUES(1, 1);
INSERT INTO t1 VALUES(2, 2);

-- Create a full materialized view.
openGauss=# CREATE MATERIALIZED VIEW mv AS select count(*) from t1;
CREATE MATERIALIZED VIEW
```

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```
-- Query the materialized view result.
openGauss=# SELECT * FROM mv;
 count
-------
     2
(1 row)

-- Insert data into the base table in the materialized view again.
openGauss=# INSERT INTO t1 VALUES(3, 3);

-- Fully refresh a full materialized view.
openGauss=# REFRESH MATERIALIZED VIEW mv;
REFRESH MATERIALIZED VIEW

-- Query the materialized view result.
openGauss=# SELECT * FROM mv;
 count
-------
     3
(1 row)

-- Delete a materialized view.
openGauss=# DROP MATERIALIZED VIEW mv;
DROP MATERIALIZED VIEW
```

## 18.1.3 Support and Constraints

### Supported Scenarios

- Generally, the query scope supported by full materialized views is the same as that supported by the CREATE TABLE AS statement.
- The distribution column can be specified when a full materialized view is created.
- Indexes can be created in a full materialized view.
- ANALYZE and EXPLAIN are supported.

### Unsupported Scenarios

- Full materialized views do not support node groups.
- Materialized views cannot be added, deleted, or modified. Only query statements are supported.

### Constraints

- The base table used to create a full materialized view must be defined on all DNs, and the node group to which the base table belongs must be an installation group.
- When a full materialized view is refreshed or deleted, a high-level lock is added to the base table. If the definition of a materialized view involves multiple tables, pay attention to the service logic to avoid deadlock.

# 18.2 Incremental Materialized View

## 18.2.1 Overview

Incremental materialized views can be incrementally refreshed. You need to manually execute statements to incrementally refresh materialized views in a

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period of time. The difference between the incremental and the full materialized views is that the incremental materialized view supports only a small number of scenarios. Currently, only base table scanning statements or UNION ALL can be used to create materialized views.

## 18.2.2 Usage

### Syntax

- Create a incremental materialized view.
  ```
  CREATE INCREMENTAL MATERIALIZED VIEW [ view_name ] AS { query_block };
  ```
- Fully refresh a materialized view.
  ```
  REFRESH MATERIALIZED VIEW [ view_name ];
  ```
- Incrementally refresh a materialized view.
  ```
  REFRESH INCREMENTAL MATERIALIZED VIEW [ view_name ];
  ```
- Delete a materialized view.
  ```
  DROP MATERIALIZED VIEW [ view_name ];
  ```
- Query a materialized view.
  ```
  SELECT * FROM [ view_name ];
  ```

### Examples

```
-- Prepare data.
CREATE TABLE t1(c1 int, c2 int);
INSERT INTO t1 VALUES(1, 1);
INSERT INTO t1 VALUES(2, 2);

-- Create an incremental materialized view.
openGauss=# CREATE INCREMENTAL MATERIALIZED VIEW mv AS SELECT * FROM t1;
CREATE MATERIALIZED VIEW

-- Insert data.
openGauss=# INSERT INTO t1 VALUES(3, 3);
INSERT 0 1

-- Incrementally refresh a materialized view.
openGauss=# REFRESH INCREMENTAL MATERIALIZED VIEW mv;
REFRESH MATERIALIZED VIEW

-- Query the materialized view result.
openGauss=# SELECT * FROM mv;
 c1 | c2
----+----
  1 |  1
  2 |  2
  3 |  3
(3 rows)

-- Insert data.
openGauss=# INSERT INTO t1 VALUES(4, 4);
INSERT 0 1

-- Fully refresh a materialized view.
openGauss=# REFRESH MATERIALIZED VIEW mv;
REFRESH MATERIALIZED VIEW

-- Query the materialized view result.
openGauss=# select * from mv;
 c1 | c2
----+----
  1 |  1
  2 |  2
  3 |  3
```

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```
 4 |  4
(4 rows)

-- Delete a materialized view.
openGauss=# DROP MATERIALIZED VIEW mv;
DROP MATERIALIZED VIEW
```

# 18.2.3 Support and Constraints

## Supported Scenarios

- Supports statements for querying a single table.
- Supports UNION ALL for querying multiple single tables.
- Creates an index in the materialized view.
- Performs the Analyze operation in the materialized view.
- Creates an incremental materialized view based on the node group of base tables. (Check whether the base tables are in the same node group and create the incremental materialized view based on the node group).

## Unsupported Scenarios

- Materialized views do not support the Stream plan, multi-table join plan, or subquery plan.
- Except for a few ALTER operations, most DDL operations cannot be performed on base tables in materialized views.
- A distribution column of a materialized view cannot be specified when the materialized view is created.
- Materialized views cannot be added, deleted, or modified. Only query statements are supported.
- Materialized views cannot be created using the temporary table, hash bucket, unlog, or partitioned table. Only the hash distribution table is supported.
- Materialized views cannot be created in nested mode (that is, a materialized view cannot be created in another materialized view).
- The column-store tables are not supported. Only row-store tables are supported.
- Materialized views of the UNLOGGED type are not supported, and the WITH syntax is not supported.

## Constraints

- If the materialized view is defined as UNION ALL, each subquery must use a different base table and the distribution column of each base table must be the same. The distribution column of the materialized view is automatically deduced and is the same as that of each base table.
- The columns defined in the materialized view must contain all distribution columns in the base table.
- When an incremental materialized view is created, fully refreshed, or deleted, a high-level lock is added to the base table. If the materialized view is defined as UNION ALL, pay attention to the service logic to avoid deadlock.

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# 19 GUC Parameters

## 19.1 GUC Parameter Usage

A database provides many operation parameters. Configurations of these parameters affect the behavior of the database system. Before modifying these parameters, learn the impact of these parameters on the database. Otherwise, unexpected results may occur.

You are advised to modify some parameters on the GaussDB console. If the parameters cannot be modified on the console, evaluate the risks and contact customer service.

### Precautions

- If the value range of a parameter is a string, the string should comply with the naming conventions of the path and file name in the OS running the target database.
- If the maximum value of a parameter is *INT_MAX*, the maximum parameter value varies by OS. *INT_MAX* indicates the maximum value of the INT data type. The value is **2147483647**.
- If the maximum value of a parameter is *DBL_MAX*, the maximum parameter value varies by OS. *DBL_MAX* indicates the maximum value of the FLOAT data type.

## 19.2 File Location

After a database has been installed, three configuration files (**postgresql.conf**, **pg_hba.conf**, and **pg_ident.conf**) are automatically generated and saved in the data directory. You can use the methods described in this section to change the names and save paths of these configuration files.

When changing the storage directory of a configuration file, set **data_directory** in **postgresql.conf** to the actual data directory.

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NOTICE

If a configuration file is incorrectly modified, the database will be seriously affected. Do not modify the configuration files mentioned in this section after installation.

## data_directory

**Parameter description**: Specifies the GaussDB **data** directory. Only the sysadmin user can access this parameter. You can set this parameter using one of the following methods:

- Set it when you install the GaussDB.
- This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, consisting of one or more characters.

**Default value**: Specify this parameter during installation. If this parameter is not specified during installation, the database is not initialized by default.

## config_file

**Parameter description**: Specifies the configuration file (**postgresql.conf**) of the primary server.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, consisting of one or more characters.

**Default value**: **postgresql.conf** (The absolute directory of this file may be displayed in the actual situation.)

## hba_file

**Parameter description**: Specifies the configuration file (**pg_hba.conf**) for host-based authentication (HBA). This parameter can be specified only in the **postgresql.conf** file and can be accessed only by the sysadmin user.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **pg_hba.conf** (The absolute directory of this file may be displayed in the actual situation.)

## ident_file

**Parameter description**: Specifies the name of the configuration file (**pg_ident.conf)** for client authentication. Only the sysadmin user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: a string

**Default value**: **pg_ident.conf** (The absolute directory of this file may be displayed in the actual situation.)

### external_pid_file

**Parameter description**: Specifies the extra PID file that can be used by the server management program. Only the sysadmin user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

This parameter takes effect only after the database restarts.

**Value range**: a string

**Default value**: empty

### enable_default_cfunc_libpath

**Parameter description**: Specifies GaussDB whether the .so file uses the default path when the C function is created.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**on**: indicates that the .so file must be placed in the specified directory ($libdir/proc_srclib) when the C function is created.

**off**: indicates that the .so file can be stored in any accessible directory when the C function is created.

**Default value**: **on**

NOTICE

If this parameter is set to **off**, the .so file can be placed in any accessible directory or the .so file provided by the system can be used, which poses security risks. Therefore, you are not advised to set this parameter to **off**.

## 19.3 Connection and Authentication

### 19.3.1 Connection Settings

This section describes parameters related to client-server connection modes.

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## listen_addresses

**Parameter description**: Specifies the TCP/IP address of the client for a server to listen on.

This parameter specifies the IP address used by the GaussDB server for listening, for example, IPv4. Multiple NICs may exist on the host and each NIC can be bound to multiple IP addresses. This parameter specifies the IP addresses to which GaussDB is bound. The client can use the IP address specified by this parameter to connect to or send requests to GaussDB.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**:

- Host name or IP address. Multiple values are separated with commas (,).
- Asterisk (*) or **0.0.0.0**, indicating that all IP addresses will be listened on, which is not recommended due to potential security risks.
- If the parameter is not specified, the server does not listen on any IP address. In this case, only Unix domain sockets can be used for database connections.

**Default value**:

After the cluster is installed, configure different default values based on the IP addresses of different instances in the **public_cloud.conf** file. The default value of CN is **listen_addresses = 'localhost,***IP address of the mgr.net NIC,IP address of the data.net NIC,IP address of the virtual.net NIC***'**. The default value of DN is **listen_addresses ='***IP address of the data.net NIC***'**.

NOTE

**localhost** indicates that only local loopback is allowed.

The **public_cloud.conf** file contains the following NIC information: **mgr.net** (management NIC), **data.net** (data NIC), and **virtual.net** (virtual NIC).

## local_bind_address

**Parameter description**: Specifies the host IP address bound to the current node for connecting to other nodes in the cluster.

This parameter is a POSTMASTER parameter.

NOTE

This parameter is specified in the configuration file during installation. Do not modify this parameter unless absolutely necessary. Otherwise, database communication will be affected.

**Default value**:

After the cluster is installed, configure different default values based on the IP addresses of different instances in the **public_cloud.conf** file. The default value of CN/DN is **local_bind_address ='***IP address of the data.net NIC***'**.

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NOTE

The **public_cloud.conf** file contains the following NIC information: **mgr.net** (management NIC), **data.net** (data NIC), and **virtual.net** (virtual NIC).

## port

**Parameter description**: Specifies the TCP port listened on by the GaussDB.

NOTE

This parameter is specified in the configuration file during installation. Do not modify this parameter unless absolutely necessary. Otherwise, database communication will be affected.

**Value range**: an integer ranging from 1 to 65535

NOTE

- When setting the port number, ensure that the port number is not in use. When setting the port numbers of multiple instances, ensure that the port numbers do not conflict.
- Ports 1 to 1023 are reserved for the operating system. Do not use them.
- When the cluster is installed using the configuration file, pay attention to the ports reserved in the communication matrix in the configuration file. For example, *dataPortBase* + 1 needs to be reserved as the port used by internal tools, and *dataPortBase* + 6 needs to be reserved as the communication port of the streaming engine message queue. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) Therefore, during cluster installation, the maximum value of port is **65532** for CNs, **65529** for DNs, and **65534** for GTMs. Ensure that the port number does not conflict with each other.

**Default value**: **5432** (The actual value is specified in the configuration file during installation.)

## max_connections

**Parameter description**: Specifies the maximum number of concurrent connections to the database. This parameter influences the concurrent processing capability of the cluster.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer. The minimum value is **10** (greater than **max_wal_senders**). The theoretical maximum value is **262143**. The actual maximum value is a dynamic value, which is calculated using the formula: 262143 – **job_queue_processes** – **autovacuum_max_workers** – **max_inner_tool_connections** – **AUXILIARY_BACKENDS** – **AV_LAUNCHER_PROCS** – **min(max(newValue/4,64),1024)**. The values of **job_queue_processes**, **autovacuum_max_workers**, and **max_inner_tool_connections** depend on the settings of the corresponding GUC parameters. **AUXILIARY_BACKENDS** indicates the number of reserved auxiliary threads, which is fixed to **20**. **AV_LAUNCHER_PROCS** indicates the number of reserved autovacuum launcher threads, which is fixed to **2**. In **min(max(newValue/4,64),1024)**, **newValue** indicates the new value.

**Default value**:

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- Independent deployment:

  CN: 8000 (60-core CPU/480-GB memory); 4000 (32-core CPU/256-GB memory); 2000 (16-core CPU/128-GB memory); 1000 (8-core CPU/64-GB memory); 100 (4-core CPU/32-GB memory and 4-core CPU/16-GB memory)

  DN: 24000 (60-core CPU/480-GB memory); 12000 (32-core CPU/256-GB memory); 6000 (16-core CPU/128-GB memory); 2500 (8-core CPU/64-GB memory); 100 (4-core CPU/32-GB memory and 4-core CPU/16-GB memory)

- Finance edition (standard):

  CN: 6000 (128-core CPU/1024-GB memory, 104-core CPU/1024-GB memory, and 96-core CPU/1024-GB memory); 4000 (96-core CPU/768-GB memory); 3500 (80-core CPU/640-GB memory); 3000 (72-core CPU/576-GB memory); 2500 (64-core CPU/512-GB memory); 2250 (60-core CPU/480-GB memory); 1000 (32-core CPU/256-GB memory); 500 (16-core CPU/128-GB memory); 200 (8-core CPU/64-GB memory)

  DN: 21000 (128-core CPU/1024-GB memory, 104-core CPU/1024-GB memory, and 96-core CPU/1024-GB memory); 16000 (96-core CPU/768-GB memory); 14000 (80-core CPU/640-GB memory); 12000 (72-core CPU/576-GB memory); 11000 (64-core CPU/512-GB memory); 9000 (60-core CPU/480-GB memory); 4000 (32-core CPU/256-GB memory); 2000 (16-core CPU/128-GB memory); 1000 (8-core CPU/64-GB memory)

- Enterprise edition:

  CN: 4000 (128-core CPU/1024-GB memory, 104-core CPU/1024-GB memory, 96-core CPU/1024-GB memory); 3000 (96-core CPU/768-GB memory); 2500 (80-core CPU/640-GB memory); 2000 (80-core CPU/512-GB memory, 72-core CPU/576-GB memory, and 64-core CPU/512-GB memory); 1800 (60-core CPU/480-GB memory); 900 (32-core CPU/256-GB memory); 350 (16-core CPU/128-GB memory); 200 (8-core CPU/64-GB memory)

  DN: 15000 (128-core CPU/1024-GB memory, 104-core CPU/1024-GB memory, and 96-core CPU/1024-GB memory); 11000 (96-core CPU/768-GB memory); 10000 (80-core CPU/640-GB memory); 8500 (72-core CPU/576-GB memory); 7500 (80-core CPU/512-GB memory and 64-core CPU/512-GB memory); 7000 (60-core CPU/480-GB memory); 3500 (32-core CPU/256-GB memory); 1500 (16-core CPU/128-GB memory); 900 (8-core CPU/64-GB memory)

- Finance edition (data computing):

  CN: 2500 (96-core CPU/768-GB memory); 1000 (72-core CPU/576-GB memory); 500 (64-core CPU/512-GB memory); 200 (32-core CPU/256-GB memory)

  DN: 8000 (96-core CPU/768-GB memory); 5000 (72-core CPU/576-GB memory); 4000 (64-core CPU/512-GB memory); 1000 (32-core CPU/256-GB memory)

**Impact of incorrect configuration:**

If the value of **max_connections** exceeds the maximum dynamic value, the node fails to be started and the following error message is displayed: "invalid value for parameter "max_connections"". Alternatively, the memory fails to be allocated during the node startup and the following error message is displayed: "Cannot allocate memory".

If the value of **max_connections** is not increased based on the external egress specifications and the memory parameter is not adjusted in proportion, when the

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service pressure is high, the memory may be insufficient, and the error message "memory is temporarily unavailable" is displayed.

In the hybrid deployment scenario, if the value of **max_connections** on the CN is greater than the value of **max_connections** divided by the number of CNs on the DN and the total pressure on the client exceeds the value of **max_connections** on the DN, the CN may fail to connect to the DN, and the error message "pooler... Too many clients already" is displayed.

NOTE

- If the number of connections of the administrator exceeds the value of **max_connections**, the administrator can still connect to the database after the connections are used up by common users. If the number of connections exceeds the value of **sysadmin_reserved_connections**, an error is reported. That is, the maximum number of connections of the administrator is equal to the value of *max_connections* + *sysadmin_reserved_connections*.
- For common users, internal jobs use some connections. Therefore, the value of this parameter is slightly less than that of *max_connections*. The value depends on the number of internal connections.
- After the thread pool is enabled, the maximum number of stream threads is the value of **max_connections**. If the number of stream threads reaches the upper limit, the error is reported: "Exceed stream thread pool limitation...". In this case, you can increase the value of **max_connections** to increase the upper limit. This parameter is a POSTMASTER parameter. Therefore, you can estimate the number of stream threads based on service requirements. Total number of stream threads = Number of concurrent services x Number of stream threads consumed by each concurrently executed statement (which can be viewed in the execution plan).

## max_inner_tool_connections

**Parameter description**: Specifies the maximum number of concurrent connections of a tool which is allowed to connect to the database. This parameter influences the concurrent connection capability of the GaussDB tool.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to *MIN* (which takes the smaller value between **262143** and *max_connections*). For details about how to calculate the value of *max_connections*, see the preceding description.

**Default value**: **50** If the default value is greater than the maximum value supported by the kernel (determined when the **gs_initdb** command is executed), an error message is displayed.

**Setting suggestions**:

You are advised to use the default value for this parameter in the primary database node.

## sysadmin_reserved_connections

**Parameter description**: Specifies the minimum number of connections reserved for administrators. You are advised not to set this parameter to a large value. This parameter is used together with the *max_connections* parameter. The maximum number of connections of the administrator is equal to the value of *max_connections* + *sysadmin_reserved_connections*.

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This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to *MIN* (which takes the smaller value between **262143** and *max_connections*). For details about how to calculate the value of *max_connections*, see the preceding description.

**Default value**: **3**

**Note:** When the thread pool function is enabled, if the thread pool is fully occupied, a processing bottleneck occurs. As a result, connections reserved by the administrator cannot be established. In this case, you can use gsql to establish connections through the primary port number + 1 to clear useless sessions.

## unix_socket_directory

**Parameter description**: Specifies the Unix domain socket directory that the GaussDB server listens to for connections from the client. Only the **sysadmin** user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

The parameter length limit varies by OS. In the Linux OS, the length of a socket path name (combination of a socket directory and a socket file name) cannot exceed 107 bytes, and the length of a directory cannot exceed 92 bytes. If the upper limit is exceeded, the error "Unix-domain socket path xxx is too long" will be reported and the process cannot be started properly. You can retrieve the **system_call** log in the **cm_agent** directory to locate configuration issues.

**Value range**: a string

**Default value**: empty. The actual value is specified by **tmpMppdbPath** in the configuration file during installation.

## unix_socket_group

**Parameter description**: Specifies the group of the Unix domain socket (the user of a socket is the user that starts the server). This parameter can work with **unix_socket_permissions** to control socket access.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. If this parameter is set to an empty string, the default group of the current user is used.

**Default value**: an empty string

## unix_socket_permissions

**Parameter description**: Specifies access permissions for the Unix domain socket.

The Unix domain socket uses the usual permission set of the Unix file system. The value of this parameter should be a number (acceptable for the **chmod** and **umask** commands). If a user-defined octal format is used, the number must start with 0.

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You are advised to set it to **0770** (only allowing access from users connecting to the database and users in the same group as them) or **0700** (only allowing access from users connecting to the database).

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: 0000 to 0777

**Default value**: **0700**

NOTE

In the Linux OS, a document has one document attribute and nine permission attributes which consist of the read (r), write (w), and execute (x) permissions of the Owner, Group, and Others groups.

The r, w, and x permissions are represented by the following numbers:

r: 4

w: 2

x: 1

-: 0

The three attributes in a group are accumulative.

For example, **-rwxrwx---** indicates the following permissions:

owner = rwx = 4+2+1 = 7

group = rwx = 4+2+1 = 7

others = --- = 0+0+0 = 0

The permission of the file is 0770.

## application_name

**Parameter description**: Specifies the client name used in the current connection request.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

When a standby node requests to replicate logs on the primary node, if this parameter is not an empty string, it is used as the name of the streaming replication slot of the standby node on the primary node. In this case, if the length of this parameter exceeds 61 bytes, only the first 61 bytes are used as the streaming replication slot name.

**Value range**: a string. The actual query result depends on the client used for queries or user configurations.

**Default value**: an empty string

## connection_info

**Parameter description**: Specifies the database connection information, including the driver type, driver version, driver deployment path, and process owner.

This parameter is a USERSET parameter used for O&M. You are advised not to change the parameter value.

**Value range:** a string

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**Default value**: empty

NOTE

- An empty string indicates that the driver connected to the database does not support automatic setting of the **connection_info** parameter or the parameter is not set by users in applications.
- The following is an example of the concatenated value of **connection_info**:
  ```
  {"driver_name":"ODBC","driver_version": "(GaussDB VxxxRxxxCxx build 290d125f) compiled at 2020-05-08 02:59:43 commit 2143 last mr 131 release","driver_path":"/usr/local/lib/psqlodbcw.so","os_user":"omm"}
  ```
  **driver_name** and **driver_version** are displayed by default. Whether **driver_path** and **os_user** are displayed is determined by users. For details, see **6.3.4 Connecting to a Database** and **6.4.2 Configuring a Data Source in the Linux OS**.

### backend_version

**Parameter description**: Specifies the version number of the synchronous connection between CNs or between a CN and a DN. This parameter involves the version number and cannot be set randomly.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 100000

## 19.3.2 Security and Authentication (postgresql.conf)

This section describes parameters about client-to-server authentication.

### authentication_timeout

**Parameter description**: Specifies the longest duration to wait before the client authentication times out. If a client is not authenticated by the server within the period, the server automatically disconnects from the client so that the client does not occupy connection resources.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 600. The smallest unit is s.

**Default value**: **1min**

### auth_iteration_count

**Parameter description**: Specifies the number of iterations during the generation of encryption information for authentication.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 2048 to 134217728

**Default value**: **10000**

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NOTICE

If the number of iterations is too small, the password storage security is reduced. If the number of iterations is too large, the performance deteriorates in scenarios involving password encryption, such as authentication and user creation. Set the number of iterations based on actual hardware conditions. You are advised to retain the default value.

## session_authorization

**Parameter description**: Specifies the user ID of the current session.

This parameter is a USERSET parameter and can be set only using the **12.14.164 SET SESSION AUTHORIZATION** syntax.

**Value range**: a string

**Default value**: **NULL**

## session_timeout

**Parameter description**: Specifies the longest duration allowed when no operations are performed on a client after it is connected to the server.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 86400. The smallest unit is s. **0** indicates that the timeout is disabled.

**Default value**: **1800**

NOTICE

The gsql client of GaussDB has an automatic reconnection mechanism. For local connection of initialized users, the client reconnects to the server if the connection breaks after the timeout.

## ssl

**Parameter description**: Specifies whether SSL connections are enabled.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that SSL connections are enabled.
- **off** indicates that SSL connections are not enabled.

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NOTICE

GaussDB supports SSL when a client connects to a CN. You are advised to enable SSL connections only on CNs. The default value is **off** on DNs. To enable SSL connections, you also need to ensure that parameters such as **ssl_cert_file**, **ssl_key_file**, and **ssl_ca_file** are configured correctly. Incorrect configurations may cause startup failure of the cluster.

**Default value**: **on** (for CNs) or **off** (for DNs)

## comm_ssl

**Parameter description**: Specifies whether to enable the SSL connection between primary DNs.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the SSL connection is enabled between primary DNs.
- **off** indicates that the SSL connection is disabled between primary DNs.

NOTICE

- It is recommended that this parameter be enabled only on DNs. The default value on CNs is **off**.
- To enable SSL connections, you also need to ensure that parameters such as **ssl_cert_file**, **ssl_key_file**, and **ssl_ca_file** are configured correctly. Incorrect configurations may cause startup failure of the cluster.

**Default value**: **off**

## require_ssl

**Parameter description**: Specifies whether the server requires SSL connections. This parameter is valid only when **ssl** is set to **on**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the server requires SSL connections.
- **off** indicates that the server does not require SSL connections.

NOTICE

GaussDB supports SSL when a client connects to a CN. It is recommended that the SSL connection be enabled only on CNs.

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**Default value**: **off**

## ssl_ciphers

**Parameter description**: Specifies the list of encryption algorithms supported by SSL. Only the sysadmin user can access the list.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. Separate multiple encryption algorithms by semicolons (;).

NOTICE

If **ssl_ciphers** is set incorrectly, the cluster cannot be started properly.

**Default value**: **ALL**

## ssl_renegotiation_limit

**Parameter description**: Specifies the allowed traffic volume over an SSL-encrypted channel before the session key is renegotiated. The renegotiation mechanism reduces the probability that attackers use the password analysis method to crack the key based on a huge amount of data but causes big performance losses. The traffic indicates the sum of transmitted and received traffic. The SSL renegotiation mechanism has been disabled because of potential risks. This parameter is reserved for version compatibility and does not take effect.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is KB. **0** indicates that the renegotiation mechanism is disabled.

**Default value**: **0**

## ssl_cert_file

**Parameter description:** Specifies the name of the file that contains the SSL server certificate. The relative path is relative to the data directory.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **server.crt**

## ssl_key_file

**Parameter description:** Specifies the name of the file that contains the SSL private key. The relative path is relative to the data directory.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: a string

**Default value**: **server.key**

## ssl_ca_file

**Parameter description**: Specifies the name of the root certificate that contains CA information. Its path is relative to the data directory.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. If it is an empty string, no CA file is loaded and client certificate verification is not performed.

**Default value**: **cacert.pem**

## ssl_crl_file

**Parameter description**: Specifies the certificate revocation list (CRL). If a client certificate is in the list, the certificate is invalid. The path is relative to the data directory.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. An empty string indicates that there is no CRL.

**Default value**: an empty string

## ssl_cert_notify_time

**Parameter description**: Specifies the number of days prior to SSL server certificate expiration that a user will receive a reminder. When the SSL certificate is initialized during connection establishment, if the duration from the current time to the certificate expiration time is shorter than the specified value, an expiration notification is recorded in the log.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 7 to 180. The unit is day.

**Default value**: **90**

## krb_server_keyfile

**Parameter description:** Specifies the location of the main configuration file of the Kerberos service.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: empty

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## krb_srvname

**Parameter description**: Specifies the Kerberos service name.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **postgres**

## krb_caseins_users

**Parameter description**: Specifies whether the Kerberos username is case-sensitive.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the Kerberos username is case-insensitive.
- **off** indicates that the Kerberos username is case-sensitive.

**Default value**: **off**

## modify_initial_password

**Parameter description**: After GaussDB is installed, there is only one initial user account (whose UID is 10) in the database. When a user logs in to the database using this initial account for the first time, this parameter determines whether the password of the initial account needs to be modified.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**NOTICE**

If the initial user password is not specified during the installation, the initial user password is empty by default after the installation. Before performing other operations, you need to set the initial user password using the gsql client. This parameter no longer takes effect and is reserved only for compatibility with upgrade scenarios.

**Value range**: Boolean

- **on** indicates that the password of the initial account needs to be modified upon the first login.
- **off** indicates that the password of the initial account does not need to be modified.

**Default value**: **off**

## password_policy

**Parameter description**: Specifies whether to check the password complexity when you run the **CREATE ROLE/USER** or **ALTER ROLE/USER** command to create or

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modify an account of GaussDB. For details about the password complexity check policy, see **7.2.9.3 Setting Password Security Policies**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

For security purposes, do not disable the password complexity policy.

**Value range**: **0** and **1**

- **0** indicates that no password complexity policy is enabled.
- **1** indicates that the default password complexity policy is enabled.

**Default value**: **1**

## password_reuse_time

**Parameter description:** Specifies whether to check the reuse interval of the new password when you run the **ALTER USER** or **ALTER ROLE** command to change a user password. For details about the password reuse policy, see **7.2.9.3 Setting Password Security Policies**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

When you change the password, the system checks the values of **password_reuse_time** and **password_reuse_max**.

- If the values of **password_reuse_time** and **password_reuse_max** are both positive numbers, an old password can be reused when it meets either of the reuse restrictions.
- If the value of **password_reuse_time** is **0**, password reuse is restricted based on the number of reuse times, and not on the reuse interval.
- If the value of **password_reuse_max** is **0**, password reuse is restricted based on the reuse interval, and not on the number of reuse times.
- If the values of both **password_reuse_time** and **password_reuse_max** are **0**, password reuse is not restricted.

**Value range**: a floating point number ranging from 0 to 3650. The unit is day.

- **0** indicates that the password reuse interval is not checked.
- A positive number indicates that a new password cannot be chosen from passwords in history that are newer than the specified number of days.

## password_reuse_max

**Parameter description**: Specifies whether to check the reuse times of the new password when you run the **ALTER USER** or **ALTER ROLE** command to change a

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user password. Only the sysadmin user can access the parameter. For details about the password reuse policy, see **7.2.9.3 Setting Password Security Policies**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

When you change the password, the system checks the values of **password_reuse_time** and **password_reuse_max**.

- If the values of **password_reuse_time** and **password_reuse_max** are both positive numbers, an old password can be reused when it meets either of the reuse restrictions.
- If the value of **password_reuse_time** is **0**, password reuse is restricted based on the number of reuse times, and not on the reuse interval.
- If the value of **password_reuse_max** is **0**, password reuse is restricted based on the reuse interval, and not on the number of reuse times.
- If the values of both **password_reuse_time** and **password_reuse_max** are **0**, password reuse is not restricted.

**Value range**: an integer ranging from 0 to 1000

- **0** indicates that the password reuse times are not checked.
- A positive number indicates that the new password cannot be the one whose reuse times exceed the specified number.

**Default value**: **0**

## password_lock_time

**Parameter description**: Specifies the duration before a locked account is automatically unlocked. For details about the automatic account locking policy, see **7.2.9.3 Setting Password Security Policies**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

The locking and unlocking functions take effect only when the values of **password_lock_time** and **failed_login_attempts** are positive numbers.

**Value range**: a floating point number ranging from 0 to 365. The unit is day. The integer part indicates the number of days, and the decimal part can be converted into hours, minutes, and seconds. For example, **password_lock_time=1.5** indicates one day and 12 hours.

- **0** indicates that an account is not automatically locked if the password verification fails.
- A positive number indicates the duration after which a locked account is automatically unlocked.

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**Default value**: **1**

## failed_login_attempts

**Parameter description**: Specifies the maximum number of incorrect password attempts before an account is locked. The account will be automatically unlocked after the time specified by **password_lock_time**. Only the **sysadmin** user can access the account. The automatic account locking policy applies in scenarios such as login and password modification using the **ALTER USER** command. For details about the policy, see **7.2.9.3 Setting Password Security Policies**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

The locking and unlocking functions take effect only when the values of **failed_login_attempts** and **password_lock_time** are positive numbers.

**Value range**: an integer ranging from 0 to 1000

- **0** indicates that the automatic locking function does not take effect.
- A positive number indicates that an account is locked when the number of incorrect password attempts reaches the specified number.

**Default value**: **10**

## password_encryption_type

**Parameter description**: Specifies the encryption type of a user password. Changing the value of this parameter does not change the password encryption type of existing users. The new encryption type is applied to passwords of new users or passwords modified after the parameter value is changed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** 0, 1, 2, or 3

- **0** indicates that passwords are encrypted with MD5.
- **1** indicates that passwords are encrypted with SHA-256 and MD5.
- **2** indicates that passwords are encrypted with SHA-256.
- **3** indicates that the passwords are encrypted in sm3 mode.

NOTICE

The MD5 encryption algorithm is not recommended because it has lower security and poses security risks.

**Default value: 2**

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## password_min_length

**Parameter description**: Specifies the minimum length of an account password. Only the **sysadmin** user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer. A password can contain 6 to 999 characters.

**Default value**: **8**

## password_max_length

**Parameter description**: Specifies the maximum length of an account password. Only the **sysadmin** user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer. A password can contain 6 to 999 characters.

**Default value**: **32**

## password_min_uppercase

**Parameter description**: Specifies the minimum number of uppercase letters that an account password must contain. Only the **sysadmin** user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 999

- **0** means no limit.
- A positive integer indicates the minimum number of uppercase letters required in a password when you create an account.

**Default value**: **0**

## password_min_lowercase

**Parameter description**: Specifies the minimum number of lowercase letters that an account password must contain. Only the **sysadmin** user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 999

- **0** means no limit.
- A positive integer indicates the minimum number of lowercase letters required in a password when you create an account.

**Default value**: **0**

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## password_min_digital

**Parameter description**: Specifies the minimum number of digits that an account password must contain. Only the **sysadmin** user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 999

- **0** means no limit.
- A positive integer indicates the minimum number of digits required in a password when you create an account.

**Default value**: **0**

## password_min_special

**Parameter description**: Specifies the minimum number of special characters that an account password must contain. Only the **sysadmin** user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 999

- **0** means no limit.
- A positive integer indicates the minimum number of special characters required in a password when you create an account.

**Default value**: **0**

## password_effect_time

**Parameter description**: Specifies the validity period of an account password.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0 to 999. The unit is day.

- **0** indicates that the validity period restriction is disabled.
- A floating point number from 1 to 999 indicates the number of days for which an account password is valid. When the password is about to expire or has expired, the system prompts the user to change the password.

**Default value**: **0**

## password_notify_time

**Parameter description**: Specifies how many days in advance a user is notified before a password expires.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 999. The unit is day.

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- **0** indicates that the reminder is disabled.
- A positive integer indicates the number of days prior to password expiration that a user will receive a reminder.

**Default value**: **7**

## 19.3.3 Communication Library Parameters

This section describes parameter settings and value ranges for communication libraries.

### tcp_keepalives_idle

**Parameter description**: Specifies the interval for transmitting keepalive signals on an OS that supports the **TCP_KEEPIDLE** socket option. If no keepalive signal is transmitted, the connection is in idle mode.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If the OS does not support **TCP_KEEPIDLE**, set this parameter to **0**.
- The parameter is ignored on an OS where connections are established using the Unix domain socket.

**Value range:** 0 to 3600. The unit is s.

**Default value**: **1min**

### tcp_keepalives_interval

**Parameter description:** Specifies the response time before retransmission on an OS that supports the **TCP_KEEPINTVL** socket option.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: 0 to 180. The unit is s.

**Default value**: **30**

NOTICE

- If the OS does not support **TCP_KEEPINTVL**, set this parameter to **0**.
- The parameter is ignored on an OS where connections are established using the Unix domain socket.

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## tcp_keepalives_count

**Parameter description**: Specifies the number of keepalive signals that can be waited before the GaussDB server is disconnected from the client on an OS that supports the **TCP_KEEPCNT** socket option.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If the OS does not support **TCP_KEEPCNT**, set this parameter to **0**.
- The parameter is ignored on an OS where connections are established using the Unix domain socket.

**Value range**: 0 to 100. **0** indicates that the connection is immediately broken if GaussDB does not receive a keepalived signal from the client.

**Default value: 20**

## tcp_user_timeout

**Parameter description**: Specifies the maximum duration for which the transmitted data can remain in the unacknowledged state before the TCP connection is forcibly closed when the GaussDB sends data on the OS that supports the TCP_USER_TIMEOUT socket option.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If the OS does not support the TCP_USER_TIMEOUT option, the value of this parameter does not take effect. The default value is **0**.
- The parameter is ignored on an OS where connections are established using the Unix domain socket.

**Value Range**: 0 to 3600000. The unit is ms. The value **0** indicates that the value is set based on the OS.

**Default value**: **0**

Note that the effective result of this parameter varies according to the OS kernel.

- For AArch64 EulerOS (Linux kernel version: 4.19), the timeout interval is the value of this parameter.
- For x86 Euler 2.5 (Linux kernel version: 3.10), the timeout interval is not the value of this parameter but the maximum value in different ranges. That is, the timeout interval is the maximum upper limit of the total Linux TCP retransmission duration to which the value of **tcp_user_timeout** belongs. For example, if **tcp_user_timeout** is set to **40000**, the total retransmission duration is 51 seconds.

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**Table 19-1** Value of tcp_user_timeout for x86 Euler 2.5 (Linux kernel version: 3.10)

| Number of Linux TCP Retransmission Times | Total Linux TCP Retransmission Duration Range (s) | Example of tcp_user_timeout (ms) | Actual Linux TCP Retransmission Duration (s) |
|---|---|---|---|
| 1 | (0.2,0.6] | 400 | 0.6 |
| 2 | (0.6,1.4] | 1000 | 1.4 |
| 3 | (1.4,3] | 2000 | 3 |
| 4 | (3,6.2] | 4000 | 6.2 |
| 5 | (6.2,12.6] | 10000 | 12.6 |
| 6 | (12.6,25.4] | 20000 | 25.4 |
| 7 | (25.4,51] | 40000 | 51 |
| 8 | (51,102.2] | 80000 | 102.2 |
| 9 | (102.2,204.6] | 150000 | 204.6 |
| 10 | (204.6,324.6] | 260000 | 324.6 |
| 11 | (324.6,444.6] | 400000 | 444.6 |

Note: The duration of each TCP retransmission increases exponentially with the number of retransmission times. When the duration of a TCP retransmission reaches 120 seconds, the duration of each subsequent retransmission does not change.

## comm_tcp_mode

**Parameter description**: Specifies whether the communication library uses the TCP or SCTP (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) to set up a data channel. The parameter setting takes effect after you restart the cluster.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

SCTP is no longer supported. This parameter is provided for compatibility, but its value is fixed at **on**.

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**Value range**: Boolean. If this parameter is set to **on** for CNs, the CNs connect to DNs using TCP. If this parameter is set to **on** for DNs, the DNs communicate with each other using TCP.

**Default value**: **on**

## comm_sctp_port

**Parameter description**: Specifies the TCP or SCTP port used to listen on data packet channels by the TCP proxy communication library or SCTP communication library. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.)

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

This port number is automatically allocated during cluster deployment. Do not change the parameter. If the port number is incorrectly configured, the database communication fails.

**Value range**: an integer ranging from 0 to 65535

**Default value**: **25110** (The actual value is the specified value of the **port** parameter plus 2.)

## comm_control_port

**Parameter description**: Specifies the TCP listening port used by the TCP proxy communication library or SCTP communication library. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.)

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

This port number is automatically allocated during cluster deployment. Do not change the parameter. If the port number is incorrectly configured, the database communication fails.

**Value range**: an integer ranging from 0 to 65535

**Default value**: **25111** (The actual value is the specified value of the **port** parameter plus 3.)

## comm_max_datanode

**Parameter description**: Specifies the maximum number of DNs supported by the TCP proxy communication library.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 8192

**Default value**: maximum number of primary DNs supported by each node

**Recommended value**: **256**

## comm_max_stream

**Parameter description**: Specifies the maximum number of concurrent data streams supported by the TCP proxy communication library. The value of this parameter must be greater than: Number of concurrent data streams x Number of operators in each stream x Square of smp.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 60000

**Default value: 1024**

NOTICE

- You are advised not to set this parameter to a large value because this will cause high memory usage (256 bytes x **comm_max_stream** x **comm_max_datanode**). If the number of concurrent data streams is large, the query is complex and the SMP is large, resulting in insufficient memory.
- If the process memory is sufficient, you can properly increase the value of **comm_max_stream**.

## comm_max_receiver

**Parameter description**: Specifies the maximum number of receiver threads for the TCP proxy communication library.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 50

**Default value: 4**

## comm_quota_size

**Parameter description**: Specifies the maximum size of packets that can be consecutively sent by the TCP proxy communication library. When you use a 1GE NIC, a small value ranging from 20 KB to 40 KB is recommended.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2048000. The default unit is KB.

**Default value**: **1 MB**

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## comm_usable_memory

**Parameter description**: Specifies the maximum memory available for buffering on the TCP proxy communication library on a DN.

NOTICE

This parameter must be set based on environment memory and the deployment method. If it is too large, an out-of-memory (OOM) exception may occur. If it is too small, the performance of the TCP proxy communication library or SCTP communication library may deteriorate.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 100 x 1024 to 1073741823. The default unit is KB.

**Default value**: **4000 MB**

## comm_memory_pool

**Parameter description**: Specifies the size of the memory pool resources that can be used by the TCP proxy communication library on a DN.

NOTICE

If the memory used by the communication library is small, set this parameter to a small value. Otherwise, set it to a large value.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 100 x 1024 to 1073741823. The default unit is KB.

**Default value**: **2000 MB**

## comm_memory_pool_percent

**Parameter description**: Specifies the percentage of the memory pool resources that can be used by the TCP proxy communication library on a DN. This parameter is used to adaptively reserve memory used by the communication libraries.

NOTICE

If the memory used by the communication library is small, set this parameter to a small value. Otherwise, set it to a large value.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: an integer ranging from 0 to 100

**Default value**: **0**

## comm_client_bind

**Parameter description**: Specifies whether to bind the client of the communication library to a specified IP address when the client initiates a connection.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the client is bound to a specified IP address.
- **off** indicates that the client is not bound to any IP addresses.

NOTICE

If multiple IP addresses of a node in the cluster are on the same network segment, set this parameter to **on**. In this case, the client is bound to the IP address specified by **listen_addresses**. The concurrency performance of the cluster depends on the number of random ports because a port can be used by only one client at a time.

**Default value**: **off**

## comm_no_delay

**Parameter description**: Specifies whether to use the **NO_DELAY** attribute of a communication library connection.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

NOTICE

If packet loss occurs because a large number of packets are received per second, set this parameter to **off** so that small packets are combined into large packets for transmission to reduce the total number of packets.

**Default value**: **off**

## comm_debug_mode

**Parameter description**: Specifies whether to enable the debug mode of the TCP proxy communication library, that is, whether to print logs about the communication layer.

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NOTICE

If this parameter is set to **on**, a huge number of logs will be printed, adding extra overhead and reducing database performance. Therefore, set it to **on** only in debugging scenarios.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the debug logs of the communication library are printed.
- **off** indicates that the debug logs of the communication library are not printed.

**Default value**: **off**

## comm_ackchk_time

**Parameter description**: Specifies the duration after which the communication library server automatically triggers ACK when no data packet is received.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 20000. The unit is ms. **0** indicates that automatic ACK triggering is disabled.

**Default value**: **2000** (2s)

## comm_timer_mode

**Parameter description**: Specifies whether to enable the timer mode of the TCP proxy communication library, that is, whether to print timer logs in each phase of the communication layer.

NOTICE

If this parameter is set to **on**, a huge number of logs will be printed, adding extra overhead and reducing database performance. Therefore, set it to **on** only in debugging scenarios.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the timer logs of the communication library are printed.
- **off** indicates that the timer logs of the communication library are not printed.

**Default value**: **off**

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## comm_stat_mode

**Parameter description**: Specifies whether to enable the statistics mode of the TCP proxy communication library, that is, whether to print statistics about the communication layer.

NOTICE

If this parameter is set to **on**, a huge number of logs will be printed, adding extra overhead and reducing database performance. Therefore, set it to **on** only in debugging scenarios.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the statistics logs of the communication library are printed.
- **off** indicates that the statistics logs of the communication library are not printed.

**Default value**: **off**

## enable_stateless_pooler_reuse

**Parameter description**: Specifies whether to enable the reuse of the pooler connection pool. After the parameter is enabled, existing idle TCP connections can be reused. The setting takes effect after the cluster is restarted.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** or **true** indicates that the pooler reuse mode is enabled.
- **off** or **false** indicates that the pooler reuse mode is disabled.

NOTICE

This parameter should be set to a same value on CNs and DNs. If this parameter is set to **off** for CNs and **on** for DNs, the cluster communication fails. Set this parameter to the same value for CNs and DNs. Restart the cluster for the setting to take effect.

**Default value**: **on**

## comm_cn_dn_logic_conn

**Parameter description**: Specifies whether logical connections are used between CNs and DNs. The setting takes effect after the cluster is restarted.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: Boolean

- **on** or **true** indicates that the connections between CNs and DNs are logical, with the libcomm component in use.
- **off** or **false** indicates that the connections between CNs and DNs are physical, with the libpq component in use.

NOTICE

Logical connections between CNs and DNs are no longer supported. This parameter is provided for compatibility, but its value is fixed at **off**.

**Default value**: **off**

## COMM_IPC

**Parameter description**: Specifies whether to print the packet sending and receiving status of each communication node.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1. **Value range**: Boolean

- **on** or **true** indicates that the function of logging packet sending and receiving status data is enabled.
- **off** or **false** indicates that the function of logging packet sending and receiving status data is disabled.

NOTICE

set logging_module='on(COMM_IPC)'; --Enabled

set logging_module='off(COMM_IPC)'; --Disabled

show logging_module; -- View the setting result.

If this parameter is set to **on**, a huge number of logs will be printed, adding extra overhead and reducing database performance. Therefore, set it to **on** only in debugging scenarios and set it to **off** after debugging.

**Default value**: **off**

## COMM_PARAM

**Parameter description**: Specifies whether to print the **session** parameter settings during node communication.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** or **true** indicates that the function of logging the **session** parameter settings is enabled.
- **off** or **false** indicates that the function of logging the **session** parameter settings is disabled.

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NOTICE

set logging_module='on(COMM_PARAM)'; --Enabled

set logging_module='off(COMM_PARAM)'; --Disabled

show logging_module; -- View the setting result.

If this parameter is set to **on**, a huge number of logs will be printed, adding extra overhead and reducing database performance. Therefore, set it to **on** only in debugging scenarios and set it to **off** after debugging.

**Default value**: **off**

# 19.4 Resource Consumption

## 19.4.1 Memory

This section describes memory parameters.

NOTICE

These parameters, except **local_syscache_threshold**, take effect only after the database restarts.

### memorypool_enable

**Parameter description**: Specifies whether to enable a memory pool.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the memory pool is enabled.
- **off** indicates that the memory pool is disabled.

**Default value**: **off**

### memorypool_size

**Parameter description**: Specifies the memory pool size.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 128 x 1024 to 1073741823. The unit is KB.

**Default value**: **512 MB**

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## enable_memory_limit

**Parameter description**: Specifies whether to enable the logical memory management module.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the logical memory management module is enabled.
- **off** indicates that the logical memory management module is disabled.

**Default value**: **on**

CAUTION

- If the value of **max_process_memory** minus **shared_buffer** minus **cstore_buffers** minus metadata size is less than 2 GB, GaussDB forcibly sets **enable_memory_limit** to **off**. Metadata is the memory used in GaussDB and is related to some concurrent parameters, such as max_connections, thread_pool_attr and max_prepared_transactions.
- If this parameter is set to **off**, the memory used by the database is not limited. When a large number of concurrent or complex queries are performed, too much memory is used, which may cause OS OOM problems.

## max_process_memory

**Parameter description**: Specifies the maximum physical memory of a database node.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 2097152 to 2147483647. The unit is KB.

**Default value**:

Independent deployment: 360 GB (60-core CPU/480 GB memory); 192 GB (32-core CPU/256 GB memory); 96 GB (16-core CPU/128 GB memory); 40 GB (8-core CPU/64 GB memory); 20 GB (4-core CPU/32 GB memory); 10 GB (4-core CPU/16 GB memory)

Finance edition (standard):

CN: 200 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 160 GB (96-core CPU/768 GB memory); 130 GB (80-core CPU/640 GB memory); 120 GB (72-core CPU/576 GB memory); 100 GB (64-core CPU/512 GB memory and 60-core CPU/480 GB memory); 50 GB (32-core CPU/256 GB memory); 20 GB (16-core CPU/128 GB memory); 10 GB (8-core CPU/64 GB memory)

DN: 350 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 260 GB (96-core CPU/768 GB memory); 220 GB (80-core CPU/640 GB memory); 200 GB (72-core CPU/576 GB memory); 180

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GB (64-core CPU/512 GB memory); 160 GB (60-core CPU/480 GB memory); 80 GB (32-core CPU/256 GB memory); 40 GB (16-core CPU/128 GB memory); 20 GB (8-core CPU/64 GB memory)

Enterprise edition:

CN: 150 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 110 GB (96-core CPU/768 GB memory); 90 GB (80-core CPU/64 GB memory); 80 GB (72-core CPU/576 GB memory); 75 GB (80-core CPU/512 GB memory and 64-core CPU/512 GB memory); 70 GB (60-core CPU/480 GB memory); 35 GB (32-core CPU/256 GB memory); 15 GB (16-core CPU/128 GB memory); 9 GB (8-core CPU/64 GB memory)

DN: 250 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 190 GB (96-core CPU/768 GB memory); 160 GB (80-core CPU/640 GB memory); 140 GB (72-core CPU/576 GB memory); 125 GB (80-core CPU/512 GB memory and 64-core CPU/512 GB memory); 120 GB (60-core CPU/480 GB memory); 60 GB (32-core CPU/256 GB memory); 25 GB (16-core CPU/128 GB memory); 15 GB (8-core CPU/64 GB memory)

Finance edition (data computing)

CN: 100 GB (96-core CPU/768 GB memory); 60 GB (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 20 GB (32-core CPU/256 GB memory)

DN: 150 GB (96-core CPU/768 GB memory); 110 GB (72-core CPU/576 GB memory); 100 GB (64-core CPU/512 GB memory); 40 GB (32-core CPU/256 GB memory)

**Setting suggestions**:

On DNs, the value of this parameter is determined based on the physical system memory and the number of primary DNs deployed on a single node. Parameter value = (Physical memory – **vm.min_free_kbytes**) x 0.7/(n + Number of primary DNs). This parameter is used to prevent node OOM caused by memory usage increase, ensuring system reliability. **vm.min_free_kbytes** indicates the OS memory reserved for the kernel to receive and send data. Its value is at least 5% of the total memory. Therefore, the value of **max_process_memory** is: Physical memory x 0.665/(n + Number of primary DNs). When the number of nodes in the cluster is less than or equal to 256, n = 1. When the number of nodes in the cluster is greater than 256 and less than or equal to 512, n = 2. When the number of nodes in the cluster is greater than 512, n = 3.

You can set this parameter on CNs to the same value as that on DNs.

RAM is the maximum memory allocated to the cluster. It equals the physical memory of servers.

**CAUTION**

If this parameter is set to a value greater than the physical memory of the server, the OS OOM problem may occur.

## local_syscache_threshold

**Parameter description**: Specifies the size of system catalog cache in a session.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

- If **enable_global_plancache** is set to **on**, **local_syscache_threshold** does not take effect when it is set to a value less than 16 MB to ensure that GPC takes effect. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) The minimum value is 16 MB.
- If **enable_global_syscache** and **enable_thread_pool** are enabled, this parameter indicates the total cache size of the current thread and sessions bound to the current thread.

**Value range**: an integer ranging from 1 x 1024 to 512 x 1024. The unit is KB.

**Default value**:

- Independent deployment: **16 MB**
- Finance edition (standard):

  32 MB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, and 80-core CPU/640 GB memory);16 MB (72-core CPU/576 GB memory, 64-core CPU/512 GB memory, 60-core CPU/480 GB memory, 32-core CPU/256 GB memory, 16-core CPU/128 GB memory, and 8-core CPU/64 GB memory)
- Enterprise edition:

  32 MB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, and 64-core CPU/512 GB memory); 16 MB (60-core CPU/480 GB memory, 32-core CPU/256 GB memory, 16-core CPU/128 GB memory, and 8-core CPU/64 GB memory)
- Finance edition (data computing): 16 MB

## enable_memory_context_control

**Parameter description**: Enables the function of checking whether the amount of memory contexts exceeds the specified limit. This parameter applies only to the DEBUG version.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the function of checking the amount of memory contexts is enabled.
- **off** indicates that the function of checking the amount of memory contexts is disabled.

**Default value**: **off**

## uncontrolled_memory_context

**Parameter description**: Specifies which memory texts will not be checked when the **enable_memory_context_control** parameter is set to **on**. This parameter applies only to the DEBUG version.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

During the query, the title meaning string "MemoryContext white list:" is added to the beginning of the parameter value.

**Value range**: a string

**Default value**: empty

## shared_buffers

**Parameter description**: Specifies the size of shared memory used by GaussDB. Increasing the value of this parameter causes GaussDB to request more System V shared memory than the default configuration allows.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 16 to 1073741823. The unit is 8 KB.

The minimum value changes according to **BLCKSZ**.

**Default value:**

Independent deployment:

CN: 4 GB (60-core CPU/480 GB memory); 2 GB (32-core CPU/256 GB memory, 16-core CPU/128 GB memory); 1 GB (8-core CPU/64 GB memory); 512 MB (4-core CPU/32 GB memory) 256 MB (4-core CPU/16 GB memory)

DN: 140 GB (60-core CPU/480 GB memory); 76 GB (32-core CPU/256 GB memory); 40 GB (16-core CPU/128 GB memory); 16 GB (8-core CPU/64 GB memory); 8 GB (4-core CPU/32 GB memory); 4 GB (4-core CPU/16 GB memory)

Finance edition (standard):

CN: 2 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 1 GB (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 512 MB (8-core CPU/64 GB memory)

DN: 140 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 100 GB (96-core CPU/768 GB memory); 80 GB (80-core CPU/640 GB memory and 72-core CPU/576 GB memory); 70 GB (64-core CPU/512 GB memory); 60 GB (60-core CPU/480 GB memory); 30 GB (32-core CPU/256 GB memory); 16 GB (16-core CPU/128 GB memory); 8 GB (8-core CPU/64 GB memory)

Enterprise edition:

CN: 2 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 1 GB (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 512 MB (8-core CPU/64 GB memory)

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DN: 100 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 76 GB (96-core CPU/768 GB memory); 64 GB (80-core CPU/640 GB memory); 56 GB (72-core CPU/576 GB memory); 50 GB (80-core CPU/512 GB memory and 64-core CPU/512 GB memory); 48 GB (60-core CPU/480 GB memory); 24 GB (32-core CPU/256 GB memory); 10 GB (16-core CPU/128 GB memory); 6 GB (8-core CPU/64 GB memory)

Finance edition (data computing):

CN: 2 GB (96-core CPU/768 GB memory); 1 GB (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 512 MB (32-core CPU/256 GB memory)

DN: 50 GB (96-core CPU/768 GB memory); 40 GB (72-core CPU/576 GB memory); 30 GB (64-core CPU/512 GB memory); 10 GB (32-core CPU/256 GB memory)

**Setting suggestions**:

1. Set this parameter on DNs to a value greater than that on CNs because most queries in GaussDB are pushed down.
2. Set **shared_buffers** to a value less than 40% of the memory. Set it to a large value for row-store tables and a small value for column-store tables. For column-store tables: **shared_buffers** = (Memory of a single server/Number of DNs on the single server) x 0.4 x 0.25
3. If **shared_buffers** is set to a larger value, increase the value of **checkpoint_segments** because a longer period of time is required to write a large amount of new or changed data.
4. If the process fails to be restarted after the value of **shared_buffers** is changed, perform either of the following operations based on the error information:
   a. Adjust the **kernel.shmall**, **kernel.shmmax**, and **kernel.shmmin** OS parameters. For details, see "Preparing for Installation > Modifying OS Configuration > Configuring Other OS Parameters" in *Installation Guide*.
   b. Run the **free -g** command to check whether the available memory and swap space of the OS are sufficient. If the memory is insufficient, manually stop other user programs that occupy much memory.
   c. Do not set **shared_buffers** to an excessively large or small value.

## segment_buffers

**Parameter description**: Specifies the memory size of a GaussDB segment-page metadata page.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 16 to 1073741823. The unit is 8 KB.

The value of **segment_buffers** must be an integer multiple of **BLCKSZ**. Currently, **BLCKSZ** is set to **8 KB**. That is, the value of **segment_buffers** must be an integer multiple of 8 KB. The minimum value changes according to **BLCKSZ**.

**Default value**: **8 MB**

**Setting suggestions**:

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- **segment_buffers** is used to cache the content of segment-paged headers, which is key metadata information. To improve performance, it is recommended that the segment headers of common tables be cached in the buffer and not be replaced. You are advised to set this parameter based on the following formula: Number of tables (including indexes and toast tables) x Number of partitions x 3 + 128. This is because each table (partition) has some extra metadata segments. Generally, a table has three segments. At last, **+128** is added because segment-page tablespace management requires a certain number of buffers.
- If this parameter is set to a small value, it takes a long time to create a segment-page table for the first time. Therefore, you are advised to set this parameter to the recommended value.

## bulk_write_ring_size

**Parameter description**: Specifies the size of a ring buffer used for parallel data import.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 16384 to 2147483647. The unit is KB.

**Default value**: **2 GB**

**Setting suggestions**: Increase the value of this parameter on DNs if a huge amount of data will be imported.

## standby_shared_buffers_fraction

**Parameter description**: Specifies the **shared_buffers** proportion used on the server where a standby instance is deployed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a double-precision floating-point number ranging from 0.1 to 1.0

**Default value: 1**

## temp_buffers

**Parameter description**: Specifies the maximum size of local temporary buffers used by a database session.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

This parameter can be modified only before the first use of temporary tables within each session. Subsequent attempts to change the value of this parameter will not take effect on that session.

A session allocates temporary buffers based on the value of **temp_buffers**. If a large value is set in a session that does not require many temporary buffers, only the overhead of one buffer descriptor is added. If a buffer is used, additional 8192 bytes will be consumed for it.

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**Value range**: an integer ranging from 100 to 1073741823. The unit is 8 KB.

**Default value**: **1 MB**

## max_prepared_transactions

**Parameter description**: Specifies the maximum number of transactions that can stay in the **prepared** state simultaneously. Increasing the value of this parameter causes GaussDB to request more System V shared memory than the default configuration allows.

When GaussDB is deployed as an HA system, set this parameter on standby servers to a value greater than or equal to that on primary servers. Otherwise, queries will fail on the standby servers.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 262143

**Default value**:

- Independent deployment:

  1200 (60-core CPU/480 GB memory and 32-core CPU/256 GB memory); 800 (16-core CPU/128 GB memory); 400 (8-core CPU/64 GB memory); 300 (4-core CPU/32 GB memory); 200 (4-core CPU/16 GB memory)

- Finance edition (standard):

  CN: 900 (128-core CPU/1024 GB memory and 104-core CPU/1024 GB memory); 800 (96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 400 (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 200 (8-core CPU/64 GB memory)

  DN: 4200 (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 2200 (32-core CPU/256 GB memory); 1200 (16-core CPU/128 GB memory); 800 (8-core CPU/64 GB memory)

- Enterprise edition:

  CN: 900 (128-core CPU/1024 GB memory and 104-core CPU/1024 GB memory); 800 (96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 400 (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 200 (8-core CPU/64 GB memory)

  DN: 1800 (128-core CPU/1024 GB memory and 104-core CPU/1024 GB memory); 1200 (96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 800 (32-core CPU/256 GB memory); 400 (16-core CPU/128 GB memory and 8-core CPU/64 GB memory)

- Finance edition (data computing):

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CN: 800 (96-core CPU/768 GB memory); 400 (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 200 (32-core CPU/256 GB memory)

DN: 2400 (96-core CPU/768 GB memory); 1200 (72-core CPU/576 GB memory); 800 (64-core CPU/512 GB memory); 400 (32-core CPU/256 GB memory)

NOTE

To avoid failures in the preparation step, the value of this parameter must be greater than the number of worker threads in **thread_pool_attr** in thread pool mode. In non-thread pool mode, the value of this parameter must be greater than or equal to the value of **max_connections**.

## work_mem

**Parameter description**: Specifies the amount of memory to be used by internal sort operations and hash tables before they write data into temporary disk files. Sort operations are required for **ORDER BY**, **DISTINCT**, and merge joins. Hash tables are used in hash joins, hash-based aggregation, and hash-based processing of **IN** subqueries.

In a complex query, several sort or hash operations may run in parallel; each operation will be allowed to use as much memory as this parameter specifies. If the memory is insufficient, data will be written into temporary files. In addition, several running sessions could be performing such operations concurrently. Therefore, the total memory used may be many times the value of **work_mem**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 64 to 2147483647. The unit is KB.

**Default value**:

- Independent deployment:

  128 MB (60-core CPU/480 GB memory, 32-core CPU/256 GB memory, and 16-core CPU/128 GB memory); 64 MB (8-core CPU/64 GB memory); 32 MB (4-core CPU/32 GB memory); 16 MB (4-core CPU/16 GB memory)

- Finance edition (standard):

  CN: 128 MB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, 60-core CPU/480 GB memory, 32-core CPU/256 GB memory, and 16-core CPU/128 GB memory); 64 MB (8-core CPU/64 GB memory)

  DN: 256 MB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, and 96-core CPU/768 GB memory); 128 MB (80-core CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, 60-core CPU/480 GB memory, 32-core CPU/256 GB memory, and 16-core CPU/128 GB memory); 64 MB (8-core CPU/64 GB memory)

- Enterprise edition:

  128 MB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB

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memory, 64-core CPU/512 GB memory, 60-core CPU/480 GB memory, 32-core CPU/256 GB memory, and 16-core CPU/128 GB memory); 64 MB (8-core CPU/64 GB memory)

- Finance edition (data computing):

  128 MB (96-core CPU/768 GB memory, 72-core CPU/576 GB memory, and 64-core CPU/512 GB memory); 64 MB (32-core CPU/256 GB memory)

NOTICE

**Setting suggestions**:

If the physical memory specified by **work_mem** is insufficient, additional operator calculation data will be written into temporary tables based on query characteristics and the degree of parallelism. This reduces performance by five to ten times, and prolongs the query response time from seconds to minutes.

- For complex serial queries, each query requires five to ten associated operations. Set **work_mem** using the following formula: **work_mem** = 50% of the memory/10.
- For simple serial queries, each query requires two to five associated operations. Set **work_mem** using the following formula: **work_mem** = 50% of the memory/5.
- For concurrent queries, set **work_mem** using the following formula: **work_mem** = **work_mem** for serial queries/Number of concurrent SQL statements.
- BitmapScan hash tables are also restricted by **work_mem**, but will not be forcibly flushed to disks. In the case of complete lossify, every 1-MB memory occupied by the hash table corresponds to a 16 GB page of BitmapHeapScan. After the upper limit of **work_mem** is reached, the memory increases linearly with the data access traffic based on this ratio.

## query_mem

**Parameter description**: Specifies the memory used by a query.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: 0 or an integer greater than 32 MB. The default unit is KB.

**Default value**: **0**

NOTICE

- If the value of **query_mem** is greater than 0, the optimizer adjusts the memory cost estimate to this value when generating an execution plan.
- If the value is set to a negative value or a positive integer less than 32 MB, the default value **0** is used. In this case, the optimizer does not adjust the estimated query memory.

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## query_max_mem

**Parameter description**: Specifies the maximum memory that can be used by a query.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: 0 or an integer greater than 32 MB. The default unit is KB.

**Default value**: **0**

NOTICE

- If the value of **query_max_mem** is greater than 0, an error is reported when the query memory usage exceeds the value.
- If the value is set to a negative value or a positive integer less than 32 MB, the default value **0** is used. In this case, the optimizer does not limit the query memory.

## maintenance_work_mem

**Parameter description:** Specifies the maximum amount of memory to be used by maintenance operations, such as **VACUUM**, **CREATE INDEX**, and **ALTER TABLE ADD FOREIGN KEY**. This parameter may affect the execution efficiency of **VACUUM**, **VACUUM FULL**, **CLUSTER**, and **CREATE INDEX**.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 1024 to 2147483647. The unit is KB.

**Default value**:

- Independent deployment:

  CN: 1 GB (60-core CPU/480 GB memory); 512 MB (32-core CPU/256 GB memory); 256 MB (16-core CPU/128 GB memory); 128 MB (8-core CPU/64 GB memory); 64 MB (4-core CPU/32 GB memory);32 MB (4-core CPU/16 GB memory)

  DN: 2 GB (60-core CPU/480 GB memory); 1 GB (32-core CPU/256 GB memory); 512 MB (16-core CPU/128 GB memory); 256 MB (8-core CPU/64 GB memory); 128 MB (4-core CPU/32 GB memory); 64 MB (4-core CPU/16 GB memory)

- Finance edition (standard):

  CN: 1 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, and 80-core CPU/640 GB memory); 512 MB (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 256 MB (60-core CPU/480 GB memory, 32-core CPU/256 GB memory, 16-core CPU/128 GB memory, and 8-core CPU/64 GB memory)

  DN: 2 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core

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CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 1 GB (32-core CPU/256 GB memory); 512 MB (16-core CPU/128 GB memory); 256 MB (8-core CPU/64 GB memory)

- Enterprise edition:

  CN: 1 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, and 80-core CPU/512 GB memory); 512 MB (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 256 MB (60-core CPU/480 GB memory, 32-core CPU/256 GB memory, 16-core CPU/128 GB memory, and 8-core CPU/64 GB memory)

  DN: 2 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 1 GB (32-core CPU/256 GB memory); 512 MB (16-core CPU/128 GB memory); 256 MB (8-core CPU/64 GB memory)

- Finance edition (data computing):

  CN: 1 GB (96-core CPU/768 GB memory); 256 MB (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 128 MB (32-core CPU/256 GB memory)

  DN: 2 GB (96-core CPU/768 GB memory); 1 GB (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 512 MB (32-core CPU/256 GB memory)

NOTICE

**Setting suggestions**:

- The value of this parameter must be greater than that of **work_mem** so that database dumps can be more quickly cleared or restored. In a database session, only one maintenance operation can be performed at a time. Maintenance is usually performed when there are not many running sessions.
- When the **19.13 Automatic Vacuuming** process is running, up to **autovacuum_max_workers** times this memory may be allocated. In this case, set **maintenance_work_mem** to a value greater than or equal to that of **work_mem**.
- If a large amount of data is to be clustered, increase the value of this parameter in the session.

## psort_work_mem

**Parameter description**: Specifies the memory capacity to be used for partial sorting in a column-store table before writing to temporary disk files. This parameter can be used for inserting tables having a partial cluster key or index, creating a table index, and deleting or updating a table.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

Several running sessions could be performing such operations concurrently. Therefore, the total memory used may be many times the value of **psort_work_mem**.

**Value range**: an integer ranging from 64 to 2147483647. The unit is KB.

**Default value**: **512 MB**

## max_loaded_cudesc

**Parameter description**: Specifies the number of cudesc cached in each column when a column-store table is scanned. Increasing the value will improve query performance and increase memory usage, particularly when there are many columns in the column-store table.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

If **max_loaded_cudesc** is set to a large value, memory may be insufficient.

**Value range**: 100 to 1073741823

**Default value: 1024**

## max_stack_depth

**Parameter description**: Specifies the maximum safe depth of the GaussDB execution stack. The safety margin is required because the stack depth is not checked in every routine in the server, but only in key potentially-recursive routines, such as expression evaluation.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 100 to 2147483647. The unit is KB.

**Default value**:

- If the value of **ulimit -s** minus 640 KB is greater than or equal to 2 MB, the default value of this parameter is **2 MB**.
- If the value of **ulimit -s** minus 640 KB is less than 2 MB, the default value of this parameter is the value of **ulimit -s** minus 640 KB.

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NOTICE

When setting this parameter, comply with the following principles:

- The database needs to reserve 640 KB stack depth. Therefore, the maximum value of this parameter is the actual stack size limit enforced by the OS kernel (as set by **ulimit -s**) minus 640 KB.
- If the value of this parameter is greater than the value of **ulimit -s** minus 640 KB before the database is started, the database fails to be started. During database running, if the value of this parameter is greater than the value of **ulimit -s** minus 640 KB, this parameter does not take effect.
- If the value of **ulimit -s** minus 640 KB is less than the minimum value of this parameter, the database fails to be started.
- Setting this parameter to a value greater than the actual kernel limit means that a running recursive function may crash an individual backend process.
- Since not all OSs provide this function, you are advised to set a specific value for this parameter.
- The default value is **2 MB**, which is relatively small and does not easily cause system breakdown.

## cstore_buffers

**Parameter description**: Specifies the shared buffer size used in column-store tables.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 16384 to 1073741823. The unit is KB.

**Default value**: **32 MB**

**Setting suggestions**:

Column-store tables use the shared buffer specified by **cstore_buffers** instead of that specified by **shared_buffers**. When column-store tables are mainly used, reduce the value of **shared_buffers** and increase that of **cstore_buffers**.

## bulk_read_ring_size

**Parameter description**: Specifies the ring buffer size used for parallel data export.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 256 to 2147483647. The unit is KB.

**Default value**: **16 MB**

## enable_early_free

**Parameter description**: Specifies whether the operator memory can be released in advance.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the operator memory can be released in advance.
- **off** indicates that the operator memory cannot be released in advance.

**Default value**: **on**

## memory_trace_level

**Parameter description**: Specifies the control level for recording memory allocation information after the dynamic memory usage exceeds 90% of the maximum dynamic memory. This parameter takes effect only when the GUC parameters **use_workload_manager** and **enable_memory_limit** are enabled. This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values

- **none**: indicates that memory application information is not recorded.
- **level1**: After the dynamic memory usage exceeds 90% of the maximum dynamic memory, the following information is recorded and the recorded memory information is saved in the *$GAUSSLOG*/**mem_log** directory.
  - Global memory overview.
  - Memory usage of the top 20 memory contexts of the instance, session, and thread types.
  - The **totalsize** and **freesize** columns for each memory context.
- **level2**: After the dynamic memory usage exceeds 90% of the maximum dynamic memory, the following information is recorded and the recorded memory information is saved in the *$GAUSSLOG*/**mem_log** directory.
  - Global memory overview.
  - Memory usage of the top 20 memory contexts of the instance, session, and thread types.
  - The **totalsize** and **freesize** columns for each memory context.
  - Detailed information about all memory applications in each memory context, including the file where the allocated memory is located, line number, and size.

**Default value**: **level1**

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NOTICE

- If this parameter is set to **level2**, the memory allocation details (file, line, and size) of each memory context are recorded, which greatly affects the performance. Therefore, exercise caution when setting this parameter.
- The recorded memory snapshot information can be queried by using the system function **gs_get_history_memory_de...**.
- If the **use_workload_manager** parameter is disabled and the **bypass_workload_manager** parameter is enabled, this parameter also takes effect. The **bypass_workload_manager** parameter is of the SIGHUP type; therefore, after the reload mode is set, you need to restart the database for the setting to take effect.
- The recorded memory context is obtained after all memory contexts of the same type with the same name are summarized.

## resilience_memory_reject_percent

**Parameter description**: Specifies the dynamic memory usage percentage for escape from memory overload. This parameter takes effect only when the GUC parameters **use_workload_manager** and **enable_memory_limit** are enabled. This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, consisting of one or more characters

This parameter consists of **recover_memory_percent** and **overload_memory_percent**. The meanings of the two parts are as follows:

- **recover_memory_percent**: Percentage of the dynamic memory usage when the memory recovers from overload to the maximum dynamic memory. When the dynamic memory usage is less than the maximum dynamic memory multiplied by the value of this parameter, the overload escape function is disabled and new connections are allowed. The value ranges from 0 to 100. The value indicates a percentage.
- **overload_memory_percent**: Percentage of the dynamic memory usage to the maximum dynamic memory when the memory is overloaded. When the dynamic memory usage is greater than the maximum dynamic memory multiplied by the value of this parameter, the current memory is overloaded. In this case, the overload escape function is triggered to kill sessions and new connections are prohibited. The value ranges from 0 to 100. The value indicates a percentage.

**Default value**: **'0,0'**, indicating that the escape from memory overload function is disabled.

**Example:**

```
resilience_memory_reject_percent = '70,90'
```

When the memory usage exceeds 90% of the upper limit, new connections are forbidden and stacked sessions are killed. When the memory usage is less than 70% of the upper limit, session killing is stopped and new connections are allowed.

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NOTICE

- You can query the maximum dynamic memory and used dynamic memory in the **pv_total_memory_detail** view. **max_dynamic_memory** indicates the maximum dynamic memory, and **dynamic_used_memory** indicates the used dynamic memory.
- If this parameter is set to a small value, the escape from memory overload process is frequently triggered. As a result, ongoing sessions are forcibly logged out, and new connections fail to be connected for a short period of time. Therefore, exercise caution when setting this parameter based on the actual memory usage.
- If the **use_workload_manager** parameter is disabled and the **bypass_workload_manager** parameter is enabled, this parameter also takes effect. The **bypass_workload_manager** parameter is of the SIGHUP type; therefore, after the reload mode is set, you need to restart the database for the setting to take effect.
- The values of **recover_memory_percent** and **overload_memory_percent** can be **0** at the same time. In addition, the value of **recover_memory_percent** must be smaller than that of **overload_memory_percent**. Otherwise, the setting does not take effect.

## 19.4.2 Disk Space

This section describes the disk space parameters, which are used to set limits on the disk space for storing temporary files.

### sql_use_spacelimit

**Parameter description**: Specifies the space size for files to be flushed to disks when a single SQL statement is executed on a single DN. The managed space includes the space occupied by ordinary tables, temporary tables, and intermediate result sets to be flushed to disks.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 2147483647. The unit is KB. **–1** indicates no limit.

**Default value: –1**

### temp_file_limit

**Parameter description**: Specifies the limit on the size of a temporary file spilled to disk in a session. The temporary file can be a sort or hash temporary file, or the storage file for a held cursor.

This is a session-level setting.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

This parameter does not apply to disk space used for temporary tables during the SQL query process.

**Value range**: an integer ranging from –1 to 2147483647. The unit is KB. **–1** indicates no limit.

**Default value**: **–1**

## 19.4.3 Kernel Resource Usage

This section describes kernel resource parameters. Whether these parameters take effect depends on OS settings.

### max_files_per_process

**Parameter description**: Specifies the maximum number of simultaneously open files allowed by each server process. If the kernel is enforcing a proper limit, setting this parameter is not required.

However, on some platforms, such as most Berkeley Software Distribution (BSD) systems, the kernel allows individual processes to open many more files than the system can support. If the message "Too many open files" is displayed, set this parameter to a smaller value. Generally, the system must meet this requirement: Number of file descriptors >= Maximum number of concurrent statements x Number of primary DNs of the current physical machine x **max_files_per_process** x 3

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 25 to 2147483647

**Default value**: **1024**

### shared_preload_libraries

**Parameter description:** Specifies one or more shared libraries to be preloaded at server start. If multiple libraries are to be loaded, separate their names using commas (,). Only the **sysadmin** user can access this parameter. For example, **$libdir/mylib** will cause **mylib.so** (or on some platforms, **mylib.sl**) to be preloaded before the loading of the standard library directory.

You can preinstall the GaussDB stored procedure library using the **$libdir/pl***XXX* syntax as described in the preceding text. *XXX* can only be **pgsql**, **perl**, **tcl**, or **python**.

By preloading a shared library and initializing it as required, the library startup time is avoided when the library is first used. However, the time to start each new server process may increase, even if that process never uses the library. Therefore, set this parameter only for libraries that will be used in most sessions.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

- If a specified library is not found, the GaussDB service will fail to start.
- Each GaussDB-supported library has a special mark that is checked to guarantee compatibility. Therefore, libraries that do not support GaussDB cannot be loaded in this way.

**Value range**: a string

**Default value**: **security_plugin**

## 19.4.4 Cost-based Vacuum Delay

This feature allows administrators to reduce the I/O impact of the **VACUUM** and **ANALYZE** statements on concurrent database activities. It is often more important to prevent maintenance statements, such as **VACUUM** and **ANALYZE**, from affecting other database operations than to run them quickly. Cost-based vacuum delay provides a way for administrators to achieve this purpose.

NOTICE

Certain vacuum operations hold critical locks and should be complete as quickly as possible. In GaussDB, cost-based vacuum delays do not take effect during such operations. To avoid uselessly long delays in such cases, the actual delay is the larger of the two calculated values:

- **vacuum_cost_delay** x **accumulated_balance**/**vacuum_cost_limit**
- **vacuum_cost_delay** x 4

### Background

During the execution of the **12.14.40 ANALYZE | ANALYSE** and **12.14.171 VACUUM** statements, the system maintains an internal counter that keeps track of the estimated cost of the various I/O operations that are performed. When the accumulated cost reaches a limit (specified by **vacuum_cost_limit**), the process performing the operation will sleep for a short period of time (specified by **vacuum_cost_delay**). Then, the counter resets and the operation continues.

By default, this feature is disabled. To enable this feature, set **vacuum_cost_delay** to a positive value.

### vacuum_cost_delay

**Parameter description**: Specifies the length of time that a process will sleep when **vacuum_cost_limit** has been exceeded.

On many systems, the effective resolution of the sleep length is 10 milliseconds. Therefore, setting this parameter to a value that is not a multiple of 10 has the same effect as setting it to the next higher multiple of 10.

This parameter is usually set to a small value, such as 10 or 20 milliseconds. Adjusting vacuum's resource consumption is best done by changing other vacuum cost parameters.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 100. A positive number enables cost-based vacuum delay and **0** disables cost-based vacuum delay.

**Default value**:

## vacuum_cost_page_hit

**Parameter description**: Specifies the estimated cost for vacuuming a buffer found in the shared buffer. It represents the cost to lock the buffer pool, look up the shared hash table, and scan the content of the page.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 10000

**Default value**: **1**

## vacuum_cost_page_miss

**Parameter description**: Specifies the estimated cost for vacuuming a buffer read from the disk. It represents the cost to lock the buffer pool, look up the shared hash table, read the desired block from the disk, and scan the block.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 10000

**Default value: 10**

## vacuum_cost_page_dirty

**Parameter description**: Specifies the estimated cost charged when vacuum modifies a block that was previously clean. It represents the extra cost required to update the dirty block out to the disk again.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 10000

**Default value: 20**

## vacuum_cost_limit

**Parameter description**: Specifies the cost limit. The vacuuming process will sleep if this limit is exceeded.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 10000

**Default value**: **1000**

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## 19.4.5 Background Writer

This section describes background writer parameters. The background writer process is used to write dirty data (new or modified data) in shared buffers to disks. This mechanism ensures that database processes seldom or never need to wait for a write action to occur when handling user queries.

It also mitigates performance deterioration caused by checkpoints because only a few of dirty pages need to be flushed to the disk when the checkpoints arrive. This mechanism, however, increases the overall net I/O load because while a repeatedly-dirtied page may otherwise be written only once per checkpoint interval, the background writer may write it several times as it is dirtied in the same interval. In most cases, continuous light loads are preferred, instead of periodical load peaks. The parameters discussed in this section can be set based on actual requirements.

### bgwriter_delay

**Parameter description**: Specifies the interval at which the background writer writes dirty shared buffers. Each time, the backend write process initiates write operations for some dirty buffers. In full checkpoint mode, the **bgwriter_lru_maxpages** parameter is used to control the amount of data to be written each time, and the process is restarted after *bgwriter_delay* ms hibernation. In incremental checkpoint mode, the number of target idle buffer pages is calculated based on the value of **candidate_buf_percent_target**. If the number of idle buffer pages is insufficient, a batch of pages are flushed to disks every *bgwriter_delay* ms. The number of flushed pages is calculated based on the target difference percentage. The maximum number of flushed pages is limited by **max_io_capacity**.

In many systems, the effective resolution of sleep delays is 10 milliseconds. Therefore, setting this parameter to a value that is not a multiple of 10 has the same effect as setting it to the next higher multiple of 10.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 10 to 10000. The unit is millisecond.

**Default value**: **2s**

**Setting suggestion:** Reduce this value in slow data writing scenarios to reduce the checkpoint load.

### candidate_buf_percent_target

**Parameter description**: Specifies the expected percentage of available buffers in the shared_buffer memory buffer in the candidate buffer chain when the incremental checkpoint is enabled. If the number of available buffers in the current candidate chain is less than the target value, the bgwriter thread starts flushing dirty pages that meet the requirements.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** a double-precision floating point number ranging from 0.1 to 0.85

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**Default value**: **0.3**

## bgwriter_lru_maxpages

**Parameter description**: Specifies the number of dirty buffers the background writer can write in each round.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 1000

NOTE

When this parameter is set to **0**, the background writer is disabled. This setting does not affect checkpoints.

**Default value**: **100**

## bgwriter_lru_multiplier

**Parameter description**: Specifies the coefficient used to estimate the number of dirty buffers the background writer can write in the next round.

The number of dirty buffers written in each round depends on the number of buffers used by server processes during recent rounds. The estimated number of buffers required in the next round is calculated using the following formula: Average number of recently used buffers x **bgwriter_lru_multiplier**. The background writer writes dirty buffers until sufficient, clean and reusable buffers are available. The number of buffers the background writer writes in each round is always equal to or less than **bgwriter_lru_maxpages**.

Therefore, the value **1.0** represents a just-in-time policy of writing exactly the number of dirty buffers predicted to be required. Larger values provide some cushion against spikes in demand, whereas smaller values intentionally leave more writes to be done by server processes.

Smaller values of **bgwriter_lru_maxpages** and **bgwriter_lru_multiplier** reduce the extra I/O load caused by the background writer, but make it more likely that server processes will have to issue writes for themselves, delaying interactive queries.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0 to 10

**Default value: 2**

## pagewriter_thread_num

**Parameter description**: Specifies the number of threads for background page flushing after the incremental checkpoint is enabled. Dirty pages are flushed in sequence to disks, promoting recovery points.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: an integer ranging from 1 to 16

**Default value**: **4**

## dirty_page_percent_max

**Parameter description**: Specifies the percentage of dirty pages to **shared_buffers** after the incremental checkpoint is enabled. When the value of this parameter is reached, the background page flush thread flushes dirty pages based on the maximum value of max_io_capacity.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0.1 to 1

**Default value**: **0.9**

## pagewriter_sleep

**Parameter description**: Specifies the interval for the pagewriter thread to flush dirty pages to disks after the incremental checkpoint is enabled. When the ratio of dirty pages to shared_buffers reaches dirty_page_percent_max, the number of pages in each batch is calculated based on the value of max_io_capacity. In other cases, the number of pages in each batch decreases proportionally.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3600000. The unit is ms.

**Default value**: **2000 ms(2s)**

## max_io_capacity

**Parameter description**: Specifies the I/O upper limit per second for the backend write process to flush pages in batches. Set this parameter based on the service scenario and the disk I/O capability. If the RTO is short or the data volume is many times that of the shared memory and the service access data volume is random, the value of this parameter cannot be too small. A small value of **max_io_capacity** reduces the number of pages flushed by the backend write process. If a large number of pages are eliminated due to service triggering, the services are affected.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 30720 to 10485760. The unit is KB.

**Default value**: **500 MB/s**

## enable_consider_usecount

**Parameter description**: Specifies whether the backend thread considers the page popularity during page replacement. You are advised to enable this parameter in large-capacity scenarios.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on**/**true**: The page popularity is considered.
- **off**/**false**: The page popularity is not considered.

**Default value**: **off**

### dw_file_num

**Parameter description**: Specifies the number of doublewrite files to be written in batches. The value is related to **pagewriter_thread_num** and cannot be greater than the value of **pagwriter_thread_num**. If the value is too large, it will be corrected to the value of **pagewriter_thread_num**.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 1 to 16

**Default value**: **1**

### dw_file_size

**Parameter description**: Specifies the size of each doublewrite file.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer, in the range [32,256]

**Default value**: **256**

## 19.4.6 Asynchronous I/O Operations

### enable_adio_debug

**Parameter description**: Specifies whether O&M personnel are allowed to generate some ADIO logs to locate ADIO issues. This parameter is used only by developers. Common users are advised not to use it. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a SUSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** or **true** indicates that generation of ADIO logs is allowed.
- **off** or **false** indicates that generation of ADIO logs is disallowed.

**Default value**: **off**

NOTE

This parameter cannot be enabled on in the current version. Even if it is manually enabled, the system automatically disables it.

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## enable_adio_function

**Parameter description**: Specifies whether to enable the ADIO function. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

NOTE

The current version does not support the asynchronous I/O function. This function is disabled by default. Do not modify the setting.

**Value range**: Boolean

- **on** or **true** indicates that the function is enabled.
- **off** or **false** indicates that the function is disabled.

**Default value**: **off**

## enable_fast_allocate

**Parameter description**: Specifies whether the quick disk space allocation is enabled. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**. This function can be enabled only in the XFS file system.

**Value range**: Boolean

- **on** or **true** indicates that the function is enabled.
- **off** or **false** indicates that the function is disabled.

**Default value**: **off**

## prefetch_quantity

**Parameter description**: Specifies the amount of the I/O that the row-store prefetches using the ADIO. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 128 to 131072. The unit is 8 KB.

**Default value**: **32 MB** (4096 x 8 KB)

## backwrite_quantity

**Parameter description**: Specifies the amount of I/O that the row-store writes using the ADIO. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 128 to 131072. The unit is 8 KB.

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**Default value**: **8 MB** (1024 x 8 KB)

## cstore_prefetch_quantity

**Parameter description**: Specifies the amount of I/O that the column-store prefetches using the ADIO. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1024 to 1048576. The unit is KB.

**Default value**: **32 MB**

## cstore_backwrite_quantity

**Parameter description**: Specifies the amount of I/O that the column-store writes using the ADIO. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1024 to 1048576. The unit is KB.

**Default value**: **8 MB**

## cstore_backwrite_max_threshold

**Parameter description**: Specifies the maximum amount of buffer I/O that the column-store writes in the database using the ADIO. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 4096 to 1073741823. The unit is KB.

**Default value**: **2 GB**

## fast_extend_file_size

**Parameter description**: Specifies the disk size that the row-store pre-scales using the ADIO. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1024 to 1048576. The unit is KB.

**Default value**: **8 MB**

## effective_io_concurrency

**Parameter description**: Specifies the number of requests that can be simultaneously processed by a disk subsystem. For the RAID array, the parameter

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value must be the number of disk drive spindles in the array. Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 1000

**Default value**: **1**

## checkpoint_flush_after

**Parameter description:** Specifies the threshold for the number of pages flushed by the checkpointer thread. If the threshold is exceeded, the operating system is instructed to flush the pages cached in the operating system asynchronously. In GaussDB, the disk page size is 8 KB.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 256. **0** indicates that the asynchronous flush function is disabled. The size of a single page is 8 KB. For example, if the value is **32**, the checkpointer thread continuously writes 32 disk pages (that is, 32 x 8 = 256 KB) before asynchronous flush.

**Default value**: **256KB** (32 pages)

## bgwriter_flush_after

**Parameter description:** Specifies the threshold for the number of pages flushed by the background writer thread. If the number of pages exceeds the threshold, the background writer thread instructs the operating system to asynchronously flush the pages cached in the operating system to disks. In GaussDB, the disk page size is 8 KB.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 256. **0** indicates that the asynchronous flush function is disabled. The size of a single page is 8 KB. For example, if the value is **64**, the background writer thread continuously writes 64 disk pages (that is, 64 x 8 = 512 KB) before asynchronous flush.

**Default value**: **512 KB** (64 pages)

## backend_flush_after

**Parameter description:** Specifies the threshold for the number of pages flushed by the backend thread. If the number of pages exceeds the threshold, the backend thread instructs the operating system to asynchronously flush the pages cached in the operating system to disks. In GaussDB, the disk page size is 8 KB.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 256. **0** indicates that the asynchronous flush function is disabled. For example, if the value is **64**, the backend thread

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continuously writes 64 disk pages (that is, 64 x 8 = 512 KB) before asynchronous flush.

**Default value**: **0**

# 19.5 Parallel Data Import

GaussDB provides a parallel data import function that enables a large amount of data to be imported in a fast and efficient manner. This section describes parameters for importing data in parallel.

## raise_errors_if_no_files

**Parameter description**: Specifies whether to distinguish between the problems "the number of imported file records is empty" and "the imported file does not exist". If this parameter is set to **on** and the problem "the imported file does not exist" occurs, GaussDB will report the error message "file does not exist".

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the messages of "the number of imported file records is empty" and "the imported file does not exist" are distinguished when files are imported.
- **off** indicates that the messages of "the number of imported file records is empty" and "the imported file does not exist" are the same when files are imported.

**Default value**: **off**

## partition_mem_batch

**Parameter description**: In order to optimize the inserting of column-store partitioned tables in batches, the data is buffered during the inserting process and then written in the disk. You can specify the number of caches through **partition_mem_batch**. If the value is too large, much memory will be consumed. If it is too small, the performance of inserting column-store partitioned tables in batches will deteriorate.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: 1 to 65535

**Default value**: **256**

## partition_max_cache_size

**Parameter description**: In order to optimize the inserting of column-store partitioned tables in batches, the data is buffered during the inserting process and then written in the disk. You can specify the data buffer cache size through **partition_max_cache_size**. If the value is too large, much memory will be

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consumed. If it is too small, the performance of inserting column-store partitioned tables in batches will deteriorate.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**:

4096 to 1073741823. The unit is KB.

**Default value**: **2GB**

## gds_debug_mod

**Parameter description**: Specifies whether to enable the debug function of Gauss Data Service (GDS). This parameter is used to better locate and analyze GDS faults. After the debug function is enabled, types of packets received or sent by GDS, peer end of GDS during command interaction, and other interaction information about GDS are written into the logs of corresponding nodes in the cluster. In this way, the state switching on the GaussDB state machine and the current state are recorded. If this function is enabled, additional log I/O resources will be consumed, affecting log performance and validity. You are advised to enable this function only when locating GDS faults.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**:

- **on** indicates that the GDS debug function is enabled.
- **off** indicates that the GDS debug function is disabled.

**Default value**: **off**

## enable_delta_store

**Parameter description**: Specifies whether to enable delta tables for column-store tables. Delta tables will improve the performance of importing a single piece of data to a column-store table and prevent table bloating. If this parameter is set to **on**, data to be imported to a column-store table will be stored in the delta table when the data volume is less than **DELTAROW_THRESHOLD** specified in table definition and otherwise will be stored in CUs of the main table. This parameter affects all operations involving data transfer of column-store tables, including **INSERT**, **COPY**, **VACUUM**, **VACUUM FULL**, **VACUUM DELTAMERGE**, and data redistribution.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**:

- **on** indicates that delta tables are enabled.
- **off** indicates that delta tables are disabled.

**Default value**: **off**

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### safe_data_path

**Parameter description:** Specifies the path prefix restriction except for the initial user. Currently, the restrictions are posed on COPY and advanced package paths. The path cannot end with a slash (/) or contain periods (..).

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** a string of up to 4096 characters

**Default value**: **NULL**

### enable_copy_server_files

**Parameter description**: Specifies whether to enable the permission to copy server files.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the permission to copy server files is enabled.
- **off** indicates that the permission to copy server files is disabled.

**Default value**: **off**

NOTICE

When the **enable_copy_server_files** parameter is disabled, only the initial user is allowed to run the **COPY FROM FILENAME** or **COPY TO FILENAME** statement. When the **enable_copy_server_files** parameter is enabled, users with the **SYSADMIN** permission or users who inherit the **gs_role_copy_files** permission of the built-in role are allowed to run the **COPY FROM FILENAME** or **COPY TO FILENAME** statement.

## 19.6 Write Ahead Log

## 19.6.1 Settings

### wal_level

**Parameter description:** Specifies the level of information to be written to the WAL. The value cannot be empty or commented out.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

- To enable WAL archiving and data streaming replication between primary and standby servers, set this parameter to **archive**, **hot_standby**, or **logical**.
- If this parameter is set to **archive** or **minimal**, **hot_standby** must be set to **off**. In a distributed environment, **hot_standby** cannot be set to **off**. Therefore, you are not advised to set this parameter to **archive** or **minimal**. Otherwise, the database cannot be started.

**Value range**: enumerated values

- **minimal**

  Advantages: Certain bulk operations (including creating tables and indexes, executing cluster operations, and copying tables) are safely skipped in logging, which can make those operations much faster.

  Disadvantages: WALs contain only basic information required for recovery from a database server crash or an emergency shutdown. Data cannot be restored from archived WALs.

- **archive**

  Adds logging required for WAL archiving, supporting the database restoration from archives.

- **hot_standby**
  - Further adds information required to run SQL queries on a standby server and takes effect after a server restart.
  - To enable read-only queries on a standby server, the **wal_level** parameter must be set to **hot_standby** on the primary server and the same value must be set on the standby server. There are few measurable differences in performance between using **hot_standby** and **archive** levels. However, feedback is welcome if any differences in their impacts on product performance are noticeable.

- **logical**

  Only when this parameter is set to **logical**, logical logs can be parsed and the primary key information is recorded in Xlogs.

**Default value**: **hot_standby**

## fsync

**Parameter description:** Specifies whether the GaussDB server uses the **fsync()** function (see **wal_sync_method**) to ensure that updates can be written to disks in a timely manner.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

- Using the **fsync()** function ensures that the data can be recovered to a known state when an OS or a hardware crashes.
- Setting this parameter to **off** may result in unrecoverable data corruption in a system crash.

**Value range**: Boolean

- **on** indicates that the **fsync()** function is used.
- **off** indicates that the **fsync()** function is not used.

**Default value**: **on**

## synchronous_commit

**Parameter description**: Specifies the synchronization mode of the current transaction.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

Generally, logs generated by a transaction are synchronized in the following sequence:

1. The primary node writes the logs to the local memory.
2. The primary node writes the logs in the local memory to the local file system.
3. The primary node flushes the logs in the local file system to disks.
4. The primary node sends the logs to the standby node.
5. The standby node receives the logs and saves them to the local memory.
6. The standby node writes the logs in the local memory to the local file system.
7. The standby node flushes the logs in the local file system to disks.
8. The standby node replays the logs to complete the incremental update of data files.

**Value range**: enumerated values

- **on** (**true**, **yes**, **1**): The primary node waits for the standby node to flush logs to disks before committing a transaction.
- **off** (**false**, **no**, **0**): The primary node commits a transaction without waiting for the primary node to flush logs to disks. This mode is also called asynchronous commit.
- **local**: The primary node waits for the primary node to flush logs to disks before committing a transaction. This mode is also called local commit.
- **remote_write**: The primary node waits for the standby node to write logs to the file system before committing a transaction. (The logs do not need to be flushed to disks.)
- **remote_receive**: The primary node waits for the standby node to receive logs before committing a transaction. (The logs do not need to be written to the file system.)

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- **remote_apply**: The primary node waits for the standby node to complete log replay before committing a transaction.
- **true**: same as **on**.
- **false**: same as **off**.
- **yes**: same as **on**.
- **no**: same as **off**.
- **1**: same as **on**.
- **0**: same as **off**.
- **2**: same as **remote_apply**.

**Default value**: **on**

## wal_sync_method

**Parameter description**: Specifies the method used for forcing WAL updates out to disk.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

If **fsync** is set to **off**, the setting of this parameter does not take effect because WAL file updates will not be forced out to disk.

**Value range**: enumerated values

- **open_datasync** indicates that WAL files are opened with the **O_DSYNC** option.
- fdatasync indicates that **fdatasync()** is called at each commit. (SUSE 10 and SUSE 11 are supported.)
- **fsync_writethrough** indicates that **fsync()** is called at each commit to force data in the buffer to be written to the disk.

  NOTE

  **wal_sync_method** can be set to **fsync_writethrough** on a Windows platform, but this setting has the same effect as setting the parameter to **fsync**.
- **fsync** indicates that **fsync()** is invoked at each commit (SUSE 10 and SUSE 11 are supported).
- **open_sync** indicates that the **open()** with the O_SYNC option is used to write WAL files (SUSE 10 and SUSE 11 are supported).

  NOTE

  Not all platforms support the preceding parameters.

**Default value: fdatasync**

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## full_page_writes

**Parameter description**: Specifies whether the GaussDB server writes the entire content of each disk page to WALs during the first modification of that page after a checkpoint.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- This parameter is needed because a page write that is in process during an OS crash might be only partially completed, leading to an on-disk page that contains a mix of old and new data. The row-level change data normally stored in WALs will not be enough to completely restore such a page during post-crash recovery. Storing the full page image guarantees that the page can be correctly restored, but at the price of increasing the amount of data that must be written to WALs.
- Setting this parameter to **off** might lead to unrecoverable data corruption after a system failure. It might be safe to set this parameter to **off** if you have hardware (such as a battery-backed disk controller) or file-system software (such as ReiserFS 4) that reduces the risk of partial page writes to an acceptably low level.

**Value range**: Boolean

- **on** indicates that this feature is enabled.
- **off** indicates that this feature is disabled.

**Default value**: **on**

## wal_log_hints

**Parameter description**: Specifies whether to write an entire page to WALs during the first modification of that page after a checkpoint, even for non-critical modifications of so-called hint bits. You are advised not to modify the setting.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the entire page is written to WALs.
- **off** indicates that the entire page is not written to WALs.

**Default value**: **on**

## wal_buffers

**Parameter description**: Specifies the number of **XLOG_BLCKSZ** used for storing WAL data. The size of each **XLOG_BLCKSZ** is 8 KB.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range:** –1 to $2^{18}$. The minimum value is –1 and the maximum value is 262144. The unit is 8 KB.

- If this parameter is set to **–1**, the value of **wal_buffers** is automatically adjusted based on the value of **shared_buffers**. The default value is 1/32 of **shared_buffers**. If the value is less than 8, it will be forcibly set to **8**. If the value is greater than 2048, it will be forcibly set to **2048**.
- If this parameter is set to a value other than **–1** and smaller than **4**, the value **4** is forcibly used.
- Independent deployment: 1 GB (60-core CPU/480 GB memory and 32-core CPU/256 GB memory); 512 MB (16-core CPU/128 GB memory); 256 MB (8-core CPU/64 GB memory); 128 MB (4-core CPU/32 GB memory); 64 MB (4-core CPU/16 GB memory)
- Finance edition (standard):

  CN: 512 MB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, and 80-core CPU/640 GB memory); 256 MB (72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 128 MB (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 64 MB (8-core CPU/64 GB memory)

  DN: 2 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, and 96-core CPU/768 GB memory); 1 GB (80-core CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, 60-core CPU/480 GB memory, and 32-core CPU/256 GB memory); 512 MB (16-core CPU/128 GB memory); 256 MB (8-core CPU/64 GB memory)
- Enterprise edition:

  CN: 512 MB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, and 80-core CPU/512 GB memory); 256 MB (72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 128 MB (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 64 MB (8-core CPU/64 GB memory)

  DN: 1 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, 60-core CPU/480 GB memory, and 32-core CPU/256 GB memory); 512 MB (16-core CPU/128 GB memory); 256 MB (8-core CPU/64 GB memory)
- Finance edition (data computing):

  CN: 256 MB (96-core CPU/768 GB memory); 125 MB (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 64 MB (32-core CPU/256 GB memory)

  DN: 1 GB (96-core CPU/768 GB memory, 72-core CPU/576 GB memory, and 64-core CPU/512 GB memory); 512 MB (32-core CPU/256 GB memory)

**Setting suggestions:** The content of the WAL buffers is written to disks at every transaction commit, so extremely large values are unlikely to provide a significant increase in system performance. However, setting this parameter to hundreds of megabytes can improve the disk write performance on a server to which a large number of transactions are committed at the same time. The default value meets user requirements in most cases.

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## wal_writer_delay

**Parameter description**: Specifies the delay between activity rounds for the WAL writer.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

A longer delay might lead to insufficient WAL buffer and a shorter delay leads to continuously writing of the WALs, thereby increasing the load of disk I/O.

**Value range**: an integer ranging from 1 to 10000. The unit is millisecond.

**Default value**: **200 ms**

## commit_delay

**Parameter description**: Specifies the duration for committed data to be stored in the WAL buffer.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- When this parameter is set to a non-zero value, the committed transaction is stored in the WAL buffer instead of being written to the WAL immediately. Then the WAL writer process flushes the buffer out to disks periodically.
- If system load is high, other transactions are probably ready to be committed within the delay. If no other transactions are ready to be committed, the delay is a waste of time.

**Value range**: an integer ranging from 0 to 100000. The unit is μs. **0** indicates no delay.

**Default value**: **0**

## commit_siblings

**Parameter description**: Specifies a threshold on the number of concurrent open transactions. If the number of concurrent open transactions is greater than the value of this parameter, a transaction that initiates a commit request will wait for a period of time specified by **commit_delay**. Otherwise, this transaction is written into WALs immediately.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 1000

**Default value**: **5**

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## wal_block_size

**Parameter description**: Specifies the size of a WAL disk block.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: an integer. The unit is byte.

**Default value**: **8192**

## wal_segment_size

**Parameter description**: Specifies the size of a WAL segment file.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: an integer. The unit is 8 KB.

**Default value**: **16 MB** (2048 x 8 KB)

## force_promote

**Parameter description**: Specifies whether to enable the forcible switchover function on the standby node.

When a cluster is faulty, the forcible switchover enables the cluster to recover services as soon as possible at the cost of losing some data. This is an escape method used when the cluster is unavailable. You are not advised to trigger this method frequently. You are not advised not to use this function if you are not clear about the impact of data loss on services.

To use this function, you need to enable it on the DN and CM Server and restart the cluster for the setting to take effect. For details about how to enable the forcible switchover function on the standby node, see "Emergency Handling > Performing a Forcible Primary/Standby Switchover" in *Troubleshooting*.

**Value range**: an integer. The value can be **0** (disabled) or **1** (enabled).

**Default value**: **0**

## wal_file_init_num

**Parameter description**: Specifies the number of Xlog segment files created by the WAL writer assistant thread at a time.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 1000000

**Default value**: **10**

## wal_debug

**Parameter description**: Specifies whether to output WAL-related debugging information. This parameter is available only when **WAL_DEBUG** is enabled during compilation.

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This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** Boolean

**Default value**: **false**

## walwriter_cpu_bind

**Parameter description**: Sets the number of CPU cores bound to the WAL writer thread.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from –1 to 2147483647

**Default value**: **–1**

## walwriter_sleep_threshold

**Parameter description**: Specifies the number of times that the idle Xlog is refreshed before the Xlog refresher enters sleep.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 50000

**Default value**: **500**

## wal_flush_timeout

**Parameter description**: Specifies the timeout interval for traversing **WalInsertStatusEntryTbl**. It is the maximum wait time for the adaptive Xlog disk flushing I/O to traverse **WalInsertStatusEntryTbl**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**NOTICE**

If the timeout interval is too long, the Xlog flushing frequency may decrease, reducing the Xlog processing performance.

**Value range**: an integer ranging from 0 to 90000000 (μs)

**Default value**: **2**

## wal_flush_delay

**Parameter description**: Specifies the wait interval when an entry in the **WAL_NOT_COPIED** state is encountered during **WalInsertStatusEntryTbl** traversal.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 90000000 (μs)

**Default value**: **1**

## 19.6.2 Checkpoints

### checkpoint_segments

**Parameter description**: Specifies the minimum number of WAL segment files in the period specified by **checkpoint_timeout**. The size of each log file is 16 MB.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483646

Increasing the value of this parameter speeds up the export of a large amount of data. Set this parameter based on **checkpoint_timeout** and **shared_buffers**. This parameter affects the number of WAL segment files that can be reused. Generally, the maximum number of reused files in the **pg_xlog** folder is twice the number of **checkpoint_segments**. The reused files are not deleted and are renamed to the WAL segment files which will be later used.

**Default value**: **1024**

### checkpoint_timeout

**Parameter description**: Specifies the maximum time between automatic WAL checkpoints.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from 30 to 3600. The unit is s.

If the value of **checkpoint_segments** is increased, you need to increase the value of this parameter. The increase of these two parameters further requires the increase of **shared_buffers**. Consider all these parameters during setting.

**Default value**: **15min**

### checkpoint_completion_target

**Parameter description:** Specifies the target of checkpoint completion.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** a double-precision floating point number ranging from 0.0 to 1.0

**Default value**: **0.5**

NOTE

**0.5** indicates that each checkpoint should be complete within 50% of the interval between checkpoints.

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## checkpoint_warning

**Parameter description**: Specifies a time in seconds. If the checkpoint interval is close to this time due to filling of checkpoint segment files, a message is sent to the server log to suggest an increase in the **checkpoint_segments** value.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is s. **0** indicates that the warning is disabled.

**Default value**: **5min**

**Recommended value**: **5min**

## checkpoint_wait_timeout

**Parameter description**: Sets the longest time that the checkpoint waits for the checkpointer thread to start.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 2 to 3600. The unit is s.

**Default value**: **1min**

## enable_incremental_checkpoint

**Parameter description**: Specifies whether to enable incremental checkpoint.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**Default value**: **on**

## enable_double_write

**Parameter description**: Specifies whether to enable the doublewrite buffer. When the incremental checkpoint is enabled, the doublewrite buffer instead of **full_page_writes** is used to prevent partial page writes.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**Default value**: **on**

## incremental_checkpoint_timeout

**Parameter description**: Specifies the maximum interval between automatic WAL checkpoints when the incremental checkpoint is enabled.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range:** an integer ranging from 1 to 3600. The unit is second.

**Default value**: **1min**

## enable_xlog_prune

**Parameter description**: Specifies whether the primary node reclaims logs if the size of Xlogs exceeds the value of **max_size_for_xlog_prune** when any standby node is disconnected.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- If this parameter is set to **on**, the primary node reclaims logs when any standby node is disconnected.
- If this parameter is set to **off**, the primary node does not reclaim logs when any standby node is disconnected.

**Default value**: **on**

## max_size_for_xlog_prune

**Parameter description**: This parameter takes effect when **enable_xlog_prune** is enabled. The working mechanism is as follows:

1. If all standby nodes specified by the **replconninfo** series GUC parameters are connected to the primary node, this parameter does not take effect.
2. If any standby node specified by the **replconninfo** series GUC parameters is not connected to the primary node, this parameter takes effect. When the number of historical logs on the primary node is greater than the value of this parameter, the logs are forcibly recycled. Exception: In synchronous commit mode (that is, the value of **synchronous_commit** is not **local** or **off**), if there are connected standby nodes, the primary node retains the logs that meet the minimum log receiving requirements on the majority of standby nodes. In this case, the number of reserved logs may exceed the value of **max_size_for_xlog_prune**.
3. If any standby node is being built, this parameter does not take effect. All logs of the primary node are retained to prevent build failures due to log recycling.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from 0 to 2147483647. The unit is KB.

**Default value**: **256GB**

## max_redo_log_size

**Parameter description:** On standby DNs, this specifies the maximum size of logs between the latest checkpoint and the current log playback location. On the primary DN, this specifies the maximum size of logs between the recovery point and the latest log location. You are advised not to set this parameter to a large value if the RTO is concerned.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from 163840 to 2147483647. The unit is KB.

**Default value**: **1048576**. The unit is KB.

## 19.6.3 Log Replay

### recovery_time_target

**Parameter description**: Specifies the time for a standby server to write and replay logs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3600. The unit is s.

**0** indicates that log flow control is disabled. A value from **1** to **3600** indicates that a standby server can write and replay logs within the period specified by the value, so that the standby server can quickly assume the primary role. If this parameter is set to a small value, the performance of the primary server is affected. If it is set to a large value, the log flow is not effectively controlled.

**Default value**: **60**

### recovery_max_workers

**Parameter description**: Specifies the maximum number of concurrent replay threads.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 20

**Default value**: **4**

### recovery_parallelism

**Parameter description**: Specifies the actual number of replay threads. This parameter is read-only.

This parameter is a POSTMASTER parameter and is affected by recovery_max_workers and recovery_parse_workers. If any value is greater than 0, recover_parallelism will be recalculated.

**Value range**: an integer ranging from 1 to 2147483647

**Default value**: **1**

### recovery_parse_workers

**Parameter description**: Specifies the number of **ParseRedoRecord** threads for the extreme RTO feature.

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This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 16

This parameter can be set to a value greater than 1 only when the extreme RTO feature is enabled. In addition, it must be used together with **recovery_redo_workers**. If both **recovery_parse_workers** and **recovery_max_workers** are enabled, the setting of **recovery_parse_workers** prevails and the concurrent replay function is disabled. The ultimate RTO does not support primary/standby/secondary mode. The value of **recovery_parse_workers** can be greater than 1 only when **replication_type** is set to **1**. In addition, when ultimate RTO is enabled, ensure that the value of **wal_receiver_buffer_size** is greater than or equal to 32 MB (64 MB is recommended). This feature does not support column-store tables, either. Therefore, disable this feature in a system where column-store tables are used or are to be used.

**Default value**: **1**

NOTE

- After V500R001C00 is upgraded to V500R001C10 or a later version, you are advised to set this parameter to **2** and restart the DN.
- After ultimate RTO is enabled, the standby node will start more worker threads whose value is equal to the value of **recovery_parse_workers** x (the value of **recovery_redo_workers** + 2) + 5, occupying more CPU, memory, and I/O resources. In hybrid deployment scenarios, host performance may be affected.
- In this version and later, the ultimate RTO does not have flow control. Flow control is controlled by the **recovery_time_target** parameter.

## recovery_redo_workers

**Parameter description**: Specifies the number of **PageRedoWorker** threads corresponding to each **ParseRedoRecord** thread when the ultimate RTO feature is enabled.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 8

This parameter must be used together with **recovery_parse_workers**, and it takes effect only when **recovery_parse_workers** is set to a value greater than 1.

**Default value**: **1**

NOTE

After V500R001C00 is upgraded to V500R001C10 or a later version, you are advised to set parameters based on the number of CPUs in the environment and restart the DN. If the number of CPUs is less than 16, you are advised to set this parameter to **2**. If the number is greater than 16 and less than 32, you are advised to set this parameter to **4**. If the number is greater than 32, you are advised to set this parameter to **8**.

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### enable_page_lsn_check

**Parameter description**: Specifies whether to enable the data page LSN check. During replay, the current LSN of the data page is checked to see if it is the expected one.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**Default value**: **on**

### redo_bind_cpu_attr

**Parameter description**: Specifies the core binding operation of the replay thread. Only the **sysadmin** user can access this parameter. This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, consisting of one or more characters

The available configuration modes are as follows: 1. **'nobind'**: The thread is not bound to a core. 2. **'nodebind: 1, 2'**: Use the CPU cores in NUMA groups 1 and 2 to bind threads. 3. **'cpubind: 0-30'**: Use the CPU cores 0 to 30 to bind threads. The value of this parameter is case-insensitive.

**Default value**: **'nobind'**

NOTE

This parameter is used for core binding in the ARM environment. You are advised to bind all replay threads to the same NUMA group for better performance. In hybrid deployment scenarios, you are advised to bind the replay threads of different nodes on the same host to different NUMA groups.

## 19.6.4 Archiving

### archive_mode

**Parameter description**: Specifies whether to archive WALs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

When **wal_level** is set to **minimal**, the **archive_mode** parameter is unavailable.

**Value range**: Boolean

- **on** indicates that the archiving is enabled.
- **off** indicates that the archiving is disabled.

**Default value**: **off**

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## archive_command

**Parameter description:** Specifies the command set by the administrator to archive WALs. You are advised to set the archive log path to an absolute path.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If both **archive_dest** and **archive_command** are configured, WALs are preferentially saved to the directory specified by **archive_dest**. The command configured by **archive_command** does not take effect.
- Any **%p** in the string is replaced by the absolute path of the file to archive, and any **%f** is replaced by only the file name. (The relative path is relative to the data directory.) Use **%%** to embed an actual **%** character in the command.
- This command returns zero only if it succeeds. The command example is as follows:
  ```
  archive_command = 'cp --remove-destination %p /mnt/server/archivedir/%f'
  ```
- **--remove-destination** indicates that files will be overwritten during the archiving.
- If there are multiple archive commands, write them to the shell script file and set **archive_command** to the command for executing the script. Example:
  ```
  -- Assume that multiple commands are as follows:
  test ! -f dir/%f && cp %p dir/%f
  -- The content of the test.sh script is as follows:
  test ! -f dir/$2 && cp $1 dir/$2
  -- The archive command is as follows:
  archive_command='sh dir/test.sh %p %f'
  ```

**Value range**: a string

**Default value: (disabled)**

## archive_dest

**Parameter description:** Specifies the path set by the administrator to archive WALs. You are advised to set the archive log path to an absolute path.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If both **archive_dest** and **archive_command** are configured, WALs are preferentially saved to the directory specified by **archive_dest**. The command configured by **archive_command** does not take effect.
- If the string is a relative path, it is relative to the data directory. Example:
  ```
  archive_dest = '/mnt/server/archivedir/'
  ```

**Value range**: a string

**Default value**: empty

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## archive_timeout

**Parameter description**: Specifies the archiving period.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- The server is forced to switch to a new WAL segment file when the period specified by this parameter has elapsed since the last file switch.
- Archived files that are closed early due to a forced switch are still of the same length as full files. Therefore, a very short **archive_timeout** will bloat the archive storage. You are advised to set **archive_timeout** to **60s**.

**Value range**: an integer ranging from 0 to 1073741823. The unit is second. The value **0** indicates that the function is disabled.

**Default value**: **0**

## archive_interval

**Parameter description**: Specifies the archiving interval.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- Log files are forcibly archived when the period specified by this parameter has elapsed.
- Archiving involves I/O operations. Therefore, frequent archiving is not allowed. In addition, the RPO cannot be set to a large value; otherwise, the PITR will be affected. You are advised to use the default value.

**Value range**: an integer ranging from 1 to 1000. The unit is second.

**Default value**: **1**

## time_to_target_rpo

**Parameter description**: Specifies the maximum *time_to_target_rpo* seconds from the time when an exception occurs on the primary cluster to the time when data is archived to the OBS recovery point in dual-cluster remote DR mode.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3600. The unit is s.

In dual-cluster remote DR mode, logs of the primary cluster are archived to OBS. **0** indicates that log flow control is disabled. 1 to 3600 indicates the maximum

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*time_to_target_rpo* seconds from the time when an exception occurs on the primary cluster to the time when data is archived to the recovery point of OBS. This ensures that the maximum duration of data loss is within the allowed range when the primary cluster breaks down due to a disaster. If this parameter is set to a small value, the performance of the primary server is affected. If it is set to a large value, the log flow is not effectively controlled.

**Default value**: **10**

# 19.7 HA Replication

## 19.7.1 Sending Server

### max_wal_senders

**Parameter description**: Specifies the maximum number of simultaneously running WAL sender processes. The value cannot be greater than or equal to that of **max_connections**.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

**wal_level** must be set to **archive**, **hot_standby**, or **logical** to allow the connection from standby servers.

**Value range:** an integer ranging from 0 to 1024. The recommended value range is 8 to 100.

NOTE

This parameter can be set to 0 only when a single DN is used and there is no primary/standby instance.

**Default value:**

**Setting suggestions**: Each log replication connection between a standby server and a primary server occupies a WAL sender thread. Therefore, the value of this parameter must be greater than or equal to the number of DNs. Otherwise, the standby server cannot connect to the primary server. When logical replication is required, each log extraction thread occupies one WAL sender thread. If logical replication is required, set **max_wal_senders** to a value greater than the number of threads required by standby servers and logical replication extraction threads.

### wal_keep_segments

**Parameter description**: Specifies the minimum number of transaction log files that can be retained in the **pg_xlog** directory. The standby node obtains the logs from the primary node to perform streaming replication.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 2 to *INT_MAX*

**Default value**: **128**

**Setting suggestions**:

- During WAL archiving or recovery from a checkpoint on the server, the system may retain more log files than the number specified by **wal_keep_segments**.
- If this parameter is set to an excessively small value, a transaction log may have been overwritten by a new transaction before requested by the standby server. As a result, the request fails and the connection between the primary and standby servers is terminated.
- If the HA system uses asynchronous transmission, increase the value of **wal_keep_segments** when data greater than 4 GB is continuously imported in COPY mode. Take T6000 board as an example. If the data to be imported reaches 50 GB, you are advised to set this parameter to **1000**. You can dynamically restore the setting of this parameter after data import is complete and the WAL synchronization is proper.

## wal_sender_timeout

**Parameter description**: Specifies the maximum duration that the sending server waits for the WAL receiving in the receiver.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

NOTICE

- If the data volume on the primary node is huge, the value of this parameter must be increased for rebuilding. For example, if the data volume on the primary node reaches 500 GB, you are advised to set this parameter to 600 seconds.
- This parameter cannot be set to a value larger than the value of **wal_receiver_timeout** or the timeout parameter for database rebuilding.

**Value range**: an integer ranging from 0 to 2147483647. The unit is ms.

**Default value**: **6s**

## max_replication_slots

**Parameter description**: Specifies the number of log replication slots in the primary server.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in Table 11-1.

**Value range:** an integer ranging from 0 to 1024. The recommended value range is 8 to 100.

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**Default value**: **20**

**Setting suggestions**:

NOTICE

When primary/standby replication, and backup and restoration are used, you are advised to set this parameter to: Number of current physical replication slots + Number of backup slots + Number of required logical replication slots.

If the actual value is smaller than the recommended value, these functions may be unavailable or abnormal.

Physical replication slots provide an automatic method to ensure that Xlog files are not removed from a primary DN before they are received by all the standby DNs, allowing high availability for the cluster. The number of physical replication slots required by the cluster is as follows: ratio of the number of standby DNs to the number of primary DNs in a group of DNs. For example, if the HA cluster has one primary DN and one standby DN, the number of physical replication slots required is 2. If the HA cluster has 1 primary DN and 3 standby DNs, the number of physical replication slots required is 3.

Backup slot records replication information during backup execution. Full backup and incremental backup correspond to two independent backup slots.

Plan the number of logical replication slots as follows:

- A logical replication slot can carry changes of only one database for decoding. If multiple databases are involved, create multiple logical replication slots.
- If logical replication is needed by multiple target databases, create multiple logical replication slots in the source database. Each logical replication slot corresponds to one logical replication link.

## max_keep_log_seg

**Parameter description**: Stream control parameter. In logical replication, physical logs are parsed and converted into logical logs locally on the DN. When the number of physical log files that are not parsed is greater than the value of this parameter, stream control is triggered. The value **0** indicates that the stream control function is disabled.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **0**

## enable_wal_shipping_compression

**Parameter description**: Specifies whether to enable cross-cluster log compression in streaming DR mode.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

- This parameter applies only to a pair of WAL senders and WAL receivers for cross-cluster transmission in streaming DR and is configured in the primary cluster.

**Value range**: Boolean

- **true** indicates that cross-cluster log compression is enabled in streaming DR mode.
- **false** indicates that cross-cluster log compression is disabled in streaming DR mode.

**Default value**: **false**

## repl_auth_mode

**Parameter description:** Specifies the validation mode for the primary/standby replication and standby node rebuilding.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If UUID validation is enabled on the primary node and a non-null repl_uuid validation code is configured, UUID validation must also be enabled on the standby node and the same repl_uuid validation code must be configured on the standby node. Otherwise, requests for log replication between the primary and standby nodes and standby node rebuilding will be rejected by the primary node.
- The SIGHUP parameter can dynamically load new values. The modification does not affect the established primary/standby connection and takes effect for subsequent primary/standby replication requests and primary/standby rebuilding requests.
- It supports the standby node rebuild validation under the Quorum and DCF protocols and the primary/standby replication validation under the Quorum protocol. It does not support primary/standby replication validation under the DCF protocol.
- It does not support the authentication between the primary and standby nodes across clusters, including the primary/standby Dorado and DR clusters.
- The UUID validation function is used to prevent data crosstalk and pollution caused by incorrect connection between the primary and standby nodes. It is not used for security purposes.
- This parameter cannot be automatically synchronized between the primary and standby nodes.

**Value range**: enumerated values

- **off**: indicates that UUID validation is disabled.

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- **default**: indicates that UUID validation is disabled.
- **uuid**: indicates that UUID validation is enabled.

**Default value**: **default**

## repl_uuid

**Parameter description:** Specifies the UUID used for primary/standby UUID validation.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If UUID validation is enabled on the primary node and a non-null repl_uuid validation code is configured, UUID validation must also be enabled on the standby node and the same repl_uuid validation code must be configured on the standby node. Otherwise, requests for log replication between the primary and standby nodes and standby node rebuilding will be rejected by the primary node.
- The SIGHUP parameter can dynamically load new values. The modification does not affect the established primary/standby connection and takes effect for subsequent primary/standby replication requests and primary/standby rebuilding requests.
- It supports the standby node rebuild validation under the Quorum and DCF protocols and the primary/standby replication validation under the Quorum protocol. It does not support primary/standby replication validation under the DCF protocol.
- It does not support the authentication between the primary and standby nodes across clusters, including the primary/standby Dorado and DR clusters.
- The UUID validation function is used to prevent data crosstalk and pollution caused by incorrect connection between the primary and standby nodes. It is not used for security purposes.
- This parameter cannot be automatically synchronized between the primary and standby nodes.

**Value range**: a string of 0 to 63 case-insensitive letters and digits. It is converted to lowercase letters for storage. An empty string indicates that UUID validation is disabled.

**Default value**: empty

## replconninfo1

**Parameter description**: Specifies the information about the first node to be listened on and authenticated by the current server. This parameter is automatically configured after the cluster is successfully installed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: a string. An empty string indicates that no information about the first node is configured.

**Default value**: the first connection information listened on by the DN.

**Example:**

```
replconninfo1 = 'localhost=127.0.0.1 localport=XXXX localheartbeatport=XXXX localservice=XXXX
remotehost=127.0.0.1 remoteport=XXXX remoteheartbeatport=XXXX remoteservice=XXXX'
```

## replconninfo2

**Parameter description**: Specifies the information about the second node to be listened on and authenticated by the current server. This parameter is automatically configured after the cluster is successfully installed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. An empty string indicates that no information about the second node is configured.

**Default value**: information about the second connection listened to by the DN.

**Example:**

```
replconninfo2 = 'localhost=127.0.0.1 localport=XXXX localheartbeatport=XXXX localservice=XXXX
remotehost=127.0.0.1 remoteport=XXXX remoteheartbeatport=XXXX remoteservice=XXXX'
```

## replconninfo3

**Parameter description**: Specifies the information about the third node to be listened on and authenticated by the current server. This parameter is automatically configured after the cluster is successfully installed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. An empty string indicates that no information about the third node is configured.

**Default value**: information about the third connection listened to by the DN.

**Example:**

```
replconninfo3 = 'localhost=127.0.0.1 localport=XXXX localheartbeatport=XXXX localservice=XXXX
remotehost=127.0.0.1 remoteport=XXXX remoteheartbeatport=XXXX remoteservice=XXXX'
```

## replconninfo4

**Parameter description**: Specifies the information about the fourth node to be listened on and authenticated by the current server. This parameter is automatically configured after the cluster is successfully installed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. An empty string indicates that no information about the fourth node is configured.

**Default value**: information about the fourth connection listened to by the DN.

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**Example:**

```
replconninfo4 = 'localhost=127.0.0.1 localport=XXXX localheartbeatport=XXXX localservice=XXXX
remotehost=127.0.0.1 remoteport=XXXX remoteheartbeatport=XXXX remoteservice=XXXX'
```

## replconninfo5

**Parameter description**: Specifies the information about the fifth node to be listened on and authenticated by the current server. This parameter is automatically configured after the cluster is successfully installed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string An empty string indicates that no information about the fifth node is configured.

**Default value**: information about the fifth connection listened to by the DN.

**Example:**

```
replconninfo5 = 'localhost=127.0.0.1 localport=XXXX localheartbeatport=XXXX localservice=XXXX
remotehost=127.0.0.1 remoteport=XXXX remoteheartbeatport=XXXX remoteservice=XXXX'
```

## replconninfo6

**Parameter description**: Specifies the information about the sixth node to be listened on and authenticated by the current server. This parameter is automatically configured after the cluster is successfully installed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. An empty string indicates that no information about the sixth node is configured.

**Default value**: information about the sixth connection listened to by the DN.

**Example:**

```
replconninfo6 = 'localhost=127.0.0.1 localport=XXXX localheartbeatport=XXXX localservice=XXXX
remotehost=127.0.0.1 remoteport=XXXX remoteheartbeatport=XXXX remoteservice=XXXX'
```

## replconninfo7

**Parameter description**: Specifies the information about the seventh node to be listened on and authenticated by the current server. This parameter is automatically configured after the cluster is successfully installed.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. An empty string indicates that no information about the seventh node is configured.

**Default value**: information about the seventh connection listened to by the DN.

**Example:**

```
replconninfo7 = 'localhost=127.0.0.1 localport=XXXX localheartbeatport=XXXX localservice=XXXX
remotehost=127.0.0.1 remoteport=XXXX remoteheartbeatport=XXXX remoteservice=XXXX'
```

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# 19.7.2 Primary Server

## synchronous_standby_names

**Parameter description**: Specifies a comma-separated list of names of potential standby servers that support synchronous replication.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**NOTICE**

- The current synchronous standby server is on the top of the list. If the current synchronous standby server is disconnected, it will be replaced immediately with the next-highest-priority standby server. Name of the next-highest-priority standby server is added to the list.
- The standby server name can be specified by setting the environment variable **PGAPPNAME**.

**Value range**: a string. If this parameter is set to *****, the name of any standby server that provides synchronous replication is matched. The value can be configured in the following format:

- ANY *num_sync* (*standby_name* [, ...])
- [FIRST] *num_sync* (*standby_name* [, ...])
- *standby_name* [, ...]

  **NOTE**

  - In the preceding command, *num_sync* indicates the number of standby nodes that need to wait for responses from the transaction, *standby_name* indicates the name of the standby node, and FIRST and ANY specify the policies for selecting standby nodes for synchronous replication from the listed servers.
  - **ANY N (dn_instanceId1, dn_instanceId2,...)** indicates that any *N* host names in the brackets are selected as the name list of standby nodes for synchronous replication. For example, **ANY 1(dn_instanceId1, dn_instanceId2)** indicates that any one of **dn_instanceId1** and **dn_instanceId2** is used as the standby node for synchronous replication.
  - **FIRST N (dn_instanceId1, dn_instanceId2, ...)** indicates that the first N primary node names in the brackets are selected as the standby node name list for synchronous replication based on the priority. For example, **FIRST 1 (dn_instanceId1, dn_instanceId2)** indicates that **dn_instanceId1** is selected as the standby node for synchronous replication.
  - The meanings of **dn_instanceId1, dn_instanceId2, ...** are the same as those of **FIRST 1 (dn_instanceId1, dn_instanceId2, ...)**.

If you use the gs_guc tool to set this parameter, perform the following operations:

```
gs_guc reload -Z datanode -N @NODE_NAME@ -D @DN_PATH@ -c "synchronous_standby_names='ANY NODE 1(dn_instanceId1, dn_instanceId2)'";
```

or

```
gs_guc reload -Z datanode -N @NODE_NAME@ -D @DN_PATH@ -c "synchronous_standby_names='ANY 1(AZ1, AZ2)'";
```

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**Default value**: *

## most_available_sync

**Parameter description**: Specifies whether to block the primary server when the primary-standby synchronization fails.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the primary server is not blocked when the synchronization fails.
- **off** indicates that the primary server is blocked when the synchronization fails.

**Default value**: **off**

## enable_stream_replication

**Parameter description**: Specifies whether data and logs are synchronized between primary and standby servers, and between primary and secondary servers.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

NOTICE

- This parameter is used for performance testing in scenarios where data synchronization to DN standby servers is enabled and where it is disabled. If this parameter is set to **off**, tests on abnormal scenarios, such as switchover and faults, cannot be performed to prevent inconsistency between the primary, standby, and secondary servers.
- This parameter is a restricted parameter, and you are advised not to set it to **off** in normal service scenarios.

**Value range**: Boolean

- **on** indicates that data and log synchronization is enabled.
- **off** indicates that data and log synchronization is disabled.

**Default value**: **on**

## enable_mix_replication

**Parameter description**: Specifies how WAL files and data are replicated between primary and standby servers, and between primary and secondary servers.

This parameter is an INTERNAL parameter. Its default value is **off** and cannot be modified.

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NOTICE

This parameter cannot be modified in normal service scenarios. That is, the WAL file and data page mixed replication mode is disabled by default.

**Value range**: Boolean

- **on** indicates that the WAL file and data page mixed replication mode is enabled.
- **off** indicates that the WAL file and data page mixed replication mode is disabled.

**Default value**: **off**

## vacuum_defer_cleanup_age

**Parameter description**: Specifies the number of transactions by which **VACUUM** will defer the cleanup of invalid row-store table records, so that **VACUUM** and **VACUUM FULL** do not clean up deleted tuples immediately.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 1000000. **0** means no delay.

**Default value**: **0**

## data_replicate_buffer_size

**Parameter description**: Specifies the amount of memory used by queues when the sender sends data pages to the receiver. The value of this parameter affects the buffer size used during the replication from the primary server to the standby server.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 4096 to 1072693248. The unit is KB.

**Default value**: **128 MB** (131072 KB)

## walsender_max_send_size

**Parameter description**: Specifies the size of the WAL or Sender buffers on the primary server.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 8 to 1048575. The unit is KB.

**Default value**: **8 MB** (8192 KB)

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## enable_data_replicate

**Parameter description**: Specifies how data is synchronized between primary and standby servers when the data is imported to a row-store table.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the primary and standby servers synchronize data using data pages when the data is imported to a row-store table. When **replication_type** is set to **1**, this parameter cannot be set to **on**. If this parameter is set to **on** using the GUC tool, its value will be forcibly changed to **off**.
- **off** indicates that the primary and standby servers synchronize data using Xlogs when the data is imported to a row-store table.

**Default value**: **off**

## ha_module_debug

**Parameter description**: Specifies the replication status log of a specific data block during data replication.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the status of each data block is recorded in logs during data replication.
- **off** indicates that the status of each data block is not recorded in logs during data replication.

**Default value**: **off**

## enable_incremental_catchup

**Parameter description**: Specifies the data catchup mode between the primary and standby servers.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the standby server uses the incremental catchup mode. That is, the standby server scans local data files on the standby server to obtain the list of differential data files between the primary and standby servers and then performs catchup between the primary and standby servers.
- **off** indicates that the standby server uses the full catchup mode. That is, the standby server scans all local data files on the primary server to obtain the list of differential data files between the primary and standby servers and then performs catchup between the primary and standby servers.

**Default value**: **on**

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## wait_dummy_time

**Parameter description**: Specifies the maximum duration for the primary server to wait for the standby and secondary servers to start and send the scanning lists when incremental data catchup is enabled in cluster.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483647. The unit is second.

**Default value**: **300**

NOTE

The unit can only be second.

## catchup2normal_wait_time

**Parameter description**: Specifies the maximum duration that the primary server is blocked during the data catchup on the standby server in the case of a single synchronous standby server.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 10000. The unit is ms.

- The value **–1** indicates that the primary server is blocked until the data catchup on the standby server is complete.
- The value **0** indicates that the primary server is not blocked during the data catchup on the standby server.
- Other values indicate the maximum duration that the primary server is blocked during the data catchup on the standby server. For example, if this parameter is set to **5000**, the primary server is blocked until the data catchup on the standby server is complete in 5s.

**Default value**: **–1**

## hadr_recovery_time_target

**Parameter description**: Specifies whether the standby database instance completes log writing and replay in streaming DR mode.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3600. The unit is second.

**0** indicates that log flow control is disabled. A value from 1 to 3600 indicates that a standby node can write and replay logs within the period specified by **hadr_recovery_time_target**. This ensures that the logs can be written and replayed within the period specified by **hadr_recovery_time_target** and the standby database instance can be promoted to primary quickly. If this parameter is set to a small value, the performance of the primary node is affected. If it is set to a large value, the log flow is not effectively controlled.

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**Default value: 60** (financial edition (data computing))

## hadr_recovery_point_target

**Parameter description**: Specifies the RPO time allowed for the standby database instance to flush logs to disks in streaming DR mode.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3600. The unit is second.

**0** indicates that log flow control is disabled. A value from 1 to 3600 indicates that the standby node can flush logs to disks within the period specified by **hadr_recovery_point_target**. This ensures that the log difference between the primary and standby database instances is controlled within the period specified by **hadr_recovery_point_target** during the switchover and the standby database instance can be promoted to primary. If this parameter is set to a small value, the performance of the primary node is affected. If it is set to a large value, the log flow is not effectively controlled.

**Default value: 10** (financial edition (data computing))

## hadr_super_user_record_path

**Parameter description**: Specifies the path for storing encrypted files of the **hadr_disaster** user in the standby cluster in streaming DR mode. This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Modification suggestion**: The value is automatically set by the streaming DR password transfer tool and does not need to be manually added.

**Value range**: a string

**Default value**: **NULL**

## check_sync_standby

**Parameter description:** Specifies whether to enable the standby node check function. After the **synchronous_standby_names** parameter is correctly configured in the primary/standby scenario, if the synchronous standby node is faulty, the write service on the primary node reports a write failure. This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range: on** or **off**

- **on** indicates that the standby node check is enabled.
- **off** indicates that the standby node check is disabled.

**Default value**: **off**

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NOTE

- This parameter cannot be synchronized in job work and autonomous transactions. Otherwise, the check may not take effect.
- If the standby node check is not configured for a specified user or session and the standby node is faulty when the forcible synchronization commission mode is enabled, the write operation on a table causes the query of the same table in another user or session to hang. In this case, you need to recover the standby node or manually terminate the hung client.
- The standby node check function cannot be enabled in scenarios (such as VACUUM ANALYZE and gs_clean) where non-write operations trigger log writing. If the standby node does not meet the requirements for synchronizing configurations to the standby node, services will be hung in this scenario. In this case, you need to manually terminate the services.

## 19.7.3 Standby Server

### hot_standby

**Parameter description**: Specifies whether the standby server is allowed to accept connections and queries after it is restored to the minrecovery point.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If this parameter is set to **on**, **wal_level** must be set to **hot_standby** or higher. Otherwise, the database startup fails.
- In a distributed system, **hot_standby** cannot be set to **off**, because this setting can affect other features of the HA system.
- If the **hot_standby** parameter was disabled and the **wal_level** parameter was set to a value smaller than the value of **hot_standby**, perform the following operations to ensure that the logs to be replayed on the standby node can be queried on the standby node before enabling the **hot_standby** parameter again:
  1. Change the value of **wal_level** of the primary and standby nodes to the value of **hot_standby** or a higher value, and restart the instances for the change to take effect.
  2. Perform the checkpoint operation on the primary node and query the **pg_stat_get_wal_senders()** function to ensure that the value of **receiver_replay_location** of each standby node is the same as that of **sender_flush_location** of the primary node. Ensure that the value adjustment of **wal_level** is synchronized to the standby nodes and takes effect, and the standby nodes do not need to replay low-level logs.
  3. Set the **hot_standby** parameter of the primary and standby nodes to **on**, and restart the instances for the setting to take effect.

**Value range**: Boolean

- **on**: allowed.

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- **off**: not allowed.

**Default value**: **on**

## max_standby_archive_delay

**Parameter description**: Specifies the wait period before queries on a standby server are canceled when the queries conflict with WAL processing and archiving in hot standby mode.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

**–1** indicates that the standby server waits until the conflicting queries are complete.

**Value range**: an integer ranging from –1 to 2147483647. The unit is ms.

**Default value**: **3s** (3000 ms)

## max_standby_streaming_delay

**Parameter description**: Specifies the wait period before queries on a standby server are canceled when the queries conflict with WAL data receiving through streaming replication in hot standby mode.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

**–1** indicates that the standby server waits until the conflicting queries are complete.

**Value range**: an integer ranging from –1 to 2147483647. The unit is ms.

**Default value**: **3s** (3000 ms)

## wal_receiver_status_interval

**Parameter description**: Specifies the maximum interval for notifying the primary server of the WAL Receiver status.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

If this parameter is set to **0**, the standby server does not send information, such as the log receiving location, to the primary server. As a result, the transaction commit on the primary server may be blocked, and the switchover may fail. In normal service scenarios, you are advised not to set this parameter to **0**.

**Value range**: an integer ranging from 0 to 2147483. The unit is s.

**Default value**: **5s**

## hot_standby_feedback

**Parameter description**: Specifies whether a standby server is allowed to send the result of a query performed on it to the primary server, preventing a query conflict.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the standby server is allowed to send the result of a query performed on it to the primary server.
- **off** indicates that the standby server is not allowed to send the result of a query performed on it to the primary server.

**Default value**: **off**

## wal_receiver_timeout

**Parameter description:** Specifies the maximum wait period for a standby server to receive data from the primary server.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is ms.

**Default value**: **6s** (6000 ms)

## wal_receiver_connect_timeout

**Parameter description**: Specifies the timeout period for a standby server to connect to the primary server.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483. The unit is s.

**Default value**: **2s**

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### wal_receiver_connect_retries

**Parameter description**: Specifies the maximum attempts that a standby server connects to the primary server

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483647

**Default value**: **1**

### wal_receiver_buffer_size

**Parameter description**: Specifies the memory buffer size for the standby and secondary servers to store the received XLOG files.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 4096 to 1047552. The unit is KB.

**Default value**: **64 MB** (65536 KB)

### primary_slotname

**Parameter description**: Specifies the slot name of the primary server corresponding to a standby server. This parameter is used for the mechanisms to verify the primary-standby relationship and delete WALs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: empty

### enable_redo_atomic_operation

**Parameter description**: Specifies whether to use atomic operations or spinlocks to update the LSN of the current thread when parallel playback is enabled.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that atomic operations are used for update.
- **off** indicates that spinlocks are used for update.

**Default value**: **on**

## 19.8 Query Planning

This section describes the method configuration, cost constants, planning algorithm, and some configuration parameters for the optimizer.

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NOTE

- Two parameters are involved in the optimizer:
  - *INT_MAX* indicates the maximum value of the INT data type. The value is **2147483647**.
  - *DBL_MAX* indicates the maximum value of the FLOAT data type.
- In addition to customer services, global query planning parameters also affect database O&M and monitoring services, such as WDR generation, scale-out, redistribution, and data import and export.

## 19.8.1 Optimizer Method Configuration

These configuration parameters provide a crude method of influencing the query plans chosen by the query optimizer. If the default plan chosen by the optimizer for a particular query is not optimal, a temporary solution is to use one of these configuration parameters to force the optimizer to choose a different plan. Better ways include adjusting the optimizer cost constants, manually running **ANALYZE**, increasing the value of the **default_statistics_target** configuration parameter, and increasing the amount of the statistics collected in specific columns using **ALTER TABLE SET STATISTICS**.

### enable_bitmapscan

**Parameter description**: Controls the query optimizer's use of bitmap-scan plan types.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

### force_bitmapand

**Parameter description**: Controls the query optimizer's use of BitmapAnd plan types.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **off**

### enable_hashagg

**Parameter description**: Controls the query optimizer's use of Hash aggregation plan types.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_hashjoin

**Parameter description**: Controls the query optimizer's use of Hash-join plan types.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_indexscan

**Parameter description**: Controls the query optimizer's use of index-scan plan types.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_indexonlyscan

**Parameter description**: Controls the query optimizer's use of index-only-scan plan types.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

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## enable_material

**Parameter description**: Controls the query optimizer's use of materialization. It is impossible to suppress materialization entirely, but setting this variable to **off** prevents the optimizer from inserting materialized nodes.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_mergejoin

**Parameter description**: Controls the query optimizer's use of merge-join plan types.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **off**

## enable_nestloop

**Parameter description**: Controls the query optimizer's use of nested-loop join plan types to fully scan internal tables. It is impossible to suppress nested-loop joins entirely, but setting this variable to **off** encourages the optimizer to choose other methods if available.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **off**

## enable_index_nestloop

**Parameter description**: Controls the query optimizer's use of the index nested-loop join plan types to scan the parameterized indexes of internal tables.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

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- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_seqscan

**Parameter description**: Controls the query optimizer's use of sequential scan plan types. It is impossible to suppress sequential scans entirely, but setting this variable to **off** encourages the optimizer to choose other methods if available.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_sort

**Parameter description**: Controls the query optimizer's use of sort methods. It is impossible to suppress explicit sorts entirely, but setting this variable to **off** encourages the optimizer to choose other methods if available.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_tidscan

**Parameter description**: Controls the query optimizer's use of Tuple ID (TID) scan plan types.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_kill_query

**Parameter description**: In CASCADE mode, when a user is deleted, all the objects belonging to the user are deleted. This parameter specifies whether the queries of the objects belonging to the user can be unlocked when the user is deleted.

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This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the unlocking is allowed.
- **off** indicates that the unlocking is not allowed.

**Default value**: **off**

## enable_stream_concurrent_update

**Parameter description**: Controls the use of stream in concurrent updates. This parameter is restricted by the **enable_stream_operator** parameter.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the optimizer can generate stream plans for the **UPDATE** statement.
- **off** indicates that the optimizer can generate only non-stream plans for the **UPDATE** statement.

**Default value**: **on**

## enable_stream_operator

**Parameter description:** Controls the query optimizer's use of stream. When this parameter is set to **off**, a large number of logs indicating that the stream plans cannot be pushed down are recorded. If you do not need these logs, you are advised to set **enable_unshipping_log** to **off** when setting **enable_stream_operator** to **off**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**:

- Independent deployment: **off**
- Finance edition (standard): **on**
- Enterprise edition: **on**
- Finance edition (data computing): **on**

## enable_stream_recursive

**Parameter description**: Specifies whether to push **WITH RECURSIVE** join queries to DNs for processing.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: Boolean

- **on** indicates that **WITH RECURSIVE** join queries will be pushed down to DNs.
- **off** indicates that **WITH RECURSIVE** join queries will not be pushed down.

**Default value**: **on**

## max_recursive_times

**Parameter description**: Specifies the maximum number of **WITH RECURSIVE** iterations.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **200**

## enable_vector_engine

**Parameter description**: Controls the query optimizer's use of vectorized executor.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_broadcast

**Parameter description**: Controls the query optimizer's use of broadcast distribution method when it evaluates the cost of stream.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## enable_change_hjcost

**Parameter description**: Specifies whether the optimizer excludes internal table running costs when selecting the Hash Join cost path. If it is set to **on**, tables with a few records and high running costs are more possible to be selected.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

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- **on**: enabled.
- **off**: disabled.

**Default value**: **off**

## best_agg_plan

**Parameter description**: The query optimizer generates three plans for the aggregate operation under the stream:

1. hashagg+gather(redistribute)+hashagg
2. redistribute+hashagg(+gather)
3. hashagg+redistribute+hashagg(+gather)

This parameter is used to control the type of hashagg plans generated by the query optimizer.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3

- **1** indicates that the first plan is forcibly generated.
- **2** indicates that the second plan is forcibly generated if the **group by** column can be redistributed. Otherwise, the first plan is generated.
- **3** indicates that the third plan is forcibly generated if the **group by** column can be redistributed. Otherwise, the first plan is generated.
- **0** indicates that the optimizer chooses an optimal plan based on the estimated costs of the three plans above.

**Default value**: **0**

## agg_redistribute_enhancement

**Parameter description**: When the aggregate operation is performed, which contains multiple **group by** columns and none of the columns is the distribution column, a **group by** column will be selected for redistribution. This parameter specifies the policy of selecting a redistribution column.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the column that can be redistributed and evaluates the most distinct value is selected for redistribution.
- **off** indicates that the first column that can be redistributed is selected for redistribution.

**Default value**: **off**

## enable_absolute_tablespace

**Parameter description**: Controls whether the tablespace can use an absolute path.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that an absolute path can be used.
- **off** indicates that an absolute path cannot be used.

**Default value**: **on**

## enable_valuepartition_pruning

**Parameter description**: Specifies whether the DFS partitioned table is dynamically or statically optimized.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the DFS partitioned table is dynamically or statically optimized.
- **off** indicates that the DFS partitioned table is not dynamically or statically optimized.

**Default value**: **on**

## expected_computing_nodegroup

**Parameter description**: Specifies a computing Node Group or the way to choose such a group. The Node Group mechanism is now for internal use only. You do not need to set it.

During join or aggregation operations, a Node Group can be selected in four modes. In each mode, the specified candidate computing Node Groups are listed for the optimizer to select the most appropriate one for the current operator.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

- **optimal**: The list of candidate computing Node Groups consists of the Node Groups where the operator's operation objects are located and the Node Group that combines all the Node Groups on which the current user has the COMPUTE permission.
- **query**: The list of candidate computing Node Groups consists of the Node Groups where the operator's operation objects are located and the Node Group that combines all the Node Groups where base tables involved in the query are located.
- *Node group name* (when **enable_nodegroup_debug** is set to **off**): The list of candidate computing Node Groups consists of the Node Group where the operator's operation objects are located and the specified Node Group.
- *Node Group name* (when **enable_nodegroup_debug** is set to **on**): A specific Node Group is used as the computing Node Group.

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**Default value**: **query**

## enable_nodegroup_debug

**Parameter description**: Specifies whether the optimizer assigns computing workloads to a specific Node Group when multiple Node Groups exist in an environment. The Node Group mechanism is now for internal use only. You do not need to set it.

This parameter takes effect only when **expected_computing_nodegroup** is set to a specific Node Group.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that computing workloads are assigned to the Node Group specified by **expected_computing_nodegroup**.
- **off** indicates no Node Group is specified to compute.

**Default value**: **off**

## stream_multiple

**Parameter description**: Specifies the weight used by the optimizer to calculate the final cost of stream operators.

The base stream cost is multiplied by this weight to obtain the final cost.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

This parameter is applicable only to Redistribute and Broadcast streams.

**Value range**: a floating point number ranging from 0 to *DBL_MAX*

**Default value**: **1**

## qrw_inlist2join_optmode

**Parameter description**: Specifies whether to enable inlist-to-join (inlist2join) query rewriting.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

- **disable** indicates that the inlist2join query rewriting is disabled.
- **cost_base** indicates that the cost-based inlist2join query rewriting is enabled.
- **rule_base** indicates that the forcible rule-based inlist2join query rewriting is enabled.

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- A positive integer indicates the threshold of inlist2join query rewriting. If the number of elements in the list is greater than the threshold, the rewriting is performed.

**Default value**: **cost_base**

## skew_option

**Parameter description**: Specifies whether an optimization policy is used.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values

- **off** indicates that the policy is disabled.
- **normal** indicates that a radical policy is used. All possible skews are optimized.
- **lazy** indicates that a conservative policy is used. Uncertain skews are ignored.

**Default value**: **normal**

## enable_dngather

**Parameter description**: Specifies whether to calculate stream plans that meet the threshold on a single DN to reduce the number of planned stream nodes.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the function is enabled.
- **off** indicates that the function is disabled.

**Default value**: **off**

## dngather_min_rows

**Parameter description**: Specifies the maximum number of rows that control **dngather**. Values less than or equal to this parameter value can be calculated on a single DN. The prerequisite is that **enable_dngather** is enabled.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from –1 to DBL_MAX

**Default value**: **500.0**

## cost_weight_index

**Parameter description**: Specifies the cost weight of index_scan.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 1e-10 to 1e+10.

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**Default value**: **1**

## default_limit_rows

**Parameter description**: Specifies the default estimated number of limit rows for generating genericplan. If this parameter is set to a positive value, the positive value is used as the estimated number of limit rows. If this parameter is set to a negative value, the negative value is converted to a percentage and used as default estimated value, that is, -5 indicates 5%.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from –100 to DBL_MAX

**Default value**: **–10**

## enforce_a_behavior

**Parameter description**: Controls the rule matching modes of regular expressions.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the A matching rule is used.
- **off** indicates that the POSIX matching rule is used.

**Default value**: **on**

## enable_force_vector_engine

**Parameter description:** Specifies whether to forcibly generate vectorized execution plans for a vectorized execution operator if the operator's child node is a non-vectorized operator. When this parameter is set to **on**, vectorized execution plans are forcibly generated.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that vectorized operators are forcibly generated.
- **off** indicates that the vectorized operator optimizer determines whether to perform vectorization.

**Default value**: **off**

## try_vector_engine_strategy

**Parameter description**: Specifies the policy for processing row-store tables by using the vectorized executor. By setting this parameter, queries containing row-store tables can be converted to vectorized execution plans for calculation, improving the execution performance of complex queries in AP-like scenarios.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values

- **off**: default value, which indicates that this function is disabled. That is, row-store tables will not be converted into vectorized execution plans for execution.
- **force**: Queries are forcibly converted to vectorized execution plans for execution no matter whether the base table to be queried is a row-store table, column-store table, or hybrid row-column store table, unless the query type or expression is not supported by the vectorized executor. In this case, the performance may deteriorate in different query scenarios.
- **optimal**: On the basis of **force**, the optimizer determines whether to convert a query statement into a vectorized execution plan based on the query complexity to avoid performance deterioration after the conversion.

**Default value**: **off**

### check_implicit_conversions

**Parameter description**: Specifies whether to check candidate index paths generated for index columns that have implicit type conversions in a query. For details about the application scenarios of this parameter, see **10.3.10 Checking the Implicit Conversion Performance**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that a check will be performed for candidate index paths generated for index columns that have implicit type conversion in a query.
- **off** indicates that a check will not be performed.

**Default value**: **off**

**NOTICE**

When this parameter is set to **on**, you need to set **enable_fast_query_shipping** to **off** so that the mechanism for identifying implicit data type conversion of index columns can take effect.

## 19.8.2 Optimizer Cost Constants

This section describes the optimizer cost constants. The cost variables described here are measured on an arbitrary scale. Only their relative values matter, therefore scaling them all up or down by the same factor will result in no change in the optimizer's choices. By default, these cost variables are based on the cost of sequential page fetches, that is, **seq_page_cost** is conventionally set to **1.0** and the other cost variables are set with reference to the parameter. However, you can use a different scale, such as actual execution time in milliseconds.

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## seq_page_cost

**Parameter description**: Specifies the optimizer's estimated cost of a disk page fetch that is part of a series of sequential fetches.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0 to *DBL_MAX*

**Default value**: **1**

## random_page_cost

**Parameter description**: Specifies the optimizer's estimated cost of an out-of-sequence disk page fetch.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**NOTICE**

Although the server allows you to set **random_page_cost** to a value less than that of **seq_page_cost**, it is not physically sensitive to do so. However, setting them equal makes sense if the database is entirely cached in RAM, because in that case there is no penalty for fetching pages out of sequence. Also, in a heavily-cached database you should lower both values relative to the CPU parameters, since the cost of fetching a page already in RAM is much smaller than it would normally be.

**Value range**: a floating point number ranging from 0 to *DBL_MAX*

**Default value**: **4**

NOTE

- This value can be overwritten for tables and indexes in a particular tablespace by setting the tablespace parameter of the same name.
- Reducing this value relative to **seq_page_cost** will cause the system to prefer index scans and raising it will make index scans relatively more expensive. You can increase or decrease both values together to change the disk I/O costs relative to CPU costs.

## cpu_tuple_cost

**Parameter description**: Specifies the optimizer's estimated cost of processing each row during a query.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0 to *DBL_MAX*

**Default value**: **0.01**

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## cpu_index_tuple_cost

**Parameter description**: Specifies the optimizer's estimated cost of processing each index entry during an index scan.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0 to *DBL_MAX*

**Default value: 0.005**

## cpu_operator_cost

**Parameter description**: Specifies the optimizer's estimated cost of processing each operator or function executed during a query.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0 to *DBL_MAX*

**Default value**: **0.0025**

## effective_cache_size

**Parameter description**: Specifies the optimizer's assumption about the effective size of the disk cache that is available to a single query.

Set this parameter based on the following factors: the GaussDB's shared buffer space, the kernel's disk buffer space, and the estimated number of concurrent queries on different tables that share the available space.

This parameter does not affect the size of the shared memory allocated during actual GaussDB running. It is used only for estimation in the plan generation phase. The value is in the unit of disk page. Usually the size of each page is 8192 bytes.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483647. The unit is 8 KB.

**Default value**:

Independent deployment:

CN: 2 GB (60-core CPU/480 GB memory); 1 GB (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 512 MB (8-core CPU/64 GB memory); 256 MB (4-core CPU/32 GB memory); 128 MB (4-core CPU/16 GB memory)

DN: 70 GB (60-core CPU/480 GB memory); 38 GB (32-core CPU/256 GB memory); 20 GB (16-core CPU/128 GB memory); 8 GB (8-core CPU/64 GB memory); 4 GB (4-core CPU/32 GB memory); 2 GB (4-core CPU/16 GB memory)

Finance edition (standard):

CN: 1 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB

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memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 512 MB (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 256 MB (8-core CPU/64 GB memory)

DN: 70 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 50 GB (96-core CPU/768 GB memory); 40 GB (80-core CPU/640 GB memory and 72-core CPU/576 GB memory); 35 GB (64-core CPU/512 GB memory); 30 GB (60-core CPU/480 GB memory); 15 GB (32-core CPU/256 GB memory); 8 GB (16-core CPU/128 GB memory); 4 GB (8-core CPU/64 GB memory)

Enterprise edition:

CN: 1 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 512 MB (32-core CPU/256 GB memory and 16-core CPU/128 GB memory); 256 MB (8-core CPU/64 GB memory)

DN: 50 GB (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 38 GB (96-core CPU/768 GB memory); 32 GB (80-core CPU/640 GB memory); 28 GB (72-core CPU/576 GB memory); 25 GB (80-core CPU/512 GB memory and 64-core CPU/512 GB memory); 24 GB (60-core CPU/480 GB memory); 12 GB (32-core CPU/256 GB memory); 5 GB (16-core CPU/128 GB memory); 3 GB (8-core CPU/64 GB memory)

Finance edition (data computing):

CN: 1 GB (96-core CPU/768 GB memory); 512 MB (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 256 MB (32-core CPU/256 GB memory)

DN: 25 GB (96-core CPU/768 GB memory); 20 GB (72-core CPU/576 GB memory); 15 GB (64-core CPU/512 GB memory); 5 GB (32-core CPU/256 GB memory)

Setting suggestions:

A larger value indicates that the optimizer prefers index scanning, and a smaller value indicates that the optimizer prefers full table scanning. Generally, the value is half of the value of **shared_buffers**. More radically, you can set the value to three fourth of the value of **shared_buffers**.

### allocate_mem_cost

**Parameter description**: Specifies the query optimizer's estimated cost of creating a hash table for memory space using hash join. This parameter is used for optimization when the hash join estimation is inaccurate.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0 to *DBL_MAX*

**Default value**: **0**

## 19.8.3 Genetic Query Optimizer

This section describes parameters related to genetic query optimizer. The genetic query optimizer (GEQO) is an algorithm that plans queries by using heuristic

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searching. This algorithm reduces planning time for complex queries and the costs of producing plans are sometimes inferior to those found by the normal exhaustive-search algorithm.

## geqo

**Parameter description**: Specifies whether to enable the genetic query optimization.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

It is best not to turn it off in execution. **geqo_threshold** provides more subtle control of GEQO.

If this parameter is modified by running the **gs_guc reload** command and the connection of a session on the current node is not from the client but from another node in the cluster to which the node belongs, this parameter does not take effect immediately on the session after the **gs_guc reload** command is executed. The setting takes effect only after the connection node is disconnected and then reconnected.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **on**

## geqo_threshold

**Parameter description**: Specifies the number of **FROM** items. Genetic query optimization is used to plan queries when the number of statements executed is greater than this value.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- For simpler queries, it is best to use the regular, exhaustive-search planner, but for queries with many tables, it is better to use GEQO to manage the queries.
- A **FULL OUTER JOIN** construct counts as only one **FROM** item.

**Value range**: an integer ranging from 2 to 2147483647

**Default value**: **12**

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## geqo_effort

**Parameter description**: Controls the trade-off between planning time and query plan quality in GEQO.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

**geqo_effort** does not do anything directly. This parameter is only used to compute the default values for the other variables that influence GEQO behavior. If you prefer, you can manually set the other parameters instead.

**Value range**: an integer ranging from 1 to 10

NOTICE

Larger values increase the time spent in query planning, but also increase the probability that an efficient query plan is chosen.

**Default value**: **5**

## geqo_pool_size

**Parameter description**: Controls the pool size used by GEQO, that is, the number of individuals in the genetic population.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

NOTICE

The value of this parameter must be at least **2**, and useful values are typically from **100** to **1000**. If this parameter is set to **0**, GaussDBselects a proper value based on **geqo_effort** and the number of tables.

**Default value**: **0**

## geqo_generations

**Parameter description**: Specifies the number of iterations of the GEQO.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

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NOTICE

The value of this parameter must be at least **1**, and useful values are typically from **100** to **1000**. If it is set to **0**, a suitable value is chosen based on **geqo_pool_size**.

**Default value**: **0**

### geqo_selection_bias

**Parameter description**: Specifies the selection bias used by GEQO. The selection bias is the selective pressure within the population.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** a floating point number ranging from 1.5 to 2.0

**Default value**: **2**

### geqo_seed

**Parameter description**: Specifies the initial value of the random number generator used by GEQO to select random paths through the join order search space.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** a floating point number ranging from 0.0 to 1.0

NOTICE

Varying the value changes the set of join paths explored, and may result in a better or worse path being found.

**Default value**: **0**

## 19.8.4 Other Optimizer Options

### enable_fast_query_shipping

**Parameter description**: Specifies whether to use the distributed framework for a query planner.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the distributed framework is not used. Execution plans are generated on CNs and DNs separately.
- **off** indicates that the distributed framework is used. Execution plans are generated on CNs and then sent to DNs for execution.

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**Default value**: **on**

## enable_trigger_shipping

**Parameter description**: Specifies whether the trigger can be pushed to DNs for DN execution.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the trigger can be pushed to DNs for DN execution.
- **off** indicates that the trigger cannot be pushed to DNs. It must be executed on CNs.

**Default value**: **on**

## enable_remotejoin

**Parameter description**: Specifies whether JOIN operation plans can be delivered to DNs for execution.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that JOIN operation plans can be delivered to DNs for execution.
- **off** indicates that JOIN operation plans cannot be delivered to DNs for execution.

**Default value**: **on**

## enable_remotegroup

**Parameter description**: Specifies whether the execution plans of **GROUP BY** and **AGGREGATE** can be delivered to DNs for execution.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the execution plans of **GROUP BY** and **AGGREGATE** can be delivered to DNs for execution.
- **off** indicates that the execution plans of **GROUP BY** and **AGGREGATE** cannot be delivered to DNs for execution.

**Default value**: **on**

## enable_remotelimit

**Parameter description**: Specifies whether the execution plan specified in the LIMIT clause can be delivered to DNs for execution.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the execution plan specified in the LIMIT clause can be pushed down to DNs for execution.
- **off** indicates that the execution plan specified in the LIMIT clause cannot be delivered to DNs for execution.

**Default value**: **on**

## enable_remotesort

**Parameter description**: Specifies whether the execution plan of the **ORDER BY** clause can be delivered to DNs for execution.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the execution plan of the **ORDER BY** clause can be delivered to DNs for execution.
- **off** indicates that the execution plan of the **ORDER BY** clause cannot be delivered to DNs for execution.

**Default value**: **on**

## enable_csqual_pushdown

**Parameter description:** Specifies whether to deliver filter criteria for a rough check during query.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that a rough check is performed with filter criteria delivered during query.
- **off** indicates that a rough check is performed without filter criteria delivered during query.

**Default value**: **on**

## explain_dna_file

**Parameter description:** Sets **explain_perf_mode** to **run** to export object files in CSV format.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

The value of this parameter must be an absolute path plus a file name with the extension **.csv**.

**Value range**: a string

**Default value**: empty

## analysis_options

**Parameter description**: Specifies whether to enable function options in the corresponding options to use the corresponding location functions, including data verification and performance statistics. For details, see the options in the value range.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: a string

- **LLVM_COMPILE** indicates that the codegen compilation time of each thread is displayed on the explain performance page. The current feature is a lab feature. Contact Huawei technical support before using it.
- **HASH_CONFLICT** indicates that the log file in the **pg_log** directory of the DN process displays the hash table statistics, including the hash table size, hash chain length, and hash conflict information.
- **STREAM_DATA_CHECK** indicates that a CRC check is performed on data before and after network data transmission.

**Default value**:
**ALL,on(),off(LLVM_COMPILE,HASH_CONFLICT,STREAM_DATA_CHECK)**, which indicates that no location function is enabled.

## explain_perf_mode

**Parameter description:** Specifies the display format of the **explain** command.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range: normal**, **pretty**, **summary**, and **run**

- **normal** indicates that the default printing format is used.
- **pretty** indicates a new format improved by using GaussDB. The new format contains a plan node ID, directly and effectively analyzing performance.
- **summary** indicates that the analysis result on this information is printed in addition to the printed information specified by **pretty**.
- **run** indicates that the system exports the printed information specified by **summary** as a CSV file for further analysis.

**Default value**: **pretty**

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NOTE

The pretty mode supports only plans that contain stream operators and does not support plans that deliver statements to DNs. Therefore, the display format is affected by the **enable_stream_operator** parameter. When **enable_stream_operator** is set to **off**, the plan containing the stream operator cannot be generated.

## cost_param

**Parameter description:** Controls use of different estimation methods in specific customer scenarios, allowing estimated values approximating to onsite values. This parameter can control various methods simultaneously by performing AND (&) on the bit of each method. A method is selected if the result value is not **0**.

- When **cost_param & 1** is set to a value other than 0, an improved mechanism is used for connecting the selection rate of non-equi-joins. This method is more accurate for estimating the selection rate of joins between two identical tables. At present, if **cost_param & 1** is set to a value other than 0, the path is not used. That is, a better formula is selected for calculation.
- When **cost_param & 2** is set to a value other than 0, the selection rate is estimated based on multiple filter criteria. The lowest selection rate among all filter criteria, but not the product of the selection rates for two tables under a specific filter criterion, is used as the total selection rate. This method is more accurate when a close correlation exists between the columns to be filtered.
- When **cost_param & 4** is not 0, the selected debugging model is not recommended when the stream node is evaluated.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **0**

## enable_partitionwise

**Parameter description:** Specifies whether to select an intelligent algorithm for joining partition tables.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that an intelligent algorithm is selected.
- **off** indicates that an intelligent algorithm is not selected.

**Default value**: **off**

## enable_fast_numeric

**Parameter description:** Specifies whether to enable optimization for numeric data calculation. Calculation of numeric data is time-consuming. Numeric data is converted into int64- or int128-type data to improve numeric data calculation performance.

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This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** or **true** indicates that optimization for numeric data calculation is enabled.
- **off** or **false** indicates that optimization for numeric data calculation is disabled.

**Default value**: **on**

## rewrite_rule

**Parameter description**: Specifies the rewriting rule for enabled optional queries. Some query rewrite rules are optional. Enabling them cannot always improve the query efficiency. In a specific customer scenario, you can set the query rewriting rules through this GUC parameter to achieve optimal query efficiency.

This parameter can control the combination of query rewriting rules, for example, there are multiple rewriting rules: rule1, rule2, rule3, and rule4. You can perform the following settings:

```
set rewrite_rule=rule1;          -- Enable query rewriting rule1
set rewrite_rule=rule2, rule3;     -- Enable the query rewriting rules rule2 and rule3
set rewrite_rule=none;         -- Disable all optional query rewriting rules
```

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

- none: Does not use any optional query rewriting rules
- Lazyagg: Uses the Lazy Agg query rewriting rules for eliminating aggregation operations in subqueries
- **magicset**: Uses the Magic Set query rewriting rules delivered from the main query to the subquery.
- **partialpush**: Uses the Partial Push query rewriting rules. For statements that cannot be pushed down, push down some subqueries to DNs for execution and the rest to CNs for execution.
- **uniquecheck**: Uses the Unique Check query rewriting rules. Optimize the subquery statements in target columns without agg and check whether the number of returned rows is 1.
- **disablerep**: Uses the Disable Replicate query rewriting rules. The performance may deteriorate after a replication table is optimized. Therefore, after this rule is enabled, subqueries cannot be optimized.
- **intargetlist**: Uses the In Target List query rewriting rules (subquery optimization in the target column).
- **predpushnormal**: Uses the Predicate Push query rewriting rules. When predicate conditions are pushed down to subqueries, the BROADCAST operator may be added to support distributed execution.
- **predpushforce**: Uses the Predicate Push query rewriting rules. Push down predicate conditions to subqueries and use indexes as much as possible for acceleration.

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- **predpush**: Selects the optimal plan based on the cost in **predpushnormal** and **predpushforce**.
- **disable_pullup_expr_sublink**: Disables optimizers to pull up expr_sublink. For details about sublink classification and pullup principles, see **10.3.6.3 Optimizing Subqueries**.

**Default value**: **magicset**

## enable_pbe_optimization

**Parameter description**: Specifies whether the optimizer optimizes the query plan for statements executed in Parse Bind Execute (PBE) mode.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the optimizer optimizes the query plan.
- **off** indicates that the optimizer does not optimize the execution.

**Default value**: **on**

## enable_light_proxy

**Parameter description**: Specifies whether the optimizer optimizes the execution of simple queries on CNs. This parameter does not take effect if the character set of the application side does not match that of the kernel side. You are advised to set the character set to UTF8 when creating a database.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the optimizer optimizes the execution of simple queries on CNs.
- **off** indicates that the optimizer does not optimize the execution.

**Default value**: **on**

## enable_global_plancache

**Parameter description**: Specifies whether to share the cache of the PBE query execution plan. If this parameter is set to **on**, the memory usage of the CNs and DNs in high concurrency scenarios can be reduced. In addition, the value of this parameter must be the same on the CN and DN. Otherwise, the packets sent from the CN to the DN do not match and an error is reported.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

When **enable_global_plancache** is enabled, to ensure that GPC takes effect, the value of **local_syscache_threshold** must be greater than or equal to 16 MB. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) If the value of **local_syscache_threshold** is less than 16 MB, set it to **16 MB**. If the value is greater than 16 MB, do not change it.

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**Value range**: Boolean

- **on** indicates that the execution plan of the PBE query is shared in the cache.
- **off** indicates that the execution plan of the PBE query is not shared in the cache.

**Default value**: **off**

## gpc_clean_timeout

**Parameter description**: When **enable_global_plancache** is set to **on**, if a plan in the shared plan list is not used within the period specified by **gpc_clean_timeout**, the plan will be deleted. This parameter is used to control the retention period of a shared plan that is not used. The current feature is a lab feature. Contact Huawei technical support before using it.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 300 to 86400. The unit is s.

**Default value**: **1800**, that is, 30 minutes

## enable_gpc_grayrelease_mode

**Parameter description**: Specifies whether to enable GPC in a distributed cluster. The cluster needs to be restarted to enable GPC. If you want to enable GPC without restarting the cluster, use **enable_gpc_grayrelease_mode**. The current feature is a lab feature. Contact Huawei technical support before using it.

Operations in a distributed cluster:

To enable GPC:

1. Enable **enable_gpc_grayrelease_mode** on all DNs.

2. Enable **enable_gpc_grayrelease_mode** on all CNs.

3. Enable the GPC parameter which is a POSTMASTER parameter. You need to reload the parameter and then kill the node in polling mode for GPC on the restarted node to take effect.

To disable GPC:

1. Ensure that **enable_gpc_grayrelease_mode** is set to **on**, reload and then disable the GPC parameter, and kill the node in polling mode for GPC on the restarted node to take effect.

2. Disable **enable_gpc_grayrelease_mode** on all CNs.

3. Disable **enable_gpc_grayrelease_mode** on all DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- on

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- off

**Default value**: **off**

## enable_opfusion

**Parameter description**: Specifies whether to optimize simple queries.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

This parameter is used to optimize the query performance of DNs. You can set **max_datanode_for_plan** to view the execution plan of a query DN. If the execution plan of the DN contains **[Bypass]**, the query can be optimized on the DN.

The restrictions on simple queries are as follows:

- Only indexscan and indexonlyscan are supported, and the filter criteria of all **WHERE** statements are on indexes.
- Only single tables can be added, deleted, modified, and queried. Join and using operations are not supported.
- Only row-store tables are supported. Partitioned tables and tables with triggers are not supported.
- Information statistics features of active SQL statements and queries per second (QPS) are not supported.
- Tables that are being scaled out or in are not supported.
- System columns cannot be queried or modified.
- Only simple **SELECT** statements are supported. For example:
  ```
  SELECT c3 FROM t1 WHERE c1 = ? and c2 =10;
  ```
  Only columns in the target table can be queried. Columns **c1** and **c2** are index columns, which can be followed by constants or parameters. You can use **for update**.
- Only simple **INSERT** statements are supported. For example:
  ```
  INSERT INTO t1 VALUES (?,10,?);
  ```
  Only one **VALUES** is supported. The type in **VALUES** can be a constant or a parameter. **RETURNING** is not supported.
- Only simple **DELETE** statements are supported. For example:
  ```
  DELETE FROM t1 WHERE c1 = ? and c2 = 10;
  ```
  Columns **c1** and **c2** are index columns, which can be followed by constants or parameters.
- Only simple **UPDATE** statements are supported. For example:
  ```
  UPDATE t1 SET c3 = c3+? WHERE c1 = ? and c2 = 10;
  ```
  The values modified in column **c3** can be constants, parameters, or a simple expression. Columns **c1** and **c2** are index columns, which can be followed by constants or parameters.

**Value range**: Boolean

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- **on** indicates that the performance logs are output.
- **off** indicates that the performance logs are not output.

**Default value**: **on**

## enable_partition_opfusion

**Parameter description:** If this parameter is enabled when the **enable_opfusion** parameter is enabled, the simple query of the partitioned table can be optimized to improve the SQL execution performance. If **enable_global_plancache** is set to **on**, this parameter does not take effect.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the performance logs are output.
- **off** indicates that the performance logs are not output.

**Default value**: **off**

## sql_beta_feature

**Parameter description**: Specifies the SQL engine's optional beta features to be enabled, including optimization of row count estimation and query equivalence estimation. These optional features provide optimization for specific scenarios, but performance deterioration may occur in some scenarios for which testing is not performed. In a specific customer scenario, you can set the query rewriting rules through this GUC parameter to achieve optimal query efficiency.

This parameter determines the combination of the SQL engine's beta features, for example, feature1, feature2, feature3, and feature4. You can perform the following settings:

```
set sql_beta_feature=feature1;          --Enable the beta feature 1 of the SQL engine.
set sql_beta_feature=feature2,feature3;    --Enable the beta features 2 and 3 of the SQL engine.
set sql_beta_feature=none;          --Disable all optional SQL engine beta features.
```

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

- **none**: None of the beta optimizer features is used.
- **sel_semi_poisson**: Uses poisson distribution to calibrate the equivalent semi-join and anti-join selection rates.
- **sel_expr_instr**: Uses the matching row count estimation method to provide more accurate estimation for **instr(col, 'const') > 0, = 0, = 1**.
- **param_path_gen**: Generates more possible parameterized paths.
- **rand_cost_opt**: Optimizes the random read cost of tables that have a small amount of data.
- **param_path_opt**: Uses the bloating ratio of the table to optimize the analysis information of indexes.
- **page_est_opt**: Optimizes the **relpages** estimation for the analysis information of non-column-store table indexes.

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- **no_unique_index_first**: Disables optimization of the primary key index scanning path first.
- **join_sel_with_cast_func**: Supports type conversion functions when the number of join rows is estimated.
- **canonical_pathkey**: after the regularization pathkey is generated (**pathkey**: a set of ordered key values of data).
- **index_cost_with_leaf_pages_only**: Considers index leaf nodes when the index cost is estimated.
- **partition_opfusion**: Enables partitioned table optimization.
- **a_style_coerce**: Enables the Decode type conversion rule to be compatible with O. For details, see **Type Resolution for CASE in ORA Compatibility Mode**.
- **plpgsql_stream_fetchall**: Enables the function of obtaining all tuple results when the SQL statements which use streams are executed on the for loop or cursor in a stored procedure.
- **partition_fdw_on**: SQL statements can be created for Postgres foreign tables based on partitioned tables.
- **predpush_same_level**: Enables the **predpush** hint to control parameterized paths at the same layer.
- **disable_bitmap_cost_with_lossy_pages**: Disables the computation of the cost of lossy pages in the bitmap path cost.

**Default value**:
**"sel_semi_poisson,sel_expr_instr,rand_cost_opt,param_path_opt,page_est_opt"**

## table_skewness_warning_threshold

**Parameter description**: Specifies the threshold for triggering a table skew alarm.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from 0 to 1

**Default value**: **1**

## table_skewness_warning_rows

**Parameter description**: Specifies the minimum number of rows for triggering a table skew alarm.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **100000**

## enable_global_stats

**Parameter description**: Specifies the current statistics collection mode, which can be global statistics collection or single-node statistics collection. By default, the global statistics collection mode is used. If this parameter is disabled, the statistics

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of the first node in the cluster are collected by default. In this case, the quality of the generated query plan may be affected. However, the information collection performance is optimal. Therefore, exercise caution when disabling this parameter.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** or **true** indicates the global statistics mode.
- **off** or **false** indicates the single-DN statistics mode.

**Default value**: **on**

## default_statistics_target

**Parameter description**: Specifies the default statistics target for table columns without a column-specific target set via **ALTER TABLE SET STATISTICS**. If this parameter is set to a positive number, it indicates the number of samples of statistics information. If this parameter is set to a negative number, percentage is used to set the statistic target. The negative number converts to its corresponding percentage, for example, -5 means 5%.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from –100 to 10000

NOTICE

- A larger positive number than the default value increases the time required to do **ANALYZE**, but might improve the quality of the optimizer's estimates.
- Changing settings of this parameter may result in performance deterioration. If query performance deteriorates, you can:
  1. Restore to the default statistics.
  2. Use hints to force the optimizer to use the optimal query plan. (For details, see **10.3.9 Hint-based Tuning**.)
- If this parameter is set to a negative value, the number of samples is greater than or equal to 2% of the total data volume, and the number of records in user tables is less than 1.6 million, the time taken by running **ANALYZE** will be longer than when this parameter uses its default value.
- If this parameter is set to a negative value, the auto-analyze function is disabled.

**Default value**: **100**

## constraint_exclusion

**Parameter description**: Controls the query optimizer's use of table constraints to optimize queries.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: enumerated values

- **on**, **true**, **yes**, and **1** indicate that constraints for all tables are examined.
- **off**, **false**, **no**, and **0** indicate that no constraints are examined.
- **partition** indicates that only constraints for inheritance child tables and **UNION ALL** subqueries are examined.

NOTICE

When **constraint_exclusion** is set to **on**, the optimizer compares query conditions with the table's **CHECK** constraints, and omits scanning tables for which the conditions contradict the constraints.

**Default value**: **partition**

NOTE

Currently, **constraint_exclusion** is enabled by default only for cases that are often used to implement table partitioning. Turning this feature on for all tables imposes extra planning on simple queries, and provides no benefit for simple queries. If you have no partitioned tables, set it to **off**.

## cursor_tuple_fraction

**Parameter description**: Specifies the optimizer's estimated fraction of a cursor's rows that are retrieved.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** a floating point number ranging from 0.0 to 1.0

NOTICE

Smaller values of this setting bias the optimizer towards using **fast start** plans for cursors, which will retrieve the first few rows quickly while perhaps taking a long time to fetch all rows. Larger values put more emphasis on the total estimated time. At the maximum setting of **1.0**, cursors are planned exactly like regular queries, considering only the total estimated time and how soon the first rows might be delivered.

**Default value**: **0.1**

## from_collapse_limit

**Parameter description**: Specifies whether the optimizer merges sub-queries into upper queries based on the resulting FROM list. The optimizer merges sub-queries into upper queries if the resulting FROM list would have no more than this many items.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: an integer ranging from 1 to 2147483647

NOTICE

Smaller values reduce planning time but may lead to inferior execution plans.

**Default value**: **8**

## join_collapse_limit

**Parameter description**: Specifies whether the optimizer rewrites **JOIN** constructs (except **FULL JOIN**) into lists of **FROM** items based on the number of the items in the result list.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483647

NOTICE

- Setting this parameter to **1** prevents join reordering. As a result, the join order specified in the query will be the actual order in which the relations are joined. The query optimizer does not always choose the optimal join order. Therefore, advanced users can temporarily set this variable to **1**, and then specify the join order they desire explicitly.
- Smaller values reduce planning time but lead to inferior execution plans.

**Default value**: **8**

## plan_mode_seed

**Parameter description**: This is a commissioning parameter. Currently, it supports only **OPTIMIZE_PLAN** and **RANDOM_PLAN**. The value **0** (for **OPTIMIZE_PLAN**) indicates the optimized plan using the dynamic planning algorithm. Other values are for **RANDOM_PLAN**, which indicates that the plan is randomly generated. **–1** indicates that users do not specify the value of the seed identifier. In this case, the optimizer generates a random integer from **1** to **2147483647** and a random execution plan based on the generated integer. A value from **1** to **2147483647** is regarded as the seed identifier, based on which the optimizer generates a random execution plan.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 2147483647

**Default value**: **0**

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NOTICE

- If **plan_mode_seed** is set to **RANDOM_PLAN**, the optimizer generates a random execution plan that may not be the optimal one. Therefore, to guarantee the query performance, the default value **0** is recommended during upgrade, scale-out, scale-in, and O&M.
- If this parameter is not set to **0**, the specified hint will not be used.

## enable_random_datanode

**Parameter description**: Specifies whether the query of the replication table is conducted on a random DN. A complete replication table is stored on each each DN for random retrieval to release the pressure on nodes.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the random query is enabled.
- **off** indicates that the random query is disabled.

**Default value**: **on**

## hashagg_table_size

**Parameter description**: Specifies the hash table size during the execution of the HASH JOIN operation.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 1073741823

**Default value**: **0**

## enable_codegen

**Parameter description**: Specifies whether code optimization is enabled. Currently, the code optimization uses the LLVM optimization. The current feature is a lab feature. Contact Huawei technical support before using it.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that code optimization is enabled.
- **off** indicates that code optimization is disabled.

NOTICE

Currently, the LLVM optimization only supports the vectorized executor feature. You are advised to disable this parameter in other scenarios.

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**Default value**: **off**

## codegen_strategy

**Parameter description**: Specifies the codegen optimization strategy that is used when an expression is converted to be codegen-based. The current feature is a lab feature. Contact Huawei technical support before using it.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** enumerated values

- **partial** indicates that even if functions that are not codegen-based exist in an expression, you can still call the LLVM dynamic optimization strategy by using the entire codegen framework of the expression.
- **pure** indicates that only when all functions in an expression can be codegen-based, the LLVM dynamic optimization strategy can be called.

NOTICE

In the scenario where query performance reduces after the codegen function is enabled, you can set this parameter to **pure**. In other scenarios, do not change the default value **partial** of this parameter.

**Default value**: **partial**

## enable_codegen_print

**Parameter description**: Specifies whether the LLVM IR function can be printed in logs. The current feature is a lab feature. Contact Huawei technical support before using it.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the LLVM IR function can be printed in logs.
- **off** indicates that the LLVM IR function cannot be printed in logs.

**Default value**: **off**

## codegen_cost_threshold

**Parameter description**: The LLVM compilation takes some time to generate executable machine code. Therefore, LLVM compilation is beneficial only when the actual execution cost is more than the sum of the code required for generating machine code and the optimized execution cost. This parameter specifies a threshold. If the estimated execution cost exceeds the threshold, LLVM optimization is performed. The current feature is a lab feature. Contact Huawei technical support before using it.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **10000**

## enable_bloom_filter

**Parameter description**: Specifies whether the BloomFilter optimization is used. This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the BloomFilter optimization can be used.
- **off** indicates that the BloomFilter optimization cannot be used.

**Default value**: **on**

## enable_extrapolation_stats

**Parameter description**: Specifies whether the extrapolation logic is used for data of DATE type based on historical statistics. The logic can increase the accuracy of estimation for tables whose statistics are not collected in time, but will possibly provide an overlarge estimation due to incorrect extrapolation. Enable the logic only in scenarios where the data of DATE type is periodically inserted. This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the extrapolation logic is used for data of DATE type based on historical statistics.
- **off** indicates that the extrapolation logic is not used for data of DATE type based on historical statistics.

**Default value**: **off**

## autoanalyze

**Parameter description**: Specifies whether to automatically collect statistics on tables that have no statistics when a plan is generated. **autoanalyze** cannot be used for foreign or temporary tables. To collect statistics, manually perform the ANALYZE operation. If an exception occurs in the database during the execution of autoanalyze on a table, after the database is recovered, the system may still prompt you to collect the statistics of the table when you run the statement again. In this case, manually perform the ANALYZE operation on the table to synchronize statistics. This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the table statistics are automatically collected.
- **off** indicates that the table statistics are not automatically collected.

**Default value**: **off**

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## query_dop

**Parameter description**: Specifies the user-defined degree of parallelism (DOP). This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –64 to 64

A value ranging from 1 to 64 indicates that the fixed SMP is enabled and the system will use the specified DOP.

**0** indicates that the SMP adaptation is enabled, and the system will dynamically select the optimal DOP based on resource usage and plan characteristics.

A value ranging from –64 to –1 indicates that the SMP adaptation is enabled, and the system limits the DOP that can be adaptively selected.

NOTE

- After enabling concurrent queries, ensure you have sufficient CPU, memory, network, and I/O resources to achieve the optimal performance.
- To prevent performance deterioration caused by an overly large value of **query_dop**, the system calculates the maximum number of available CPU cores for a DN and uses the number as the upper limit for this parameter. If the value of **query_dop** is greater than 4 and also the upper limit, the system resets **query_dop** to the upper limit.

**Default value**: **1**

## enable_analyze_check

**Parameter description**: Checks whether statistics were collected about tables whose **reltuples** and **relpages** are displayed as **0** in **pg_class** during plan generation.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the tables will be checked.
- **off** indicates that the tables will not be checked.

**Default value**: **off**

## enable_sonic_hashagg

**Parameter description**: Specifies whether to use the hash aggregation operator designed for column-oriented hash tables when certain constraints are met.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the hash aggregation operator designed for column-oriented hash tables is used when certain constraints are met.
- **off** indicates that the hash aggregation operator designed for column-oriented hash tables is not used.

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NOTE

- When the hash aggregation operator designed for column-oriented hash tables is used, the memory usage of the query can be reduced. However, in scenarios when **enable_codegen** is set to **on** and the performance is significantly improved, the performance of the operator may deteriorate.
- If **enable_sonic_hashagg** is set to **on**, when certain constraints are met, the hash aggregation operator designed for column-oriented hash tables is used and its name is displayed as **Sonic Hash Aggregation** in the output of the Explain Analyze/Performance operation. When the constraints are not met, the operator name is displayed as **Hash Aggregation**. For details, see **10.3.2.2 Description**.

**Default value**: **on**

## enable_sonic_hashjoin

**Parameter description**: Specifies whether to use the hash join operator designed for column-oriented hash tables when certain constraints are met.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the hash join operator designed for column-oriented hash tables is used when certain constraints are met.
- **off** indicates that the hash join operator designed for column-oriented hash tables is not used.

NOTE

- Currently, the parameter can be used only for Inner Join.
- If **enable_sonic_hashjoin** is enabled, the memory usage of query using the Hash Inner operator can be reduced. However, in scenarios where the code generation technology can significantly improve performance, the performance of the operator may deteriorate.
- If **enable_sonic_hashjoin** is set to **on**, when certain constraints are met, the hash join operator designed for column-oriented hash tables is used and its name is displayed as **Sonic Hash Join** in the output of the Explain Analyze/Performance operation. When the constraints are not met, the operator name is displayed as **Hash Join**. For details, see **10.3.2.2 Description**.

**Default value**: **on**

## enable_sonic_optspill

**Parameter description**: Specifies whether to optimize the number of files to be written to disks for the Hash Join operator designed for column-oriented hash tables. If this parameter is set to **on**, the number of files written to disks does not increase significantly when the Hash Join operator writes a large number of files to disks.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the optimization is enabled.

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- **off** indicates that the optimization is disabled.

**Default value**: **on**

## log_parser_stats

**Parameter description**: Specifies whether the optimizer outputs the performance logs of the parser module. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the performance logs are output.
- **off** indicates that the performance logs are not output.

**Default value**: **off**

## log_planner_stats

**Parameter description**: Specifies whether the optimizer outputs the performance logs of the planner module. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the performance logs are output.
- **off** indicates that the performance logs are not output.

**Default value**: **off**

## log_executor_stats

**Parameter description**: Specifies whether the optimizer outputs the performance logs of the executor module. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the performance logs are output.
- **off** indicates that the performance logs are not output.

**Default value**: **off**

## log_statement_stats

**Parameter description**: Specifies whether the optimizer outputs the performance logs of a statement. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

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This parameter is a SUSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the performance logs are output.
- **off** indicates that the performance logs are not output.

**Default value**: **off**

## plan_cache_mode

**Parameter description**: Specifies the policy for generating an execution plan in the **prepare** statement.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: enumerated values

- **auto** indicates that the **custom plan** or **generic plan** is selected by default.
- **force_generic_plan** indicates that the **generic plan** is forcibly used.
- **force_custom_plan** indicates that the **custom plan** is forcibly used.

NOTE

- This parameter is valid only for the **prepare** statement. It is used when the parameterized field in the **prepare** statement has severe data skew.
- **custom plan** is a plan generated after you run the **prepare** statement where parameters in the **execute** statement is embedded. The **custom plan** generates a plan based on specific parameters in the **execute** statement. This scheme generates a preferred plan based on specific parameters each time and has good execution performance. The disadvantage is that the plan needs to be regenerated before each execution, resulting in a large amount of repeated optimizer overhead.
- **generic plan** is a plan generated after you run the **prepare** statement. The plan policy binds parameters to the plan when you run the **execute** statement and execute the plan. The advantage of this scheme is that repeated optimizer overheads can be avoided in each execution. The disadvantage is that the plan may not be optimal when data skew occurs for the bound parameters and may result in poor plan execution performance.

**Default value**: **auto**

## enable_router

**Parameter description:** Specifies whether to enable the manual node pushdown function.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the performance logs are output.
- **off** indicates that the performance logs are not output.

**Default value**: **off**

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## router

**Parameter description**: Controls the detailed attributes of the router function. This parameter is valid only when **enable_router** and **enable_light_proxy** are enabled. This parameter is used to calculate the DN where the given distribution column is located based on the hash distribution column of the table. After the router is set, the supported SQL statements are pushed down to the DN for execution. If the router is incorrectly configured, data may be saved to an incorrect DN, causing unpredictable problems. Therefore, be cautious when running this command.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

This parameter consists of two parts:
**'schema_name.table_name,"distribute_keys"'**. The meanings are as follows:

- **schema_name.table_name**: indicates the schema name and table name. If schema_name is not set, the default value current_schema is used.
- **distribute_keys**: Values of all distribution columns in the distribution table are separated by commas (,). The sequence of the values must be the same as that of the distribution columns in the table.

**Default value**: empty

## enable_auto_explain

**Parameter description**: Specifies whether to enable the function of automatically printing execution plans. This parameter is used to locate slow stored procedures or slow queries and is valid only for the currently connected CN.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean. The value **on** indicates that the function is enabled, and the value **off** indicates that the function is disabled.

**Default value**: **off**

## auto_explain_level

**Parameter description**: Specifies the log level for automatically printing execution plans.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Enumeration type. The value can be **log** or **notice**. **log** indicates that the execution plan is printed in logs. **notice** indicates that the execution plan is printed in notification mode.

**Default value**: **log**

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## auto_explain_log_min_duration

**Parameter description**: Specifies how long execution plans are automatically printed for. Plans can be printed only when the time required to execute the plans is greater than the value of **auto_explain_log_min_duration**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is ms.

- **0**: All executed plans are generated.
- **3000**: All execution plans will be generated after the execution of a statement takes more than 3000 ms.

**Default value**: **0**

## max_datanode_for_plan

**Parameter description**: Specifies the number of execution plans to be displayed on the DN when an FQS plan is generated. The number of plans that are displayed on the DN is determined by the smaller value between the number of DNs on the cluster and the value of this parameter.

For statements executed by PBE, only plans generated in kernel prepare precompilation mode can be displayed. Plans generated in JDBC precompilation mode cannot be displayed.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 8192

**Default value**: **0**

## session_sequence_cache

**Parameter description**: Specifies the **sequence** value applied for one-time interaction in the current session. The unused values are automatically discarded after the session ends. When using **sequence** to import data in batches, you can increase the value of this parameter to improve the insertion speed and high concurrency performance. When a single data record is inserted concurrently, set this parameter to **1** to reduce the sequence change. If you have high requirements on continuity, you need to specify the required cache when creating a sequence. If the value of this parameter is greater than that of cache, the value automatically becomes invalid.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483647

**Default value**: **10**

NOTE

The default value is **10**. In high-concurrency scenarios, the performance of single and batch insertion is good.

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# 19.9 Error Reporting and Logging

## 19.9.1 Logging Destination

### log_destination

**Parameter description**: GaussDB supports several methods of logging server messages. Set this parameter to a list of desired log destinations separated by commas. (For example, log_destination="stderr,csvlog")

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

The valid values are **stderr**, **csvlog**, **syslog**, and **eventlog**.

- **stderr** indicates that logs are printed to the screen.
- **csvlog** indicates that logs are output in comma separated value (CSV) format. The prerequisite for generating logs in CSV format is that **logging_collector** must be set to **on**. For details, see **19.9.4 Using CSV Log Output**.
- **syslog** indicates that logs are recorded using the syslog of the OS. GaussDB can record logs using syslog from **LOCAL0** to **LOCAL7**. For details, see **syslog_facility**. To record logs using syslog, add the following information to syslog daemon's configuration file:
  **local0.*** */var/log/postgresql*

**Default value: stderr**

### logging_collector

**Parameter description**: Specifies whether to enable the logger process to collect logs. This process captures log messages sent to **stderr** or **csvlog** and redirects them into log files.

This method is more effective than recording logs to syslog because some types of messages cannot be displayed in syslog output, such as messages indicating the loading failures of dynamic link libraries and error messages generated by scripts (for example, **archive_command**).

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

It is possible to log to **stderr** without using the logging collector and the log messages will go to where the server's **stderr** is directed. However, this method is only suitable for low log volumes due to difficulties in rotating log files.

**Value range**: Boolean

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- **on** indicates that the log collection is enabled.
- **off** indicates that the log collection is disabled.

**Default value**: **on**

## log_directory

**Parameter description**: Specifies the directory for storing log files when **logging_collector** is set to **on**. The value can be an absolute path, or relative to the data directory. The **log_directory** parameter can be dynamically modified using the **gs_guc reload** command. Only the sysadmin user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- If this parameter is set to an invalid path, the cluster cannot be started.
- If you modify the **log_directory** parameter using the **gs_guc reload** command, and the specified path is valid, the log files are output to this new path. If the specified path is invalid, the log files are output to the valid path set last time and the database operation is not affected. The invalid value is still written into the configuration file.
- In the sandbox environment, the path cannot contain /var/chroot. For example, if the absolute path of log is **/var/chroot/var/lib/log/Ruby/pg_log/cn_log**, you only need to set the path to **/var/lib/log/Ruby/pg_log/cn_log**.

NOTE

- Valid path: Users have read and write permissions on the path.
- Invalid path: Users do not have read or write permissions on an invalid path.

**Value range**: a string

**Default value**: specified during installation

## log_filename

**Parameter description**: Specifies the names of generated log files when **logging_collector** is set to **on**. The value is treated as a strftime pattern, so %-escapes can be used to specify time-varying file names. Only the sysadmin user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

- You are advised to use %-escapes to specify the log file names for efficient management of log files.
- If **log_destination** is set to **csvlog**, log files are output in CSV format with timestamped names, for example, **server_log.1093827753.csv**.

**Value range**: a string

**Default value**: **postgresql-***%Y-%m-%d_%H%M%S*.**log**

## log_file_mode

**Parameter description**: Specifies the permissions of log files when **logging_collector** is set to **on**. This parameter is invalid on Windows. The parameter value is usually a number in the format acceptable to the **chmod** and **umask** system calls.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

- Before setting this parameter, set **log_directory** to store the logs to a directory other than the data directory.
- Do not make the log files world-readable because they might contain sensitive data.

**Value range**: an octal integer ranging from 0000 to 0777 (that is, 0 to 511 in the decimal format)

NOTE

- **0600** indicates that log files are readable and writable only to the server administrator.
- **0640** indicates that log files are readable and writable to members of the administrator's group.

**Default value: 0600**

## log_truncate_on_rotation

**Parameter description**: Specifies the writing mode of the log files when **logging_collector** is set to **on**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

A setting example is as follows:

Assume that you want logs to be kept for 7 days, a log file generated each day to be named **server_log.Mon** on Monday, **server_log.Tue** on Tuesday, and so forth, and this week's log files to be overwritten by next week's log files. Then you can set **log_filename** to **server_log.%a**, **log_truncate_on_rotation** to **on**, and

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**log_rotation_age** to **1440** (indicating that the valid duration of the log file is 24 hours).

**Value range**: Boolean

- **on** indicates that GaussDB overwrites the existing log files of the same name on the server.
- **off** indicates that GaussDB appends the logging messages to the existing log files of the same name on the server.

**Default value**: **off**

## log_rotation_age

**Parameter description**: Specifies the interval for creating a log file when **logging_collector** is set to **on**. If the duration from the time when the last log file was created to the current time is greater than the value of **log_rotation_age**, a new log file will be generated.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 35791394. The unit is min. **0** indicates that the time-based creation of new log files is disabled.

**Default value**: **1d** (1440 min)

## log_rotation_size

**Parameter description**: Specifies the maximum size of a server log file when **logging_collector** is set to **on**. If the total size of messages in a log file exceeds the specified value, a log file will be generated.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2097151. The unit is KB.

**0** indicates that the capacity-based creation of new log files is disabled.

**Default value: 20 MB**

## syslog_facility

**Parameter description**: Specifies the syslog facility to be used when **log_destination** is set to **syslog**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values. Valid values are **local0**, **local1**, **local2**, **local3**, **local4**, **local5**, **local6**, and **local7**.

**Default value: local0**

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### syslog_ident

**Parameter description**: Specifies the identifier of GaussDB messages in syslog logs when **log_destination** is set to **syslog**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **postgres**

### event_source

**Parameter description**: Specifies the identifier of GaussDB messages in logs when **log_destination** is set to **eventlog**.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **PostgreSQL**

## 19.9.2 Logging Time

### client_min_messages

**Parameter description**: Specifies which level of messages will be sent to the client. Each level covers all the levels following it. The lower the level is, the fewer messages are sent.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

A same value for **client_min_messages** and **log_min_messages** does not indicate the same level.

**Value range**: enumerated type. The valid values are **debug**, **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error**, **fatal** and **panic**. Among them, **debug** and **debug2** are equivalent. For details about the parameters, see **Table 19-2**. If the configured level is higher than **error**, for example, **fatal** or **panic**, the system changes the level to **error** by default.

**Default value**: **notice**

### log_min_messages

**Parameter description**: Specifies which level of messages will be written into the server log. Each level covers all the levels following it. The lower the level is, the fewer messages will be written into the log.

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This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

A same value for **client_min_messages** and **log_min_messages** does not indicate the same level.

**Value range**: enumerated type. The valid values are **debug**, **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error**, **fatal** and **panic**. Among them, **debug** and **debug2** are equivalent. For details about the parameters, see **Table 19-2**.

**Default value**: **warning**

## log_min_error_statement

**Parameter description**: Controls which SQL statements that cause an error condition are recorded in the server log.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values. Valid values are **debug**, **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error**, **fatal**, and **panic**. For details about the parameters, see **Table 19-2**.

NOTE

- The default is **error**, indicating that statements causing errors, log messages, fatal errors, or panics will be logged.
- **panic** indicates that SQL statements that cause an error condition will not be logged.

**Default value**: **error**

## log_min_duration_statement

**Parameter description**: Specifies the threshold for logging the duration of a completed statement. If a statement runs for a duration greater than or equal to the specified value, its duration will be logged.

Setting this parameter can be helpful in tracking down unoptimized queries. For clients using extended query protocols, the time required for parsing, binding, and executing steps are logged independently.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

When using this option together with **log_statement**, the text of statements that are logged because of **log_statement** will not be repeated in the duration log message. If you are not using **syslog**, it is recommended that you log the process ID (PID) or session ID using **log_line_prefix** so that you can link the statement message to the later duration message.

**Value range**: an integer ranging from –1 to 2147483647. The unit is ms.

- If this parameter is set to **250**, all SQL statements that run for 250 ms or longer will be logged.
- **0** indicates that the execution durations of all the statements are logged.
- **–1** indicates that the duration logging is disabled.

**Default value:** 3s (that is, 3000 ms)

## backtrace_min_messages

**Parameter description**: Prints the function's stack information to the server's log file if the information generated is greater than or equal to the level specified by this parameter.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

This parameter is used to locate problems on-site. Frequent stack printing will affect the system's overhead and stability. Therefore, set the value of this parameter to a rank other than **fatal** or **panic** during problem location.

**Value range**: enumerated values

Valid values are **debug**, **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error**, **fatal**, and **panic**. For details about the parameters, see **Table 19-2**.

**Default value**: **panic**

**Table 19-2** explains message severities used by GaussDB. If logging output is sent to syslog or eventlog, severity is translated in GaussDB as shown in the table.

**Table 19-2** Message severity levels

| Severity | Description | System Log | Event Log |
| --- | --- | --- | --- |
| debug[1-5] | Provides detailed debug information. | DEBUG | INFORMATION |

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| Severity | Description | System Log | Event Log |
| --- | --- | --- | --- |
| log | Reports information of interest to administrators, for example, checkpoint activity. | INFO | INFORMATION |
| info | Provides information implicitly requested by users, for example, output from **VACUUM VERBOSE**. | INFO | INFORMATION |
| notice | Provides information that might be helpful to users, for example, truncation of long identifiers and index created as part of the primary key. | NOTICE | INFORMATION |
| warning | Provides warnings of likely problems, for example, **COMMIT** outside a transaction block. | NOTICE | WARNING |
| error | Reports an error that causes a command to terminate. | WARNING | ERROR |
| fatal | Reports the reason that causes a session to terminate. | ERR | ERROR |
| panic | Reports an error that caused all database sessions to terminate. | CRIT | ERROR |

## plog_merge_age

**Parameter description**: Specifies the output period of performance log data. The current feature is a lab feature. Contact Huawei technical support before using it.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**NOTICE**

The parameter value is in milliseconds. You are advised to set it to a multiple of 1000. That is, the value is in seconds. The performance log files controlled by this parameter are stored in the **$GAUSSLOG/gs_profile/**<*node_name*> directory in .prf format. *node_name* is the value of **pgxc_node_name** in the **postgres.conf** file.

**Value range**: a number ranging from 0 to 2147483647. The unit is ms.

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**0** indicates that the current session will not log performance data. A value other than 0 indicates that the current session will log performance data based on the period specified by this parameter.

A small value indicates that much data is logged, which seriously affects performance.

**Default value: 0s**

## 19.9.3 Logging Content

### debug_print_parse

**Parameter description**: Specifies whether to print parsing tree results.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the printing is enabled.
- **off** indicates that the printing is disabled.

**Default value**: **off**

### debug_print_rewritten

**Parameter description**: Specifies whether to print query rewriting results.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the printing is enabled.
- **off** indicates that the printing is disabled.

**Default value**: **off**

### debug_print_plan

**Parameter description**: Specifies whether to print the query execution plan to logs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the printing is enabled.
- **off** indicates that the printing is disabled.

**Default value**: **off**

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NOTICE

- Debugging information about **debug_print_parse**, **debug_print_rewritten**, and **debug_print_plan** are printed only when the log level is set to **log** or higher. When these parameters are set to **on**, their debugging information will be recorded in server logs and will not be sent to client logs. You can change the log level by setting **client_min_messages** and **log_min_messages**.
- Do not invoke the **gs_encrypt_aes128** and **gs_decrypt_aes128** functions when **debug_print_plan** is set to **on**, preventing the risk of sensitive information disclosure. You are advised to filter parameter information of the **gs_encrypt_aes128** and **gs_decrypt_aes128** functions in the log files generated when **debug_print_plan** is set to **on** before providing the log files to external maintenance engineers for fault locating. After you finish using the logs, delete them as soon as possible.

## debug_pretty_print

**Parameter description**: Indents the logs produced by **debug_print_parse**, **debug_print_rewritten**, and **debug_print_plan**. The output format is more readable but much longer than that generated when this parameter is set to **off**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the indentation is enabled.
- **off** indicates that the indentation is disabled.

**Default value**: **on**

## log_checkpoints

**Parameter description**: Specifies whether the statistics on checkpoints and restart points are recorded in the server logs. When this parameter is set to **on**, statistics on checkpoints and restart points are recorded in the log messages, including the number of buffers written and the time spent in writing them.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the statistics on checkpoints and restart points are recorded in the server logs.
- **off** indicates that the statistics on checkpoints and restart points are not recorded in the server logs

**Default value**: **off**

## log_connections

**Parameter description**: Specifies whether to record connection request information of the client.

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This parameter is a BACKEND parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

Some client programs, such as gsql, attempt to connect twice while determining if a password is required. In this case, duplicate "connection receive" messages do not necessarily indicate a problem.

**Value range**: Boolean

- **on** indicates that the request information is recorded.
- **off** indicates that the request information is not recorded.

**Default value**: **off**

## log_disconnections

**Parameter description**: Specifies whether to record disconnection request information of the client.

This parameter is a BACKEND parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the request information is recorded.
- **off** indicates that the request information is not recorded.

**Default value**: **off**

## log_duration

**Parameter description**: Specifies whether to record the duration of every completed SQL statement. For clients using extended query protocols, the time required for parsing, binding, and executing steps are logged independently.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **off**: Compared with this option, **log_min_duration_statement** forcibly records the query text.
- If this parameter is set to **on** and **log_min_duration_statement** is set to a positive value, the duration of each completed statement is logged but the query text is included only for statements exceeding the threshold. This behavior can be used for gathering statistics in high-load situation.

**Default value**: **off**

## log_error_verbosity

**Parameter description**: Specifies the amount of detail written in the server log for each message that is logged.

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This parameter is a SUSET parameter. Set it based on instructions provided in Table 11-1.

**Value range:** enumerated values

- **terse** indicates that the output excludes the DETAIL, HINT, QUERY, and CONTEXT error information.
- **verbose** indicates that the output includes the SQLSTATE error code, the source code file name, function name, and number of the line in which the error occurs.
- **default** indicates that the output includes the DETAIL, HINT, QUERY, and CONTEXT error information, and excludes the SQLSTATE error code, the source code file name, function name, and number of the line in which the error occurs.

**Default value**: **default**

## log_hostname

**Parameter description**: By default, connection log messages only show the IP address of the connecting host. The host name can be recorded when this parameter is set to **on**. It may take some time to parse the host name. Therefore, the database performance may be affected.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the host name is simultaneously recorded.
- **off** indicates that the host name is not simultaneously recorded.

**Default value**: **off**

## log_line_prefix

**Parameter description**: Specifies the prefix format of each log information. A prefix is a printf-style string that is output at the beginning of each line of the log. The "escape sequences" which begin with **%** are replaced with status information as listed in Table 19-3.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Table 19-3** Escape characters

| Escape Character | Effect |
| --- | --- |
| %a | Application name |
| %u | Username |
| %d | Database name |

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| Escape Character | Effect |
| --- | --- |
| %r | Remote host name or IP address and remote port. If **log_hostname** is set to **off**, only the IP address and remote port are displayed. |
| %h | Remote host name or IP address. If **log_hostname** is set to **off**, only the IP address is displayed. |
| %p | Thread ID |
| %t | Timestamp without milliseconds (no time zone in the Windows OS) |
| %m | Timestamp with milliseconds |
| %n | Node from which an error is reported |
| %i | Command tag: type of command executed in the current session |
| %e | SQLSTATE error code |
| %c | Session ID: For details, see the note below the table. |
| %l | Number of the log line for each session, starting from 1 |
| %s | Start time of a session |
| %v | Virtual transaction ID (backendID/ localXID) |
| %x | Transaction ID (**0** indicates that no transaction ID is assigned) |
| %q | Produces no output. If the current thread is a backend thread, this escape sequence is ignored and subsequent escape sequences are processed. Otherwise, this escape sequence and subsequent escape sequences are all ignored. |
| %S | Session ID |
| %T | Trace ID |
| %% | The character % |

**NOTE**

The %c escape character prints a unique session ID consisting of two 4-byte hexadecimal numbers separated by a period (.). The numbers are the process startup time and the process ID. Therefore, %c can also be used as a space saving way of printing those items. For example, run the following query to generate the session ID from **pg_stat_activity**:

```
SELECT to_hex(EXTRACT(EPOCH FROM backend_start)::integer) || '.' ||
       to_hex(pid)
FROM pg_stat_activity;
```

- If you set a non-empty value for **log_line_prefix**, ensure that its last character is a space, to provide visual separation from the rest of the log line. A punctuation character can be used, too.
- Syslog generates its own timestamp and process ID information. Therefore, you do not need to include those escapes characters when you are logging in to syslog.

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**Value range**: a string

**Default value**: **'%m %n %u %d %h %p %S %x %a '**

NOTE

**%m %n %u %d %h %p %S %x %a** indicates the session start timestamp, error reporting node, username, database name, remote host name or IP address, thread ID, session ID, transaction ID, and application name.

## log_lock_waits

**Parameter description**: If the time for which a session waits to acquire a lock is longer than the value of **deadlock_timeout**, this parameter specifies whether to record this message in the database. This is useful in determining if lock waits are causing poor performance.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the information is recorded.
- **off** indicates that the information is not recorded.

**Default value**: **off**

## log_statement

**Parameter description**: Specifies which SQL statements are recorded. For clients using extended query protocols, logging occurs when an Execute message is received, and values of the Bind parameters are included (with any embedded single quotation marks doubled).

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

Statements that contain simple syntax errors are not logged even if **log_statement** is set to **all**, because the log message is emitted only after basic parsing has been completed to determine the statement type. If an extended query protocol is used, statements that fail before the execution phase (during parse analysis or planning) are not logged, either. Set **log_min_error_statement** to **ERROR** or lower to log such statements.

**Value range:** enumerated values

- **none** indicates that no statement is recorded.
- **ddl** indicates that all data definition statements, such as CREATE, ALTER, and DROP, are recorded.
- **mod** indicates that all DDL statements and data modification statements, such as INSERT, UPDATE, DELETE, TRUNCATE, and COPY FROM, are recorded.

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- **all** indicates that all statements, including the PREPARE, EXECUTE, and EXPLAIN ANALYZE statements, are recorded.

**Default value**: **none**

## log_temp_files

**Parameter description**: Specifies whether to record the deletion information of temporary files. Temporary files can be created for sorting, hashing, and storing temporary querying results. If the recording is enabled, a log entry is generated for each temporary file when it is deleted.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 2147483647. The unit is KB.

- A positive value indicates that the deletion information of temporary files whose size is larger than the specified value of **log_temp_files** is recorded.
- **0** indicates that the delete information of all temporary files is recorded.
- **–1** indicates that the delete information of any temporary files is not recorded.

**Default value**: **–1**

## log_timezone

**Parameter description**: Specifies the time zone used for timestamps written in the server log. Different from **TimeZone**, this parameter takes effect for all sessions in the database.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. You can obtain it by querying the **PG_TIMEZONE_NAMES** view.

**Default value**: Set this parameter based on the OS time zone.

NOTE

The default value will be changed when **gs_initdb** is used to set system environments.

## logging_module

**Parameter description**: Specifies whether module logs are output on the server. This parameter is a session-level parameter, and you are advised not to use the **gs_guc** tool to set it.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **off**. All the module logs are not output on the server. You can view the logs by running **show logging_module**.

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```
ALL,on(),off(GUC,SLRU,MEM_CTL,AUTOVAC,CACHE,ADIO,SSL,GDS,TBLSPC,WLM,OBS,EXECUTOR,VEC_EXECU
TOR,STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,OPT_SETOP,OPT_SKEW,UDF,COO
P_ANALYZE,WLMCP,ACCELERATE,PARQUET,PLANHINT,SNAPSHOT,XACT,HANDLE,CLOG,EC,REMOTE,CN_RETR
Y,PLSQL,TEXTSEARCH,SEQ,REDO,FUNCTION,PARSER,INSTR,INCRE_CKPT,DBL_WRT,RTO,HEARTBEAT,COMM_I
PC,COMM_PARAM,ENCODING_CHECK)
```

**Setting method**: Run **show logging_module** to view which modules are controllable. For example, the query output result is as follows:

```
openGauss=# show logging_module;
logging_module
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
ALL,on(),off(GUC,SLRU,MEM_CTL,AUTOVAC,CACHE,ADIO,SSL,GDS,TBLSPC,WLM,OBS,EXECUTOR,VEC_EXECU
TOR,STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,OPT_SETOP,OPT_SKEW,UDF,COO
P_ANALYZE,WLMCP,ACCELERATE,PARQUET,PLANHINT,SNAPSHOT,XACT,HANDLE,CLOG,EC,REMOTE,CN_RETR
Y,PLSQL,TEXTSEARCH,SEQ,REDO,FUNCTION,PARSER,INSTR,INCRE_CKPT,DBL_WRT,RTO,HEARTBEAT,COMM_I
PC,COMM_PARAM,ENCODING_CHECK)
(1 row)
```

Controllable modules are identified by uppercase letters, and the special ID **ALL** is used for setting all module logs. You can control the output of module logs by setting **logging_module** to **on** or **off**. Enable log output for SSL:

```
openGauss=# set logging_module='on(SSL)';
SET
openGauss=# show
logging_module;
       logging_module
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
ALL,on(SSL),off(GUC,SLRU,MEM_CTL,AUTOVAC,CACHE,ADIO,GDS,TBLSPC,WLM,OBS,EXECUTOR,VEC_EXECU
TOR,STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,OPT_SETOP,OPT_SKEW,UDF,COO
P_ANALYZE,WLMCP,ACCELERATE,PARQUET,PLANHINT,SNAPSHOT,XACT,HANDLE,CLOG,EC,REMOTE,CN_RETR
Y,PLSQL,TEXTSEARCH,SEQ,REDO,FUNCTION,PARSER,INSTR,INCRE_CKPT,DBL_WRT,RTO,HEARTBEAT,COMM_I
PC,COMM_PARAM,ENCODING_CHECK)
(1 row)
```

SSL log output is enabled.

The **ALL** identifier can be used to quickly enable or disable log output for all modules.

```
openGauss=# set logging_module='off(ALL)';
SET
openGauss=# show
logging_module;
        logging_module
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
ALL,on(),off(GUC,SLRU,MEM_CTL,AUTOVAC,CACHE,ADIO,SSL,GDS,TBLSPC,WLM,OBS,EXECUTOR,VEC_EXECU
TOR,STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,OPT_SETOP,OPT_SKEW,UDF,COO
P_ANALYZE,WLMCP,ACCELERATE,PARQUET,PLANHINT,SNAPSHOT,XACT,HANDLE,CLOG,EC,REMOTE,CN_RETR
Y,PLSQL,TEXTSEARCH,SEQ,REDO,FUNCTION,PARSER,INSTR,INCRE_CKPT,DBL_WRT,RTO,HEARTBEAT,COMM_I
PC,COMM_PARAM,ENCODING_CHECK)
(1 row)

openGauss=# set logging_module='on(ALL)';
SET
openGauss=# show
logging_module;
       logging_module
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------
ALL,on(GUC,SLRU,MEM_CTL,AUTOVAC,CACHE,ADIO,SSL,GDS,TBLSPC,WLM,OBS,EXECUTOR,VEC_EXECUTOR,
```

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```
STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,OPT_SETOP,OPT_SKEW,UDF,COOP_AN
ALYZE,WLMCP,ACCELERATE,PARQUET,PLANHINT,SNAPSHOT,XACT,HANDLE,CLOG,EC,REMOTE,CN_RETRY,PLS
QL,TEXTSEARCH,SEQ,REDO,FUNCTION,PARSER,INSTR,INCRE_CKPT,DBL_WRT,RTO,HEARTBEAT,COMM_IPC,C
OMM_PARAM,ENCODING_CHECK),off()
(1 row)
```

**Dependency**: The value of this parameter depends on the settings of **log_min_level**.

## enable_unshipping_log

**Parameter description**: Specifies whether to log statements that are not pushed down. The logs help locate performance issues that may be caused by statements not pushed down. If **enable_stream_operator** is set to **off** and this parameter is set to **on**, a large number of logs indicating that plans cannot be pushed down are recorded. If you do not need these logs, you are advised to set both **enable_unshipping_log** and **enable_stream_operator** to **off**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that statements not pushed down are logged.
- **off** indicates that statements not pushed down are not logged.

**Default value**: **off**

## opfusion_debug_mode

**Parameter description**: Checks whether simple queries are optimized for debugging. If this parameter is set to **log**, you can view the specific reasons why queries are not optimized in the DN execution plans.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** enumerated values

- **off** indicates that reasons why queries are not optimized are not included.
- **log** indicates that reasons why queries are not optimized are included in the DN execution plan.

**NOTICE**

- You need to set **max_datanode_for_plan** to view the DN execution plans.
- To view the reasons why queries are not optimized in the log, set **opfusion_debug_mode** to **log**, **log_min_messages** to **debug4**, and **logging_module** to **on(OPFUSION)**. Note that a large amount of log messages may be generated. Therefore, execute only a small number of jobs during debugging.

**Default value**: **off**

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### enable_debug_vacuum

**Parameter description**: Specifies whether to allow output of some VACUUM-related logs for problem locating. This parameter is used only by developers. Common users are advised not to use it.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on/true** indicates that output of VACUUM-related logs is allowed.
- **off/false** indicates that output of VACUUM-related logs is disallowed.

**Default value**: **off**

### resource_track_log

**Parameter description**: Specifies the log level of self-diagnosis. Currently, this parameter takes effect only in multi-column statistics. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

- **summary**: Brief diagnosis information is displayed.
- **detail**: Detailed diagnosis information is displayed.

Currently, the two parameter values differ only when there is an alarm about multi-column statistics not collected. If the parameter is set to **summary**, such an alarm will not be displayed. If it is set to **detail**, such an alarm will be displayed.

**Default value**: **summary**

## 19.9.4 Using CSV Log Output

### Prerequisites

- The **log_destination** parameter is set to **csvlog**.
- The **logging_collector** parameter is set to **on**.

### Definition of csvlog

Log lines are emitted in comma separated values (CSV) format.

An example table definition for storing CSV-format log output is shown as follows:

```
CREATE TABLE postgres_log
(
log_time timestamp(3) with time zone,
node_name text,
user_name text,
database_name text,
process_id bigint,
connection_from text,
"session_id" text,
session_line_num bigint,
```

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```
command_tag text,
session_start_time timestamp with time zone,
virtual_transaction_id text,
transaction_id bigint,
query_id bigint,
module text,
error_severity text,
sql_state_code text,
message text,
detail text,
hint text,
internal_query text,
internal_query_pos integer,
context text,
query text,
query_pos integer,
location text,
application_name text
);
```

For details, see **Table 19-4**.

**Table 19-4** Meaning of each csvlog field

| Field | Description | Field | Description |
| --- | --- | --- | --- |
| log_time | Timestamp in milliseconds | module | Log module |
| node_name | Node name | error_severity | ERRORSTATE code |
| user_name | Username | sql_state_code | SQLSTATE code |
| database_name | Database name | message | Error message |
| process_id | Process ID | detail | Detailed error message |
| connection_from | Port number of the client host | hint | Prompt message |
| session_id | Session ID | internal_query | Internal query (This field is used to query the information leading to errors if any.) |
| session_line_num | Number of lines in each session | internal_query_pos | Pointer for an internal query |
| command_tag | Command tag | context | Environment |

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| Field | Description | Field | Description |
| --- | --- | --- | --- |
| session_start_time | Start time of a session | query | Character count at the position where errors occur |
| virtual_transaction_id | Regular transaction | query_pos | Pointer at the position where errors occur |
| transaction_id | Transaction ID | location | Position where errors occur in the GaussDB source code if **log_error_verbosity** is set to **verbose** |
| query_id | Query ID | application_name | Application name |

Run the following command to import a log file to this table:

```
COPY postgres_log FROM '/opt/data/pg_log/logfile.csv' WITH csv;
```

NOTE

The log name (**logfile.csv**) here needs to be replaced with the name of a log generated.

### Simplifying Input

Simplify importing CSV log files by performing the following operations:

- Set **log_filename** and **log_rotation_age** to provide a consistent, predictable naming solution for log files. By doing this, you can predict when an individual log file is complete and ready to be imported.
- Set **log_rotation_size** to **0** to disable size-based log rollback, as it makes the log file name difficult to predict.
- Set **log_truncate_on_rotation** to **on** so that old log data cannot be mixed with the new one in the same file.

## 19.10 Alarm Detection

During the running of the cluster, error scenarios can be detected and informed to users in a timely manner. You can view the **system_alarm** log written by the alarm in the *$GAUSSLOG*/**cm** or the *$GAUSSLOG*/**pg_log/gtm** directory.

### enable_alarm

**Parameter description**: Specifies whether to enable the alarm detection thread to detect fault scenarios that may occur in the database.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

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- **on** indicates that the alarm detection thread is enabled.
- **off** indicates that the alarm detection thread is disabled.

**Default value**: **on**

NOTE

This parameter takes effect only on CNs and DNs.

## connection_alarm_rate

**Parameter description**: Specifies the ratio restriction on the maximum number of allowed parallel connections to the database. The maximum number of concurrent connections to the database is **max_connections** x **connection_alarm_rate**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** a floating point number ranging from 0.0 to 1.0

**Default value**: **0.9**

## alarm_report_interval

**Parameter description**: specifies the interval at which an alarm is reported.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer. The unit is s.

**Default value: 10**

## alarm_component

**Parameter description**: Certain alarms are suppressed during alarm reporting. That is, the same alarm will not be repeatedly reported by an instance within the period specified by **alarm_report_interval**. Its default value is **10s**. In this case, the parameter specifies the location of the alarm component that is used to process alarm information. Only the sysadmin user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

- If **--alarm-type** in the **gs_preinstall** script is set to **5**, no third-party component is connected and alarms are written into the **system_alarm** log. In this case, the value of **alarm_component** is **/opt/huawei/snas/bin/snas_cm_cmd**.
- If **--alarm-type** in the **gs_preinstall** script is set to **1**, a third-party component is connected. In this case, the value of **alarm_component** is the absolute path of the executable program of the third-party component.

**Default value**: **/opt/huawei/snas/bin/snas_cm_cmd**

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# 19.11 Statistics During the Database Running

## 19.11.1 Query and Index Statistics Collector

The query and index statistics collector is used to collect statistics during database running. The statistics include the times of inserting and updating a table and index, the number of disk blocks and tuples, and the time required for the last cleanup and analysis on each table. The statistics can be viewed by querying system view **pg_stats** and **pg_statistic**. The following parameters are used to set the statistics collection feature in the server scope.

### track_activities

**Parameter description:** Collects statistics about the commands that are being executed in session. For a stored procedure, if this parameter is enabled, you can view the PERFORM statement, stored procedure calling statement, SQL statement, and OPEN CURSOR statement that are being executed in the stored procedure in the pg_stat_activity view.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the statistics collection function is enabled.
- **off** indicates that the statistics collection function is disabled.

**Default value**: **on**

### track_counts

**Parameter description:** Collects statistics about database activities.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the statistics collection function is enabled.
- **off** indicates that the statistics collection function is disabled.

NOTE

When the database to be cleaned up is selected from the **AutoVacuum** automatic cleanup process, the database statistics are required. In this case, the default value is set to **on**.

**Default value**: **on**

### track_io_timing

**Parameter description:** Collects statistics about I/O timing in the database. The I/O timing statistics can be queried by using the **pg_stat_database** parameter.

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This parameter is a SUSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- If this parameter is set to **on**, the collection function is enabled. In this case, the collector repeatedly queries the operating system at the current time. As a result, large number of costs may occur on some platforms. Therefore, the default value is set to **off**.
- **off** indicates that the statistics collection function is disabled.

**Default value**: **off**

## track_functions

**Parameter description:** Collects statistics of the number and duration of function invocations.

This parameter is a SUSET parameter. Set it based on instructions provided in Table 11-1.

NOTICE

When the SQL functions are set to inline functions queried by the invoking, these SQL functions cannot be traced no matter these functions are set or not.

**Value range**: enumerated values

- **pl** indicates that only procedural language functions are traced.
- **all** indicates that SQL and C language functions are traced. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)
- **none** indicates that the function tracing function is disabled.

**Default value**: **none**

## track_activity_query_size

**Parameter description**: Specifies byte counts of the current running commands used to trace each active session.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 100 to 102400

**Default value: 1024**

## update_process_title

**Parameter description:** Collects statistics updated with a process name each time the server receives a new SQL statement.

The process name can be viewed on Windows task manager by running the **ps** command.

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This parameter is an INTERNAL parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the statistics collection function is enabled.
- **off** indicates that the statistics collection function is disabled.

**Default value**: **off**

## stats_temp_directory

**Parameter description**: Specifies the directory for storing temporary statistics. Only the **sysadmin** user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

NOTICE

If a RAM-based file system directory is used, the actual I/O cost can be lowered and the performance can be improved.

**Value range**: a string

**Default value**: **pg_stat_tmp**

## track_thread_wait_status_interval

**Parameter description**: Specifies the interval of collecting the thread status information.

This parameter is a SUSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 0 to 1440. The unit is min.

**Default value**: **30min**

## enable_save_datachanged_timestamp

**Parameter description**: Specifies whether to record the time when **INSERT**, **UPDATE**, **DELETE**, or **EXCHANGE**/**TRUNCATE**/**DROP PARTITION** is performed on table data.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the time when an operation is performed on table data will be recorded.
- **off** indicates that the time when an operation is performed on table data will not be recorded.

**Default value**: **on**

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### track_sql_count

**Parameter description**: Collects statistics on the statements (**SELECT**, **INSERT**, **UPDATE**, **MERGE INTO**, and **DELETE**) that are being executed in a session.

In the x86-based centralized deployment scenario, the hardware configuration specifications are 32-core CPU and 256 GB memory. When the Benchmark SQL 5.0 tool is used to test performance, the performance fluctuates by about 0.8% by enabling or disabling this parameter.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the statistics collection function is enabled.
- **off** indicates that the auditing function is disabled.

**Default value**: **on**

NOTE

If **track_sql_count** is set to **off**, querying the **gs_sql_count** or **pgxc_sql_count** view returns **0**.

## 19.11.2 Performance Statistics

During the running of the database, the lock access, disk I/O operation, and invalid message processing are involved. All these operations are the bottleneck of the database performance. The performance statistics provided by GaussDB can facilitate the performance fault location.

### Generating Performance Statistics Logs

**Parameter description**: For each query, the following four parameters record the performance statistics of corresponding modules in the server log:

- The **log_parser_stats** parameter records the performance statistics of a parser in the server log.
- The **log_planner_stats** parameter records the performance statistics of a query optimizer in the server log.
- The **log_executor_stats** parameter records the performance statistics of an executor in the server log.
- The **log_statement_stats** parameter records the performance statistics of the whole statement in the server log.

All these parameters can only provide assistant analysis for administrators, which are similar to the getrusage() of the Linux OS.

These parameters are SUSET parameters. Set them based on instructions provided in **Table 11-1**.

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NOTICE

- The **log_statement_stats** records the total statement statistics whereas other parameters record statistics only about their corresponding modules.
- The **log_statement_stats** parameter cannot be enabled together with any parameter recording statistics about a module.

**Value range**: Boolean

- **on** indicates that performance statistics are recorded.
- **off** indicates that performance statistics are not recorded.

**Default value**: **off**

## 19.11.3 Hotspot Key Statistics

In the distributed architecture, if applications access a node in a short period of time, the resource usage of the node is too high, affecting the normal running of the database. GaussDB provides the function of quickly detecting hotspot keys to quickly determine whether there are hotspot keys and the distribution of hotspot keys.

### enable_hotkeys_collection

**Parameter description**: Specifies whether to automatically collect statistics on the accessed key values in the database.

This parameter is a SUSET parameter. Set it based on instructions provided in Table 11-1.

NOTE

If you set parameters using **gs_guc** set, you need to restart the database for the GUC parameters to take effect. During the restart, hotspot key information is cleared.

When the GUC parameter is disabled, the query result of the hotspot key is empty and a message is displayed indicating that the GUC parameter is disabled. However, when the function is disabled, the hotspot key clearance API can still be used.

**Value range**: Boolean

- **on** indicates that the statistics collection function is enabled.
- **off** indicates that the auditing function is disabled.

**Default value**: **off**

# 19.12 Workload Management

The current feature is a lab feature. Contact Huawei technical support before using it.

If database resource usage is not controlled, concurrent tasks may preempt resources. As a result, the OS will be overloaded and cannot respond to user tasks; or even crash and cannot provide any services to users. The GaussDB workload

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management balances the database workload based on available resources to prevent database overloads.

## use_workload_manager

**Parameter description**: Specifies whether to enable the resource management function. This parameter must be set to a same value on CNs and DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the resource management function is enabled.
- **off** indicates that the resource management function is disabled.

  NOTE

  - If method 2 in **Table 11-1** is used to change the parameter value, the new value takes effect only for the threads that are started after the change. In addition, the new value does not take effect for new jobs that are executed by backend threads and reused threads. You can make the new value take effect for these threads by using **kill session** or restarting the node.
  - After the value of **use_workload_manager** changes from **off** to **on**, statistics about storage resources when **use_workload_manager** was **off** are not collected. To collect statistics about such resources, run the following statement:

    ```
    select gs_wlm_readjust_user_space(0);
    ```

**Default value**: **on**

## enable_control_group

**Parameter description**: Specifies whether to enable the Cgroups. This parameter must be set to a same value on CNs and DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the Cgroups are enabled.
- **off** indicates that the Cgroups are disabled.

**Default value**: **on**

NOTE

If method 2 in **Table 11-1** is used to change the parameter value, the new value takes effect only for the threads that are started after the change. In addition, the new value does not take effect for new jobs that are executed by backend threads and reused threads. You can make the new value take effect for these threads by using **kill session** or restarting the node.

## enable_backend_control

**Parameter description**: Specifies whether to move database permanent threads to the **DefaultBackend** control group. This parameter must be set to a same value on CNs and DNs.

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This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that permanent threads are moved to the **DefaultBackend** control group.
- **off** indicates that permanent threads are not moved to the **DefaultBackend** control group.

**Default value**: **on**

## enable_vacuum_control

**Parameter description**: Specifies whether to move the autovacuum worker thread to the **Vacuum** control group. This parameter must be set to a same value on CNs and DNs.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the autovacuum worker thread is moved to the **Vacuum** control group.
- **off** indicates that the autovacuum worker thread is not moved to the **Vacuum** control group.

**Default value**: **on**

## enable_perm_space

**Parameter description**: Specifies whether to enable the perm space function. This parameter must be set to a same value on CNs and DNs.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the perm space function is enabled.
- **off** indicates that the perm space function is disabled.

**Default value**: **on**

## enable_verify_active_statements

**Parameter description**: Specifies whether to enable the background calibration during static self-adaptive workload balancing. This parameter must be used on CNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the background calibration is enabled.

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- **off** indicates that the background calibration is disabled.

**Default value**: **on**

## max_active_statements

**Parameter description**: Specifies the maximum number of concurrent jobs in each CN. This parameter can be used in only CNs.

The database administrator should set the value of this parameter based on system resources (for example, CPU, I/O, and memory resources) to ensure that the system resources can be fully utilized and the system will not be crashed by too many concurrent jobs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 2147483647 The values **–1** and **0** indicate that the number of concurrent jobs is not limited.

## parctl_min_cost

**Parameter description**: Specifies the execution cost threshold of a statement. If the execution cost of a statement exceeds the specified value, the statement is subject to the concurrent limit of a resource pool. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 2147483647

- If the value is **–1** or the cost of executing a statement is less than 10, the statement is not subject to the concurrency limit of the resource pool.
- If the value is greater than or equal to **0**, **enable_dynamic_workload** is set to **off**, and the cost of executing a statement exceeds the value and is greater than or equal to 10, the statement is subject to the concurrency limit of the resource pool.

**Default value**: **100000**

## cgroup_name

**Parameter description**: Specifies the name of the Cgroup in use or changes the priority of items in the queue of the Cgroup.

If you set **cgroup_name** and then **session_respool**, the Cgroup associated with **session_respool** takes effect. If you reverse the order, the Cgroup associated with **cgroup_name** takes effect.

If the workload Cgroup level is specified during the **cgroup_name** change, the database does not check the Cgroup level. The level ranges from 1 to 10.

This parameter is a USERSET parameter. Set it based on method 3 in **Table 11-1**.

You are advised not to set **cgroup_name** and **session_respool** at the same time.

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**Value range**: a string

**Default value**: **DefaultClass:Medium**

NOTE

**DefaultClass:Medium** indicates the **Medium** Cgroup that belongs to the **Timeshare** Cgroup under the **DefaultClass** Cgroup.

## cpu_collect_timer

**Parameter description**: Specifies how frequently CPU data is collected during statement execution on DNs.

The database administrator should set a proper collection frequency based on system resources (for example, CPU, I/O, and memory resources). A too small value will affect the execution efficiency and a too large value will reduce the accuracy of exception handling.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483647. The unit is s.

**Default value**: **30**

## enable_cgroup_switch

**Parameter description**: Specifies whether a statement is automatically switched to the TopWD group when the statement is executed by control group type.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that a statement is automatically switched to the TopWD group when the statement is executed by control group type.
- **off** indicates that a statement is not automatically switched to the TopWD group when the statement is executed by control group type.

**Default value**: **off**

## memory_tracking_mode

**Parameter description**: Specifies the memory information recording mode.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**:

- **none** indicates that memory statistics are not collected.
- **peak** indicates that statistics on the peak value of the query level memory are collected. The value is recorded in the database log and can also be output by using **explain analyze**.
- **normal** indicates that memory statistics are collected in real time but no file is generated.

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- **executor** indicates that a statistics file is generated, containing the context information of all allocated memory used on the execution layer.
- **fullexec** indicates that a statistics file is generated, containing the information about all memory contexts requested by the execution layer.

**Default value**: **none**

## memory_detail_tracking

**Parameter description**: Specifies the memory context allocation priority of a thread and the plannodeid of the query for which the current thread is running. This parameter is only suitable for the DEBUG version.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: a string

**Default value**: **–1** for **Memory Context Sequent Count** and **Plan Nodeid**, indicating an empty value

NOTICE

You are advised to retain the default value for this parameter.

## enable_resource_track

**Parameter description**: Specifies whether the real-time resource monitoring is enabled. This parameter must be set to a same value on CNs and DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the resource monitoring is enabled.
- **off** indicates that the resource monitoring is disabled.

**Default value**: **on**

## enable_resource_record

**Parameter description**: Specifies whether resource monitoring records are archived. If this parameter is set to **on**, records in the **history** views (**GS_WLM_SESSION_HISTORY** and **GS_WLM_OPERATOR_HISTORY**) are archived to the corresponding **info** views (**GS_WLM_SESSION_INFO** and **GS_WLM_OPERATOR_INFO**) at an interval of 3 minutes. After being archived, the records are deleted from the **history** views. This parameter must be set to a same value on CNs and DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

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- **on** indicates that the resource monitoring records are archived.
- **off** indicates that the resource monitoring records are not archived.

**Default value**: **off**

## enable_logical_io_statistics

**Parameter description**: Specifies whether to enable the logical I/O statistics function during resource monitoring. If this function is enabled, the **read_kbytes**, **write_kbytes**, **read_counts**, **write_counts**, **read_speed**, and **write_speed** fields in the **PG_TOTAL_USER_RESOURCE_INFO** view will collect statistics on the byte count, number of times, and speed of logical read and write. Fields related to logical read and write in the system catalogs **GS_WLM_USER_RESOURCE_HISTORY** and **GS_WLM_INSTANCE_HISTORY** will collect statistics on the logical read and write of related users and instances.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the function is enabled.
- **off** indicates that the function is disabled.

**Default value**: **on**

## enable_user_metric_persistent

**Parameter description**: Specifies whether the historical monitoring data of user resources is dumped. If this parameter is set to **on**, data in the **PG_TOTAL_USER_RESOURCE_INFO** view is periodically sampled and saved to the system catalog **GS_WLM_USER_RESOURCE_HISTORY**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**on** indicates that the historical monitoring data of user resources is dumped.

**off** indicates that the historical monitoring data of user resources is not dumped

**Default value**: **on**

## user_metric_retention_time

**Parameter description**: Specifies the retention days of the historical monitoring data of user resources. This parameter is valid only when **enable_user_metric_persistent** is set to **on**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3650. The unit is day.

If this parameter is set to **0**, the historical monitoring data of user resources is permanently stored.

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If the value is greater than **0**, the historical monitoring data of user resources is stored for the specified number of days.

**Default value**: **7**

## enable_instance_metric_persistent

**Parameter description**: Specifies whether the instance resource monitoring data is dumped. When this parameter is set to **on**, the instance monitoring data is saved to the system catalog **GS_WLM_INSTANCE_HISTORY**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the instance resource monitoring data is dumped.
- **off** indicates that the instance resource monitoring data is not dumped.

**Default value**: **on**

## instance_metric_retention_time

**Parameter description**: Specifies the retention days of the historical monitoring data of instance resources. This parameter is valid only when **enable_instance_metric_persistent** is set to **on**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3650. The unit is day.

- If this parameter is set to **0**, the historical monitoring data of instance resources is permanently stored.
- If the value is greater than **0**, the historical monitoring data of instance resources is stored for the specified number of days.

**Default value**: **7**

## resource_track_level

**Parameter description**: Specifies the resource monitoring level of the current session. This parameter is valid only when **enable_resource_track** is set to **on**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values

- **none** indicates that resources are not monitored.
- **query** indicates that resources used at the query level are monitored.
- **operator** indicates that resources used at query and operator levels are monitored.

**Default value**: **query**

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## resource_track_cost

**Parameter description**: Specifies the minimum execution cost for resource monitoring on statements in the current session. This parameter is valid only when **enable_resource_track** is set to **on**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 2147483647

- **–1** indicates that resource monitoring is disabled.
- If the value is greater than or equal to 0:
  - A value ranging from **0** to **9** indicates that statements whose execution cost is greater than or equal to 10 will be monitored.
  - A value greater than or equal to **10** indicates that statements whose execution cost exceeds this value will be monitored.

**Default value**: **100000**

## resource_track_duration

**Parameter description**: Specifies the minimum statement execution time that determines whether information about jobs of a statement recorded in the real-time view will be dumped to a historical view after the statement is executed. Job information will be dumped from the real-time view (with the suffix **statistics**) to a historical view (with the suffix **history**) if the statement execution time is no less than this value. This parameter is valid only when **enable_resource_track** is set to **on**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is s.

- **0** indicates that historical information about all statements recorded in the real-time resource monitoring view are archived.
- If the value is greater than **0**, historical information about a statement whose execution time exceeds this value will be archived.

**Default value**: **1min**

## dynamic_memory_quota

**Parameter description**: Specifies the memory quota in adaptive workload scenarios, that is, the proportion of maximum available memory to total system memory.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 100

**Default value**: **80**

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## disable_memory_protect

**Parameter description**: Stops memory protection. To query system views when system memory is insufficient, set this parameter to **on** to stop memory protection. This parameter is used only to diagnose and debug the system when system memory is insufficient. Set it to **off** in other scenarios.

This parameter is a USERSET parameter and is valid only for the current session. Set this parameter following the method 3 in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that memory protection stops.
- **off** indicates that memory is protected.

**Default value**: **off**

## query_band

**Parameter description**: Specifies the job type of the current session.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: empty

## enable_bbox_dump

**Parameter description**: Specifies whether the black box function is enabled. The core files can be generated even when the core dump mechanism is not configured in the system. This function is valid only for CNs or DNs. For CMA, CMS, GTM, and fenced UDF, the system core mechanism must be configured to capture core files.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the black box function is enabled.
- **off** indicates that the black box function is disabled.

**Default value**: **on**

NOTICE

The generation of core files by the black box function depends on the open ptrace interface of the operating system. If the permission is insufficient (errno = 1), ensure that the **/proc/sys/kernel/yama/ptrace_scope** configuration is correct.

## enable_ffic_log

**Parameter description:** Specifies whether to enable the first failure information capture (FFIC) function. This function is valid only for CNs or DNs. For CMA, CMS,

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GTM, and fenced UDF, the system core mechanism must be configured to capture core files.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the FFIC function is enabled.
- **off** indicates that the FFIC function is disabled.

**Default value**: **on**

## enable_dynamic_workload

**Parameter description**: Specifies whether to enable the dynamic workload management function.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the dynamic workload management function is enabled.
- **off** indicates that the dynamic workload management function is disabled.

NOTICE

- If memory adaptation is enabled, you do not need to use **work_mem** to optimize the operator memory usage. The system will generate a plan for each statement based on the current workload, estimating the memory used by each operator and by the entire statement. In a concurrency scenario, statements are queued based on the system workload and their memory usage.
- In some cases, the optimizer cannot accurately estimate the number of rows and thereby underestimates or overestimates memory usage. If the memory usage is underestimated, the allocated memory will be automatically increased during statement running. If the memory usage is overestimated, system memory resources will not be fully used, and the number of statements waiting in a queue will increase, which probably results in low performance. To improve performance, identify the statements whose estimated memory usage is much greater than the peak memory of the DN and adjust the value of **query_mem** accordingly. For details, see **10.3.8 Configuring Key Parameters for SQL Tuning**.
- Importing column-store partitioned tables consumes many memory resources and is performance-sensitive. Dynamic workload management is not recommended for such an import.

## enable_acceleration_cluster_wlm

Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

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**Parameter description**: Specifies whether to enable the dynamic workload management function to accelerate the cluster. This parameter is valid only for computing resource pools. If this parameter is set to **on** in the cluster, the related logic is not enabled.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the dynamic workload management function is enabled for the cluster.
- **off** indicates that the dynamic workload management function is disabled for the cluster.

**Default value**: **off**

## enable_dywlm_adjust

**Parameter description**: Specifies whether inaccurate resource values will be dynamically adjusted. This parameter must be set to a same value on CNs and DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that inaccurate resource values will be dynamically adjusted.
- **off** indicates that inaccurate resource values will not be dynamically adjusted.

**Default value**: **on**

## enable_force_memory_control

**Parameter description**: Specifies whether to control simple queries based on memory usage when the concurrency control is enabled in a resource pool. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.) This parameter must be set to a same value on CNs and DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that simple queries are controlled.
- **off** indicates that simple queries are not controlled.

**Default value**: **off**

## enable_reaper_backend

**Parameter description**: Specifies whether the signal sent by a subthread when it exits is collected by a separate thread.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: Boolean

- **on** indicates that the signal is collected by a separate thread.
- **off** indicates that the signal is not collected by a separate thread.

**Default value**: **on**

## memory_fault_percent

**Parameter description**: Specifies the percentage of memory application failures during the memory fault test. This parameter is used only in the DEBUG version.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **0**

## bbox_dump_count

**Parameter description**: Specifies the maximum number of core files that are generated by GaussDB and can be stored in the path specified by **bbox_dump_path**. If the number of core files exceeds this value, old core files will be deleted. This parameter is valid only when **enable_bbox_dump** is set to **on**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 20

**Default value**: **8**

NOTE

When core files are generated during concurrent SQL statement execution, the number of files may be larger than the value of **bbox_dump_count**.

## bbox_dump_path

**Parameter description**: Specifies the path where the black box core files are generated. This parameter is valid only when **enable_bbox_dump** is set to **on**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: empty The default path where the black box core files are generated is /**proc/sys/kernel/core_pattern**. If the path is not a directory or you do not have the write permission on the directory, black box core files will be generated under the data directory of the database.

## bbox_blanklist_items

**Parameter description**: Specifies the anonymized data items of black box core files. This parameter is valid only when **enable_bbox_dump** is set to **on**.

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This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string of sensitive data items separated by commas (,).

**Default value**: empty which indicates that all supported sensitive data items of the core files generated by the black box are anonymized.

Currently, the following data items can be anonymized:

- SHARED_BUFFER: data buffer
- XLOG_BUFFER: redo log buffer
- DW_BUFFER: doublewrite data buffer
- XLOG_MESSAGE_SEND: buffer for sending primary/standby replication logs
- WALRECIVER_CTL_BLOCK: buffer for receiving primary/standby replication logs
- DATA_MESSAGE_SEND: buffer for sending primary/standby replication data
- DATA_WRITER_QUEUE: buffer for receiving primary/standby replication data

## bypass_workload_manager

**Parameter description**: Specifies whether to enable I/O control. This parameter must be set to a same value on CNs and DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

If **use_workload_manager** is not set to **on**, this parameter can be used to enable the I/O control independently. After the I/O control is enabled, you can set **io_limits** or **io_priority** to configure control details.

**Value range**: Boolean

- **on** indicates that the I/O control is enabled.
- **off** indicates that the I/O control is disabled.

## io_limits

**Parameter description**: Specifies the upper limit of Input/output operations per second (IOPS).

This parameter is a USERSET parameter. Set it based on method 3 in **Table 11-1**.

**Value range**: an integer ranging from 0 to 1073741823

**Default value**: **0**

## io_priority

**Parameter description**: Specifies the I/O priority for jobs that consume many I/O resources. It takes effect when the I/O usage reaches 50%.

This parameter is a USERSET parameter. Set it based on method 3 in **Table 11-1**.

**Value range**: enumerated values

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- **None** indicates no control.
- **Low** indicates that the IOPS is reduced to 10% of the original value.
- **Medium** indicates that the IOPS is reduced to 20% of the original value.
- **High** indicates that the IOPS is reduced to 50% of the original value.

**Default value**: **None**

## io_control_unit

**Parameter description**: Specifies the unit used to count the number of I/Os during I/O control in row-store scenarios. This parameter must be set to a same value on CNs and DNs.

This parameter is a SIGHUP parameter. Set it based on method 3 in **Table 11-1**.

Set a certain number of I/Os as one unit. This unit is used during the I/O control.

**Value range**: an integer ranging from 1000 to 1000000

**Default value**: **6000**

## session_respool

**Parameter description**: Specifies the resource pool associated with the current session.

This parameter is a USERSET parameter. Set it based on method 3 in **Table 11-1**.

If you set **cgroup_name** and then **session_respool**, the Cgroup associated with **session_respool** takes effect. If you reverse the order, the Cgroup associated with **cgroup_name** takes effect.

If the workload Cgroup level is specified during the **cgroup_name** change, the database does not check the Cgroup level. The level ranges from 1 to 10.

You are not advised to set **cgroup_name** and **session_respool** at the same time.

**Value range**: a string. This parameter can be set to the resource pool configured through **create resource pool**.

**Default value**: **invalid_pool**

## enable_transaction_parctl

**Parameter description**: Specifies whether to control transaction block statements and stored procedure statements.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that transaction block statements and stored procedure statements are controlled.
- **off** indicates that transaction block statements and stored procedure statements are not controlled.

**Default value**: **on**

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## session_statistics_memory

**Parameter description**: Specifies the memory size of a real-time query view.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 5 x 1024 to 50% of **max_process_memory**. The unit is KB.

**Default value**: **5 MB**

## topsql_retention_time

**Parameter description**: Specifies the retention period of historical TopSQL data in the **gs_wlm_session_query_info_all** and **gs_wlm_operator_info** tables.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3650. The unit is day. If it is set to **0**, the data is stored permanently. If the value is greater than **0**, the data is stored for the specified number of days.

**Default value**: **0**

## session_history_memory

**Parameter description**: Specifies the memory size of a historical query view.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 10 x 1024 to 50% of **max_process_memory**. The unit is KB.

**Default value: 10 MB**

## node_group_mode

**Parameter description**: Displays the current node group mode.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: a string

**Default value**: **"node group"**

## current_logic_cluster

**Parameter description**: Displays the name of the current logical cluster. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: a string

**Default value**: empty

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### transaction_pending_time

**Parameter description** Specifies the maximum queuing time of transaction block statements and stored procedure statements if **enable_transaction_parctl** is set to **on**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 1073741823. The unit is s.

- **–1** or **0** indicates that no queuing timeout is specified for transaction block statements and stored procedure statements. The statements can be executed when resources are available.
- A value greater than **0** indicates that if transaction block statements and stored procedure statements have been queued for a time longer than the specified value, they are forcibly executed regardless of the current resource situation.

**Default value**: **0**

NOTICE

This parameter is valid only for internal statements of stored procedures and transaction blocks. That is, this parameter takes effect only for the statements whose **enqueue** value is **Transaction** or **StoredProc** in **PG_SESSION_WLMSTAT**.

## 19.13 Automatic Vacuuming

The **autovacuum** process automatically runs the **VACUUM** and **ANALYZE** statements to recycle the record space marked as deleted and update statistics about the table.

### autovacuum

**Parameter description**: Specifies whether to start the **autovacuum** process in the database. Ensure that the **track_counts** parameter is set to **on** before starting the **autovacuum** process.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

NOTE

- Set the **autovacuum** parameter to **on** if you want to start the automatic cleanup of abnormal two-phase transactions when the system recovers from faults.
- If **autovacuum** is set to **on** and **autovacuum_max_workers** to **0**, the autovacuum process is started only when the system recovers from faults to clean up abnormal two-phase transactions.
- If **autovacuum** is set to **on** and **autovacuum_max_workers** to a value greater than **0**, the **autovacuum** process is started to clean up two-phase transactions and processes when the system recovers from faults.

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NOTICE

Even if **autovacuum** is set to **off**, the autovacuum process will be started automatically when a transaction ID wraparound is about to occur. When a **CREATE DATABASE** or **DROP DATABASE** operation fails, it is possible that the transaction has been committed or rolled back on some nodes whereas some nodes are still in the prepared state. In this case, perform the following operations to manually restore the nodes:

1. Use the gs_clean tool (setting the **option** parameter to -N) to query the xid of the abnormal two-phase transaction and nodes in the prepared status.
2. Log in to the nodes in the prepared state. Administrators connect to an available database such as **postgres** and run the **set xc_maintenance_mode = on** statement.
3. Commit or roll back the two-phase transaction based on the global transaction status.

**Value range**: Boolean

- **on** indicates that the **autovacuum** process is started.
- **off** indicates that the **autovacuum** process is not started.

**Default value**: **on**

## autovacuum_mode

**Parameter description**: Specifies whether the autoanalyze or autovacuum function is started. This parameter is valid only when **autovacuum** is set to **on**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: enumerated values

- **analyze** indicates that only autoanalyze is performed.
- **vacuum** indicates that only autovacuum is performed.
- **mix** indicates that both autoanalyze and autovacuum are performed.
- **none** indicates that neither of them is performed.

**Default value**: **mix**

## autoanalyze_timeout

**Parameter description**: Specifies the timeout period of autoanalyze. If the duration of autoanalyze on a table exceeds the value of **autoanalyze_timeout**, the autoanalyze is automatically canceled.

The timeout check cannot be completely accurate. In principle, the statistics on each CN must be consistent. Therefore, the synchronization between CNs will not be interrupted even if the synchronization times out. As a result, the actual execution time may exceed the user-defined time.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

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**Value range**: an integer ranging from 0 to 2147483, in seconds. The value **0** indicates no timeout.

**Default value**: **5min** (300s)

## autovacuum_io_limits

**Parameter description**: Specifies the upper limit of I/Os triggered by the autovacuum process per second.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from –1 to 1073741823. **–1** indicates that the default cgroup is used.

**Default value**: **–1**

## log_autovacuum_min_duration

**Parameter description**: Records each step performed by the autovacuum process to the server log when the execution time of the autovacuum process is greater than or equal to a certain value. This parameter helps track the autovacuum behavior.

For example, set the **log_autovacuum_min_duration** parameter to **250ms** to record the information about the autovacuum commands running longer than or equal to 250 ms.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from –1 to 2147483647. The unit is ms.

- **0** indicates that all autovacuum actions are recorded in the log.
- **–1** indicates that all autovacuum actions are not recorded in the log.
- A value other than **–1** indicates that a message is recorded when an autovacuum action is skipped due to a lock conflict.

**Default value**: **–1**

## autovacuum_max_workers

**Parameter description**: Specifies the maximum number of autovacuum worker threads that can run at the same time. The upper limit of this parameter is related to the values of **max_connections** and **job_queue_processes**.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer. The minimum value is **0**, indicating that autovacuum is not enabled. The theoretical maximum value is **262143**, but the actual maximum value is a dynamic value calculated by the following formula: 262143 – Value of **max_inner_tool_connections** – Value of **max_connections** – Value of **job_queue_processes** – Number of auxiliary threads – Number of autovacuum launcher threads – 1. The number of auxiliary threads and the number of

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autovacuum launcher threads are specified by two macros. Their default values are **20** and **2** respectively.

**Default value**: **3**

## autovacuum_naptime

**Parameter description**: Specifies the interval between activity rounds for the autovacuum process.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 2147483. The unit is s.

**Default value**: **10min** (600s)

## autovacuum_vacuum_threshold

**Parameter description**: Specifies the threshold for triggering the **VACUUM** operation. When the number of deleted or updated records in a table exceeds the specified threshold, the **VACUUM** operation is executed on this table.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 2147483647.

**Default value**: **50**

## autovacuum_analyze_threshold

**Parameter description**: Specifies the threshold for triggering the **ANALYZE** operation. When the number of deleted, inserted, or updated records in a table exceeds the specified threshold, the **ANALYZE** operation is executed on this table.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 2147483647.

**Default value**: **50**

## autovacuum_vacuum_scale_factor

**Parameter description**: Specifies a fraction of the table size added to the **autovacuum_vacuum_threshold** parameter when deciding whether to vacuum a table.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a floating point number ranging from 0.0 to 100.0

**Default value**: **0.2**

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## autovacuum_analyze_scale_factor

**Parameter description**: Specifies a fraction of the table size added to the **autovacuum_analyze_threshold** parameter when deciding whether to analyze a table.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a floating point number ranging from 0.0 to 100.0

**Default value**: **0.1**

## autovacuum_freeze_max_age

**Parameter description**: Specifies the maximum age (in transactions) that a table's **pg_class.relfrozenxid** field can attain before a VACUUM operation is performed.

- The old files under the subdirectory of **pg_clog/** can also be deleted by the **VACUUM** operation.
- Even if the **autovacuum** process is not started, the system will invoke the process to prevent transaction ID wraparound.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 100000 to 576460752303423487

**Default value**: **4000000000**

## autovacuum_vacuum_cost_delay

**Parameter description**: Specifies the value of the cost delay used in the **autovacuum** operation.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from –1 to 100. The unit is ms. **–1** indicates that the normal vacuum cost delay is used.

**Default value**: **20ms**

## autovacuum_vacuum_cost_limit

**Parameter description:** sets the value of the cost limit used in the **autovacuum** operation.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from –1 to 10000 **–1** indicates that the normal vacuum cost limit is used.

**Default value**: **–1**

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### twophase_clean_workers

**Parameter description**: Specifies the maximum number of concurrent cleanup operations that can be performed by the gs_clean tool.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-2.

**Value range**: an integer ranging from 1 to 10

**Default value**: **3**

### defer_csn_cleanup_time

**Parameter description**: Specifies the interval of recycling transaction IDs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-2.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **5s** (5000 ms)

# 19.14 Default Settings of Client Connection

## 19.14.1 Statement Behavior

This section describes related default parameters involved in the execution of SQL statements.

### search_path

**Parameter description**: Specifies the order in which schemas are searched when an object is referenced with no schema specified. The value of this parameter consists of one or more schema names. Different schema names are separated by commas (,).

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

- If the schema of temporary tables exists in the current session, the scheme can be listed in **search_path** by using the alias **pg_temp**, for example, **'pg_temp,public'**. The schema of temporary tables has the highest search priority and is always searched before all the other schemas specified in **pg_catalog** and **search_path**. Therefore, do not explicitly specify **pg_temp** to be searched after other schemas in **search_path**. This setting will not take effect and an error message will be displayed. If the alias **pg_temp** is used, the temporary schema will be searched only for tables, views, and data types, and not for functions or operators.
- The system catalog schema, **pg_catalog**, has the second highest search priority and is the first to be searched among all the schemas, excluding **pg_temp**, specified in **search_path**. Therefore, do not explicitly specify **pg_catalog** to be searched after other schemas in **search_path**. This setting will not take effect and an error message will be displayed.

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- When an object is created without a specific target schema, the object will be placed in the first valid schema listed in **search_path**. An error is reported if the search path is empty.
- The current effective value of the search path can be examined through the SQL function **current_schema**. This is different from examining the value of **search_path**, because the **current_schema** function displays the first valid schema name in **search_path**.

**Value range**: a string

NOTE

- When this parameter is set to **"$user", public**, shared use of a database (where no users have private schemas, and all share use of public), private per-user schemas and combinations of them are supported. Other effects can be obtained by modifying the default search path setting, either globally or per-user.
- When this parameter is set to a null string (''), the system automatically converts it into a pair of double quotation marks ("").
- If the content contains double quotation marks, the system considers them as insecure characters and converts each double quotation mark into a pair of double quotation marks.

**Default value**: **"$user",public**

NOTE

**$user** indicates the name of the schema with the same name as the current session user. If the schema does not exist, **$user** will be ignored.

## current_schema

**Parameter description**: Specifies the current schema.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **"$user",public**

NOTE

**$user** indicates the name of the schema with the same name as the current session user. If the schema does not exist, **$user** will be ignored.

## default_tablespace

**Parameter description**: Specifies the default tablespace of the created objects (tables and indexes) when a **CREATE** command does not explicitly specify a tablespace.

- The value of this parameter is either the name of a tablespace, or an empty string that indicates the use of the default tablespace of the current database. If a non-default tablespace is specified, users must have CREATE privilege for it. Otherwise, creation attempts will fail.
- This parameter is not used for temporary tables. For them, the **temp_tablespaces** is used instead.

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- This parameter is not used when users create databases. By default, a new database inherits its tablespace setting from the template database.

  This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. An empty string indicates that the default tablespace is used.

**Default value**: empty

## default_storage_nodegroup

**Parameter description**: Specifies the Node Group where a table is created by default. This parameter takes effect only for ordinary tables.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

- **installation** indicates that tables will be created in the Node Group created during database installation.
- A value other than **installation** indicates that tables will be created in the Node Group specified by this parameter.

**Value range**: a string

**Default value**: **installation**

## temp_tablespaces

**Parameter description**: Specifies one or more tablespaces to which temporary objects (temporary tables and their indexes) will be created when a CREATE command does not explicitly specify a tablespace. Temporary files for sorting large data sets are created in these tablespaces.

The value of this parameter can be a list of names of tablespaces. When there is more than one name in the list, GaussDB chooses a random tablespace from the list upon the creation of a temporary object each time. However, within a transaction, successively created temporary objects are placed in successive tablespaces in the list. If the element selected from the list is an empty string, GaussDB will automatically use the default tablespace of the current database instead.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string An empty string indicates that all temporary objects are created only in the default tablespace of the current database. For details, see **default_tablespace**.

**Default value**: empty

## check_function_bodies

**Parameter description**: Specifies whether to enable validation of the function body string during the execution of **CREATE FUNCTION**. Verification is occasionally disabled to avoid problems, such as forward references when you

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restore function definitions from a dump. After the function is enabled, the word syntax of the PL/SQL in the stored procedure is verified, including the data type, statement, and expression. The SQL statements in the stored procedure are not checked in the Create phase. Instead, they are checked during running.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that validation of the function body string is enabled during the execution of **CREATE FUNCTION**.
- **off** indicates that validation of the function body string is disabled during the execution of **CREATE FUNCTION**.

**Default value**: **on**

## default_transaction_isolation

**Parameter description**: Specifies the default isolation level of each transaction.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

NOTE

The current version does not support the setting of the default transaction isolation level. The default value is **read committed**. Do not change the value.

**Value range**: enumerated values

- **read uncommitted** indicates that a transaction reads the uncommitted modifications made by other transactions.
- **read committed** indicates that the data read by a transaction is committed at the moment it is read.
- **repeatable read** indicates that the data that has been read by the current transaction cannot be modified by other transactions until the current transaction completes, thereby preventing unrepeatable reads.
- **serializable**: Currently, this isolation level is not supported in GaussDB. It is equivalent to **repeatable read**.

**Default value: read committed**

## default_transaction_read_only

**Parameter description**: Specifies whether each new transaction is in read-only state.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

CAUTION

If this parameter is set to **on**, the DML and write transactions cannot be executed.

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**Value range**: Boolean

- **on** indicates that the transaction is in read-only state.
- **off** indicates that the transaction is in read/write state.

**Default value**: **off**

## default_transaction_deferrable

**Parameter description**: Specifies the default deferrable status of each new transaction. It currently has no effect on read-only transactions or those running at isolation levels lower than serializable.

GaussDB does not support the serializable isolation level. Therefore, the parameter takes no effect.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that a transaction is delayed by default.
- **off** indicates that a transaction is not delayed by default.

**Default value**: **off**

## session_replication_role

**Parameter description**: Specifies the behavior of replication-related triggers and rules for the current session.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**NOTICE**

Setting this parameter will discard all the cached execution plans.

**Value range**: enumerated values

- **origin** indicates that the system copies operations such as insert, delete, and update from the current session.
- **replica** indicates that the system copies operations such as insert, delete, and update from other places to the current session.
- **local** indicates that the system will detect the role that has logged in to the database when using the function to copy operations and will perform related operations.

**Default value**: **origin**

## statement_timeout

**Parameter description**: If the statement execution time (starting from the time the server receives the command) is longer than the duration specified by the parameter, error information is displayed and the statement exits.

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This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1. The default value is **0**, indicating that the parameter does not take effect.

**Value range**: an integer ranging from 0 to 2147483647. The unit is ms.

**Default value**: **0**

## vacuum_freeze_min_age

**Parameter description:** Specifies whether VACUUM replaces the xmin column of a record with FrozenXID when scanning a table (in the same transaction).

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 0 to 576460752303423487

NOTE

Although you can set this parameter to any value, VACUUM will limit the effective value to half the value of **autovacuum_freeze_max_age** by default.

**Default value**: **2000000000**

## vacuum_freeze_table_age

**Parameter description**: Specifies when VACUUM scans the whole table and freezes old tuples. VACUUM performs a full table scan if the difference between the current transaction ID and the value of pg_class.relfrozenxid64 is greater than the specified time.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 0 to 576460752303423487

NOTE

Although you can set this parameter to any value, **VACUUM** will limit the effective value to 95% of **autovacuum_freeze_max_age** by default. Therefore, a periodic manual VACUUM has a chance to run before an anti-wraparound autovacuum is launched for the table.

**Default value**: **4000000000**

## bytea_output

**Parameter description:** Specifies the output format for values of the bytea type.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: enumerated values

- **hex** indicates that the binary data is converted to hexadecimal format.
- **escape** indicates that the traditional PostgreSQL format is used. It takes the approach of representing a binary string as a sequence of ASCII characters, while converting those bytes that cannot be represented as an ASCII character into special escape sequences.

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**Default value**: **hex**

## xmlbinary

**Parameter description**: Specifies how binary values are to be encoded in XML.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTE

Currently, this parameter does not support data of the XML type.

**Value range**: enumerated values

- base64
- hex

**Default value**: **base64**

## xmloption

**Parameter description**: Specifies whether DOCUMENT or CONTENT is implicit when converting between XML and string values.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

NOTE

Currently, this parameter does not support data of the XML type.

**Value range**: enumerated values

- **document** indicates an HTML document.
- **content** indicates a common string.

**Default value**: **content**

## max_compile_functions

**Parameter description**: Specifies the maximum number of function compilation results stored in the server. Excessive functions and compilation results of stored procedures may occupy large memory space. Setting this parameter to a proper value can reduce the memory usage and improve system performance.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483647

**Default value: 1000**

## gin_pending_list_limit

**Parameter description**: Specifies the maximum size of the GIN pending list which is used when **fastupdate** is enabled. If the list grows larger than this maximum

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size, it is cleaned up by moving the entries in it to the main GIN data structure in batches. This setting can be overridden for individual GIN indexes by changing index storage parameters.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 64 to 2147483647. The unit is KB.

**Default value**: **4MB**

## 19.14.2 Locale and Formatting

This section describes parameters related to the time format setting.

### DateStyle

**Parameter description**: Specifies the display format for date and time values, as well as the rules for interpreting ambiguous date input values.

This variable contains two independent components: the output format specifications (ISO, Postgres, SQL, or German) and the input/output order of year/month/day (DMY, MDY, or YMD). The two components can be set separately or together. The keywords Euro and European are synonyms for DMY; the keywords US, NonEuro, and NonEuropean are synonyms for MDY.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **'ISO, MDY'**

NOTE

**gs_initdb** will initialize this parameter so that its value is the same as that of **lc_time**.

If this parameter is modified by running the **gs_guc reload** command and the connection of a session on the current node is not from the client but from another node in the cluster to which the node belongs, this parameter does not take effect immediately on the session after the **gs_guc reload** command is executed. The setting takes effect only after the connection node is disconnected and then reconnected.

**Setting Suggestions**: The ISO format is recommended. Postgres, SQL, and German use abbreviations for time zones, such as **EST**, **WST**, and **CST**. These abbreviations can be ambiguous. For example, **CST** can represent Central Standard Time (USA) UT-6:00, Central Standard Time (Australia) UT+9:30, and China Standard Time UT+8:00. This may lead to incorrect time zone conversion and cause errors.

### IntervalStyle

**Parameter description**: Specifies the display format for interval values.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values

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- **sql_standard** indicates that output matching SQL standards will be generated.
- **postgres** indicates that output matching PostgreSQL 8.4 will be generated when the **DateStyle** parameter is set to **ISO**.
- **postgres_verbose** indicates that output matching PostgreSQL 8.4 will be generated when the **DateStyle** parameter is set to **non_ISO**.
- **iso_8601** indicates that output matching the time interval "format with designators" defined in ISO 8601 will be generated.
- **oracle** indicates that output matching the numtodsinterval function in the Oracle database will be generated. For details, see **numtodsinterval**.

NOTICE

The **IntervalStyle** parameter also affects the interpretation of ambiguous interval input.

If this parameter is modified by running the **gs_guc reload** command and the connection of a session on the current node is not from the client but from another node in the cluster to which the node belongs, this parameter does not take effect immediately on the session after the **gs_guc reload** command is executed. The setting takes effect only after the connection node is disconnected and then reconnected.

**Default value**: **postgres**

## TimeZone

**Parameter description**: Specifies the time zone for displaying and interpreting timestamps.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. You can obtain it by querying the **PG_TIMEZONE_NAMES** view.

**Default value**:

NOTE

**gs_initdb** will set a time zone value that is consistent with the system environment.

If this parameter is modified by running the **gs_guc reload** command and the connection of a session on the current node is not from the client but from another node in the cluster to which the node belongs, this parameter does not take effect immediately on the session after the **gs_guc reload** command is executed. The setting takes effect only after the connection node is disconnected and then reconnected.

## timezone_abbreviations

**Parameter description**: Specifies the time zone abbreviations that will be accepted by the server.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: a string. You can obtain it by querying the **pg_timezone_names** view.

**Default value**: **Default**

NOTE

**Default** indicates abbreviations that work in most of the world. There are also other abbreviations, such as **Australia** and **India** that can be defined for a particular installation.

## extra_float_digits

**Parameter description**: Adjusts the number of digits displayed for floating-point values, including float4, float8, and geometric data types. The parameter value is added to the standard number of digits (FLT_DIG or DBL_DIG as appropriate).

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from –15 to 3

NOTE

- This parameter can be set to **3** to include partially-significant digits. It is especially useful for dumping float data that needs to be restored exactly.
- This parameter can also be set to a negative value to suppress unwanted digits.

**Default value**: **0**

## client_encoding

**Parameter description**: Specifies the client-side encoding (character set).

Set this parameter based on the situation of the front-end services. Try to keep the encoding consistent on the client and server to improve efficiency.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: encoding compatible with PostgreSQL. **UTF8** indicates that the database encoding is used.

NOTE

- You can run the **locale -a** command to check the system-supported locales and the corresponding encodings, and select one as required.
- By default, **gs_initdb** will initialize the setting of this parameter based on the current system environment. You can also run the **locale** command to check the current configuration environment.
- To use consistent encoding for communication within the cluster, retain the default value of **client_encoding**. Modification to this parameter in the **postgresql.conf** file (by using the **gs_guc** tool, for example) does not take effect.

**Default value**: **UTF8**

**Recommended value**: **SQL_ASCII** or **UTF8**

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## lc_messages

**Parameter description**: Specifies the language in which messages are displayed.

- Acceptable values are system-related.
- On some systems, this locale category does not exist. Setting this variable will still work, but there will be no effect. In addition, translated messages for the desired language may not exist. In this case, you can still see the English messages.

  This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

NOTE

- You can run the **locale -a** command to check the system-supported locales and the corresponding encodings, and select one as required.
- By default, **gs_initdb** will initialize the setting of this parameter based on the current system environment. You can also run the **locale** command to check the current configuration environment.

**Default value**: **C**

## lc_monetary

**Parameter description**: Specifies the display format of monetary values. It affects the output of functions such as **to_char**. Acceptable values are system-related.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

NOTE

- You can run the **locale -a** command to check the system-supported locales and the corresponding encodings, and select one as required.
- By default, **gs_initdb** will initialize the setting of this parameter based on the current system environment. You can also run the **locale** command to check the current configuration environment.
- If this parameter is modified by running the **gs_guc reload** command and the connection of a session on the current node is not from the client but from another node in the cluster to which the node belongs, this parameter does not take effect immediately on the session after the **gs_guc reload** command is executed. The setting takes effect only after the connection node is disconnected and then reconnected.

**Default value**: **C**

## lc_numeric

**Parameter description**: Specifies the display format of numbers. It affects the output of functions such as **to_char**. Acceptable values are system-related.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

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NOTE

- You can run the **locale -a** command to check the system-supported locales and the corresponding encodings, and select one as required.
- By default, **gs_initdb** will initialize the setting of this parameter based on the current system environment. You can also run the **locale** command to check the current configuration environment.
- If this parameter is modified by running the **gs_guc reload** command and the connection of a session on the current node is not from the client but from another node in the cluster to which the node belongs, this parameter does not take effect immediately on the session after the **gs_guc reload** command is executed. The setting takes effect only after the connection node is disconnected and then reconnected.

**Default value**: **C**

## lc_time

**Parameter description**: Specifies the display format of time and locale. It affects the output of functions such as **to_char**. Acceptable values are system-related.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

NOTE

- You can run the **locale -a** command to check the system-supported locales and the corresponding encodings, and select one as required.
- By default, **gs_initdb** will initialize the setting of this parameter based on the current system environment. You can also run the **locale** command to check the current configuration environment.
- If this parameter is modified by running the **gs_guc reload** command and the connection of a session on the current node is not from the client but from another node in the cluster to which the node belongs, this parameter does not take effect immediately on the session after the **gs_guc reload** command is executed. The setting takes effect only after the connection node is disconnected and then reconnected.

**Default value**: **C**

## default_text_search_config

**Parameter description**: Specifies the text search configuration.

If the specified text search configuration does not exist, an error will be reported. If the specified text search configuration is deleted, set **default_text_search_config** again. Otherwise, an error will be reported, indicating incorrect configuration.

- The text search configuration is used by text search functions that do not have an explicit argument specifying the configuration.
- When a configuration file matching the environment is determined, **gs_initdb** will initialize the configuration file with a setting that corresponds to the environment.

  This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: a string

NOTE

GaussDB supports the following two configurations: **pg_catalog.english** and **pg_catalog.simple**.

**Default value**: **pg_catalog.english**

## 19.14.3 Other Default Parameters

This section describes the default database loading parameters.

### dynamic_library_path

**Parameter description**: Specifies the path that the system will search for a shared database file that is dynamically loadable. When a dynamically loadable module needs to be opened and the file name specified in the **CREATE FUNCTION** or **LOAD** command does not have a directory component, the system will search this path for the required file. Only the sysadmin user can access this parameter.

The value of **dynamic_library_path** must be a list of absolute paths separated by colons (:) or by semi-colons (;) on the Windows OS. When the name of a path starts with the special variable $libdir, the variable will be replaced with the directory in which the module provided by GaussDB is installed. For example:

```
dynamic_library_path = '/usr/local/lib/postgresql:/opt/testgs/lib:$libdir'
```

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

NOTE

If the value of this parameter is set to an empty character string, the automatic path search is turned off.

**Default value**: **$libdir**

### gin_fuzzy_search_limit

**Parameter description**: Specifies the upper limit of the size of the set returned by GIN indexes.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **0**

### local_preload_libraries

**Parameter description**: Specifies one or more shared libraries that are to be preloaded at connection start. If multiple libraries are to be loaded, separate their names with commas (,). All library names are converted to lower case unless double-quoted.

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- Any user can change this option. Therefore, library files that can be loaded are restricted to those saved in the **plugins** subdirectory of the standard library installation directory. It is the database administrator's responsibility to ensure that libraries in this directory are all safe. Entries in **local_preload_libraries** can specify the library directory explicitly, for example, **$libdir/plugins/mylib**, or just specify the library name, for example, **mylib**. (**mylib** is equivalent to **$libdir/plugins/mylib**.)
- Unlike **shared_preload_libraries**, there are no differences in performance between loading a module at session start or doing this during the session. The intent of this feature is to allow debugging or performance-measurement libraries to be loaded into specific sessions without an explicit LOAD command. For example, debugging can be enabled under a given user name by setting this parameter to **ALTER USER SET**.
- If a specified library is not found, the connection attempt will fail.
- Every GaussDB-supported library has a "magic block" that is checked to guarantee compatibility. For this reason, non-GaussDB-supported libraries cannot be loaded in this way.

This parameter is a BACKEND parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: empty

# 19.15 Lock Management

In GaussDB, a deadlock may occur when concurrently executed transactions compete for resources. This section describes parameters used for managing transaction locks.

## deadlock_timeout

**Parameter description**: Specifies the time, in milliseconds, to wait on a lock before checking whether there is a deadlock condition. When the applied lock exceeds the preset value, the system will check whether a deadlock occurs. This parameter takes effect only for common locks.

- The check for deadlock is relatively expensive. Therefore, the server does not check it when waiting for a lock every time. Deadlocks do not frequently occur when the system is running. Therefore, the system just needs to wait on the lock for a while before checking for a deadlock. Increasing this value reduces the time wasted in needless deadlock checks, but slows down reporting of real deadlock errors. On a heavily loaded server, you may need to raise it. The value you have set needs to exceed the transaction time. By doing this, the possibility that a lock will be checked for deadlocks before it is released will be reduced.
- If you want to write the lock wait time during query execution to logs by setting **log_lock_waits**, ensure that the value of **log_lock_waits** is less than the specified value (or the default value) of **deadlock_timeout**.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: an integer ranging from 1 to 2147483647. The unit is ms.

**Default value**: **1s**

## lockwait_timeout

**Parameter description**: Specifies the timeout for attempts to acquire a lock. If the time spent in waiting for a lock exceeds the specified time, an error is reported. This parameter takes effect only for common locks.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is ms.

**Default value**: **20min**

## update_lockwait_timeout

**Parameter description**: Specifies the maximum duration that a lock waits for concurrent updates on a row to complete when the concurrent update feature is enabled. If the time spent in waiting for a lock exceeds the specified time, an error is reported. This parameter takes effect only for common locks.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is ms.

**Default value**: **120000** (2 minutes)

## max_locks_per_transaction

**Parameter description**: Determines the average number of object locks allocated for each transaction.

- The size of the shared lock table is calculated under the condition that a maximum of *N* independent objects need to be locked at any time. *N* = **max_locks_per_transaction** x (**max_connections** + **max_prepared_transactions**). Objects whose amount does not exceed the preset number can be locked simultaneously at any time. You may need to increase this value if many different tables are modified in a single transaction. This parameter can only be set at database start.
- Increasing the value of this parameter may cause GaussDB to request more System V-shared memory than the OS's default configuration allows.
- When running a standby server, you must set this parameter to a value that is no less than that on the primary server. Otherwise, queries will not be allowed on the standby server.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from 10 to 2147483647

**Default value**: **256**

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## max_pred_locks_per_transaction

**Parameter description**: Specifies the average number of predicate locks allocated for each transaction.

- The size of the shared predicate lock table is calculated under the condition that a maximum of *N* independent objects need to be locked at any time. *N* = **max_pred_locks_per_transaction** x (**max_connections** + **max_prepared_transactions**). Objects whose amount does not exceed the preset number can be locked simultaneously at any time. You may need to increase this value if many different tables are modified in a single transaction. This parameter can only be set at server start.
- Increasing the value of this parameter may cause GaussDB to request more System V-shared memory than the OS's default configuration allows.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from 10 to 2147483647

**Default value**: **64**

## gs_clean_timeout

**Parameter description**: Controls the average interval between **gs_clean** invocations by the Coordinator.

- Transactions in GaussDB are committed in two phases. An unfinished two-phase transaction may hold a table-level lock, keeping tables from being locked by other connections. In this case, the database needs to invoke the **gs_clean** tool to clean unfinished two-phase transactions. **gs_clean_timeout** is used to control the interval for the Coordinator to invoke the **gs_clean** tool.
- A larger value of this parameter indicates a low frequency of **gs_clean** invocation to clean unfinished two-phase transactions.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483. The unit is s.

**Default value**: **1min**

## partition_lock_upgrade_timeout

**Parameter description**: Specifies the timeout for attempts to upgrade an exclusive lock (read allowed) to an access exclusive lock (read/write blocked) on a partitioned table during the execution of some query statements. If there are concurrent read transactions running, the lock upgrade will need to wait. This parameter sets the waiting timeout for lock upgrade attempts.

- When you do **MERGE PARTITION** and **CLUSTER PARTITION** on a partitioned table, temporary tables are used for data rearrangement and file exchange. To concurrently perform as many operations as possible on the partitions, exclusive locks are acquired for the partitions during data rearrangement and access exclusive locks are acquired during file exchange.

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- Generally, a partition waits until it acquires a lock, or a timeout occurs if the partition waits for a period longer than the value specified by the **lockwait_timeout** parameter.
- When doing **MERGE PARTITION** or **CLUSTER PARTITION** on a partitioned table, an access exclusive lock needs to be acquired during file exchange. If the lock fails to be acquired, the acquisition is retried at an interval of 50 ms until timeout occurs. The **partition_lock_upgrade_timeout** parameter specifies the time to wait before the lock acquisition attempt times out.
- If this parameter is set to **–1**, the lock upgrade never times out. The lock upgrade is continuously retried until it succeeds.

  This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 3000. The unit is s.

**Default value**: **1800**

## fault_mon_timeout

**Parameter description**: Specifies the period for detecting lightweight deadlocks. This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 1440. The unit is minute.

**Default value**: **5min**

## enable_online_ddl_waitlock

**Parameter description**: Specifies whether to block DDL operations to wait for the release of cluster locks, such as **pg_advisory_lock** and **pgxc_lock_for_backup**. This parameter is mainly used in online OM operations and you are not advised to modify the settings.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **off**

## xloginsert_locks

**Parameter description**: Specifies the number of locks on concurrent write-ahead logging. This parameter is used to improve the efficiency of writing write-ahead logs.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from 1 to 1000

**Default value**: **16**

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## num_internal_lock_partitions

**Parameter description**: Specifies the number of internal lightweight lock partitions. It is mainly used for performance optimization in various scenarios. The content is organized in the KV format of keywords and numbers. Different types of locks are separated by commas (,). The sequence does not affect the setting result. For example, **CLOG_PART=256,CSNLOG_PART=512** is equivalent to **CSNLOG_PART=512,CLOG_PART=256**. If you set the same keyword multiple times, only the latest setting takes effect. For example, if you set **CLOG_PART** to **256** and **CLOG_PART** to **2**, the value of **CLOG_PART** is **2**. If no keyword is set, the default value is used. The usage description, maximum value, minimum value, and default value of each lock type are as follows:

- **CLOG_PART**: number of Clog file controllers. Increasing the value of this parameter improves the Clog writing efficiency and transaction submission performance, but increases the memory usage. Decreasing the value of this parameter reduces the memory usage, but may increase the conflict of writing Clogs and affect the performance. The value ranges from 1 to 256.
- **CSNLOG_PART**: number of CSNLOG file controllers. Increasing the value of this parameter improves the CSNLOG log writing efficiency and transaction submission performance, but increases the memory usage. Decreasing the value of this parameter reduces the memory usage, but may increase the conflict of writing CSNLOG logs and affect the performance. The value ranges from 1 to 512.
- **LOG2_LOCKTABLE_PART**: two logarithms of the number of common table lock partitions. Increasing the value can improve the concurrency of obtaining locks in the normal process, but may increase the time required for transferring and clearing locks. When waiting events occur in **LockMgrLock**, you can increase the value to improve the performance. The minimum value is 4, that is, the number of lock partitions is 16. The maximum value is 16, that is, the number of lock partitions is 65536.
- **TWOPHASE_PART**: number of partitions of the two-phase transaction lock. Increasing the value can increase the number of concurrent two-phase transaction commits. The value ranges from 1 to 64.
- **FASTPATH_PART**: maximum number of locks that each thread can obtain without using the primary lock table. Increasing the value of this parameter will consume more memory. The value ranges from 20 to 10000.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**:

- **CLOG_PART**: **256**
- **CSNLOG_PART**: **512**
- **LOG2_LOCKTABLE_PART**: **4**
- **TWOPHASE_PART**: **1**
- **FASTPATH_PART**: **20**

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# 19.16 Version and Platform Compatibility

## 19.16.1 Compatibility with Earlier Versions

This section describes the parameters that control the backward compatibility and external compatibility of GaussDB. A backward compatible database supports applications of earlier versions. This section describes parameters used for controlling backward compatibility of a database.

### array_nulls

**Parameter description**: Controls whether the array input parser recognizes unquoted NULL as a null array element.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that null values can be entered in arrays.
- **off** indicates backward compatibility with the old behavior. Arrays containing the value **NULL** can still be created when this parameter is set to **off**.

**Default value**: **on**

### backslash_quote

**Parameter description**: Controls whether a single quotation mark can be represented by \' in a string text.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

NOTICE

When the string text meets the SQL standards, \ has no other meanings. This parameter only affects the handling of non-standard-conforming string texts, including escape string syntax (E'...').

**Valid value**: enumerated values

- **on** indicates that the use of \' is always allowed.
- **off** indicates that the use of \' is rejected.
- **safe_encoding** indicates that the use of \' is allowed only when client encoding does not allow ASCII \ within a multibyte character.

**Default value**: **safe_encoding**

### default_with_oids

**Parameter description**: Specifies whether **CREATE TABLE** and **CREATE TABLE AS** include an **OID** field in newly-created tables if neither **WITH OIDS** nor **WITHOUT**

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**OIDS** is specified. It also determines whether OIDs will be included in tables created by **SELECT INTO**.

It is not recommended that OIDs be used in user tables. Therefore, this parameter is set to **off** by default. When OIDs are required for a particular table, **WITH OIDS** needs to be specified during the table creation.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that **CREATE TABLE** and **CREATE TABLE AS** can include an **OID** field in newly-created tables.
- **off** indicates that **CREATE TABLE** and **CREATE TABLE AS** cannot include any OID field in newly-created tables.

**Default value**: **off**

## escape_string_warning

**Parameter description**: Specifies whether to issue a warning when a backslash (\) is used as an escape in an ordinary character string.

- Applications that wish to use a backslash (\) as an escape need to be modified to use escape string syntax (E'...'). This is because the default behavior of ordinary character strings treats the backslash as an ordinary character in each SQL standard.
- This variable can be enabled to help locate code lines that need to be changed.
- If E'...' is used as an escape, logs may be incomplete in some scenarios.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**Default value**: **on**

## lo_compat_privileges

**Parameter description**: Specifies whether to enable backward compatibility for the privilege check of large objects.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**on** indicates that the privilege check is disabled when users read or modify large objects. This setting is compatible with versions earlier than PostgreSQL 9.0.

**off** indicates that privilege check is enabled for large objects.

**Default value**: **off**

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## quote_all_identifiers

**Parameter description**: Specifies whether to forcibly quote all identifiers even if they are not keywords when the database generates SQL. This will affect the output of **EXPLAIN** and the results of functions, such as pg_get_viewdef. For details, see the **--quote-all-identifiers** parameter of **gs_dump**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the forcible quotation is enabled.
- **off** indicates that the forcible quotation is disabled.

**Default value**: **off**

## sql_inheritance

**Parameter description**: Controls the inheritance semantics. This parameter specifies the access policy of descendant tables. **off** indicates that subtables cannot be accessed by commands. That is, the ONLY keyword is used by default. It is set for compatibility with versions earlier than PostgreSQL 7.1.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that subtables can be accessed.
- **off** indicates that subtables cannot be accessed.

**Default value**: **on**

## standard_conforming_strings

**Parameter description**: Controls whether ordinary string texts ('...') treat backslashes as ordinary texts as specified in the SQL standard.

- Applications can check this parameter to determine how string texts will be processed.
- It is recommended that characters be escaped by using the escape string syntax (E'...').

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that backslashes are treated as ordinary texts.
- **off** indicates that backslashes are not treated as ordinary texts.

**Default value**: **on**

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### synchronize_seqscans

**Parameter description**: Controls sequential scans of tables to synchronize with each other, so that concurrent scans read the same data block at about the same time and share the I/O workload.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that a scan may start in the middle of the table and then "wrap around" the end to cover all rows to synchronize with the activity of scans already in progress. This may result in unpredictable changes in the row ordering returned by queries that have no ORDER BY clause.
- **off** indicates that the scan always starts from the table heading.

**Default value**: **on**

### enable_beta_features

**Parameter description**: Specifies whether to enable some features that are not officially released and are used only for POC verification, such as GDS table join. Exercise caution when enabling these extended features because they may cause errors in some scenarios.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the features are enabled for forward compatibility. Note that enabling them may cause errors in certain scenarios.
- **off** indicates that the features are disabled.

**Default value**: **off**

## 19.16.2 Platform and Client Compatibility

Many platforms use the database system. External compatibility of the database system provides a lot of convenience for platforms.

### transform_null_equals

**Parameter description**: Specifies whether expressions of the form expr = NULL (or NULL = expr) are treated as expr IS NULL. They return true if expr evaluates to the null value, and false otherwise.

- The correct SQL-standard-compliant behavior of expr = NULL is to always return null (unknown).
- Filtered forms in Microsoft Access generate queries that appear to use expr = NULL to test for null values. If you turn this option on, you can use this interface to access the database.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

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**Value range**: Boolean

- **on** indicates that expressions of the form expr = NULL (or NULL = expr) are treated as expr IS NULL.
- **off** indicates that expr = NULL always returns null (unknown).

**Default value**: **off**

NOTE

New users are always confused about the semantics of expressions involving **NULL** values. Therefore, **off** is used as the default value.

## support_extended_features

**Parameter description**: Specifies whether extended database features are supported.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that extended database features are supported.
- **off** indicates that extended database features are not supported.

**Default value**: **off**

## lastval_supported

**Parameter description**: Specifies whether the lastval function can be used.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that the lastval function can be used and the nextval function cannot be pushed down.
- **off** indicates that the lastval function cannot be used and the nextval function can be pushed down.

**Default value**: **off**

## sql_compatibility

**Parameter description**: Specifies the type of mainstream database with which the SQL syntax and statement behavior of the database is compatible. This parameter is an INTERNAL parameter. It can be viewed but cannot be modified.

**Value range**: enumerated values

- **ORA** indicates that the SQL syntax and statement behavior of the database is compatible with the Oracle database.
- **TD** indicates that the SQL syntax and statement behavior of the database is compatible with the Teradata database.

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- **MYSQL** indicates that the SQL syntax and statement behavior of the database is compatible with the MySQL database.
- **PG** indicates that the database is compatible with the PostgreSQL database.

**Default value**: **MYSQL**

NOTICE

- This parameter can be set only when you run the **CREATE DATABASE** command to create a database.
- In the database, this parameter must be set to a specific value. It can be set to **ORA** or **TD** and cannot be changed randomly. Otherwise, the setting is not consistent with the database behavior.

## behavior_compat_options

**Parameter description**: Specifies database compatibility behavior. Multiple items are separated by commas (,).

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **""**

NOTE

- Currently, only items in **19.16.2 Platform and Client Compatibility** are supported.
- Multiple items are separated by commas (,), for example, **set behavior_compat_options='end_month_calculate,display_leading_zero';**.

**Table 19-5** Compatibility configuration items

| Compatibility Configuration Item | Behavior |
| --- | --- |
| display_leading_zero | Specifies how floating point numbers are displayed.<br>• If this item is not specified, for a decimal number between –1 and 1, the 0 before the decimal point is not displayed. For example, 0.25 is displayed as **.25**.<br>• If this item is specified, for a decimal number between –1 and 1, the 0 before the decimal point is displayed. For example, 0.25 is displayed as **0.25**. |

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| Compatibility Configuration Item | Behavior |
| --- | --- |
| end_month_calculate | Specifies the calculation logic of the **add_months** function.<br>Assume that the two parameters of the add_months function are **param1** and **param2**, and that the month of **param1** and **param2** is **result**.<br>● If this item is not specified, and the **Day** of **param1** indicates the last day of a month shorter than **result**, the **Day** in the calculation result will equal that in **param1**. For example:<br>`openGauss=# select add_months('2018-02-28',3) from sys_dummy;`<br>`add_months`<br>`---------------------`<br>`2018-05-28 00:00:00`<br>`(1 row)`<br>● If this item is specified, and the **Day** of **param1** indicates the last day of a month shorter than **result**, the **Day** in the calculation result will equal that in **result**. For example:<br>`openGauss=# select add_months('2018-02-28',3) from sys_dummy;`<br>`add_months`<br>`---------------------`<br>`2018-05-31 00:00:00`<br>`(1 row)` |
| compat_analyze_sample | Specifies the sampling behavior of the ANALYZE operation.<br>If this item is specified, the sample collected by the ANALYZE operation will be limited to around 30,000 records, controlling CN memory consumption and maintaining the stability of ANALYZE. |
| bind_schema_tablespace | Binds a schema with the tablespace with the same name.<br>If a tablespace name is the same as *sche_name*, **default_tablespace** will also be set to *sche_name* if **search_path** is set to *sche_name*. |
| bind_procedure_searchpath | Specifies the search path of the database object for which no schema name is specified.<br>If no schema name is specified for a stored procedure, the search is performed in the schema to which the stored procedure belongs.<br>If the stored procedure is not found, the following operations are performed:<br>● If this item is not specified, the system reports an error and exits.<br>● If this item is specified, the search continues based on the settings of **search_path**. If the issue persists, the system reports an error and exits. |

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| Compatibility Configuration Item | Behavior |
| --- | --- |
| correct_to_number | Controls the compatibility of the **to_number()** result.<br>If this item is specified, the value of **to_number()** is the same as that of **pg11**. Otherwise, the value is the same as that of Oracle. |
| unbind_divide_bound | Controls the range check on the result of integer division.<br>If this item is specified, you do not need to check the range of the division result. For example, the result of INT_MIN/(-1) can be *INT_MAX*+1. If this item is not specified, an out-of-bounds error is reported because the result is greater than *INT_MAX*. |
| convert_string_digit_to_numeric | Determines whether to convert columns of the character string type to those of the numeric type before columns of these two types are compared. |
| return_null_string | Specifies how to display the empty result (empty string '') of the lpad() and rpad() functions.<br>● If this item is not specified, the empty string is displayed as **NULL**.<br>openGauss=# select length(lpad('123',0,'*')) from *sys_dummy*;<br>length<br>--------<br><br>(1 row)<br>● If this item is specified, the empty string is displayed as single quotation marks (''').<br>openGauss=# select length(lpad('123',0,'*')) from *sys_dummy*;<br>length<br>--------<br>0<br>(1 row) |
| compat_concat_variadic | Specifies the compatibility of variadic results of the **concat()** and **concat_ws()** functions.<br>If this item is specified and a **concat** function has a parameter of the variadic type, different result formats in Oracle and Teradata are retained. If this item is not specified and a **concat** function has a parameter of the variadic type, the result format of Oracle is retained for both Oracle and Teradata. This option has no effect on MySQL because MySQL has no variadic type. |

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| Compatibility Configuration Item | Behavior |
| --- | --- |
| merge_update_multi | When MERGE INTO... WHEN MATCHED THEN UPDATE (see **12.14.144 MERGE INTO**) and INSERT... ON DUPLICATE KEY UPDATE (see **12.14.141 INSERT**) are used, control the UPDATE behavior if a piece of target data in the target table conflicts with multiple pieces of source data.<br>If this item is specified and the preceding scenario exists, the system performs multiple UPDATE operations on the conflicting row. If this item is not specified and the preceding scenario exists, an error is reported, that is, the MERGE or INSERT operation fails. |
| plstmt_implicit_savepoint | Determines whether the execution of an UPDATE statement in a stored procedure has an independent subtransaction.<br>If this parameter is set, the implicit savepoint is enabled before executing each UPDATE statement in the stored procedure, and the subtransaction is rolled backed to the latest savepoint in the EXCEPTION block by default, ensuring that only the modification of failed statements is rolled back. This option is used to be compatible with the **EXCEPTION** behavior of the O database. |
| hide_tailing_zero | Configuration item for numeric display. If this parameter is not set, numeric values are displayed based on the specified precision. If this parameter is set, all numeric values are output with trailing zeros (after a decimal point) hidden, including the to_char(numeric, format) scenario.<br>For example:<br>`set behavior_compat_options='hide_tailing_zero';`<br>`select cast(123.123 as numeric(15,10));`<br>`numeric`<br>`---------`<br>`123.123`<br>`(1 row)` |
| plsql_security_definer | After this parameter is enabled, the definer permission is used by default when a stored procedure is created. |
| char_coerce_compat | Specifies the behavior when the char(n) type is converted to other variable-length string types. By default, spaces at the end are omitted when the char(n) type is converted to other variable-length string types. After this parameter is enabled, spaces at the end are not omitted during conversion. In addition, if the length of the char(n) type exceeds the length of other variable-length string types, an error is reported. This parameter is valid only when the **sql_compatibility** parameter is set to **ORA**. After this parameter is enabled, spaces at the end are not omitted in implicit conversion, explicit conversion, or conversion by calling the **text(bpchar)** function. |

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| Compatibility Configuration Item | Behavior |
| --- | --- |
| truncate_numeric_tail_zero | Configuration item for numeric display. If this parameter is not set, numeric values are displayed based on the default precision. If this parameter is set, all numeric values are output with trailing zeros (after a decimal point) hidden, except for to_char(numeric, format). |
| array_count_compat | Controls the array.count function. If the parameter is enabled, the function returns **0**. Otherwise, the function returns null. |
| aformat_regexp_match | Determines the matching behavior of regular expression functions.<br>When this parameter is set and **sql_compatibility** is set to **A** or **B**, the options supported by the **flags** parameter of the regular expression are changed as follows:<br>1. . By default, the character '\n' cannot be matched.<br>2. When **flags** contains the **n** option, the character '\n' can be matched.<br>3. The **regexp_replace(source, pattern replacement)** function replaces all matching substrings.<br>4. **regexp_replace(source, pattern, replacement, flags)** returns null when the value of **flags** is **''** or null.<br>Otherwise, the meanings of the options supported by the **flags** parameter of the regular expression are as follows:<br>1. . By default, the character '\n' can be matched.<br>2. The **n** option in **flags** indicates that the multi-line matching mode is used.<br>3. The **regexp_replace(source, pattern replacement)** function replaces only the first matched substring.<br>4. If the value of **flags** is **''** or null, the return value of **regexp_replace(source, pattern, replacement, flags)** is the character string after replacement. |
| disable_emptystr2null | Disables the function of converting an empty string to null by default for the text, clob, blob, and raw character string types. |

## a_format_version

**Parameter description**: Specifies the database platform compatibility configuration item. The value of this parameter is an enumerated string.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

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**Default value**: ""

NOTE

Set a character string for the compatibility configuration item, for example, **set a_format_version='10c'**.

**Table 19-6** Compatibility configuration items

| Compatibility Configuration Item | Compatibility Behavior Control |
| --- | --- |
| 10c | Compatible version of platform A |

## a_format_dev_version

**Parameter description**: Specifies the database platform minor version compatibility configuration item. The value of this parameter is an enumerated string.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-2.

**Value range**: a string

**Default value**: ""

NOTE

Set a character string for the compatibility configuration item, for example, **set a_format_dev_version='s1'**.

**Table 19-7** Compatibility configuration items

| Compatibility Configuration Item | Compatibility Behavior Control |
| --- | --- |
| s1 | • Compatible minor version of platform A, which affects functions TRUNC(date, fmt), ROUND(date, fmt), NVL2, LPAD, RPAD, ADD_MONTHS, MONTHS_BETWEEN, REGEXP_REPLACE, REGEXP_COUNT, TREAT, EMPTY_CLOB, and INSTRB.<br>• After this parameter is enabled, the int casted from text can be rounded off. |

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## plpgsql.variable_conflict

**Parameter description:** Sets the priority of using stored procedure variables and table columns with the same name.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

- **error** indicates that a compilation error is reported when the name of a stored procedure variable is the same as that of a table column.
- **use_variable** indicates that if the name of a stored procedure variable is the same as that of a table column, the variable is used preferentially.
- **use_column** indicates that if the name of a stored procedure variable is the same as that of a table column, the column name is used preferentially.

**Default value**: **error**

## td_compatible_truncation

**Parameter description**: Specifies whether to enable features compatible with a Teradata database. You can set this parameter to **on** when connecting to a database compatible with the Teradata database, so that when you perform the INSERT operation, overlong strings are truncated based on the allowed maximum length before being inserted into char- and varchar-type columns in the target table. This ensures all data is inserted into the target table without errors reported.

NOTE

The string truncation function cannot be used if the INSERT statement includes a foreign table.

If inserting multi-byte character data (such as Chinese characters) to database with the character set byte encoding (such as SQL_ASCII or LATIN1), and the character data crosses the truncation position, the string is truncated based on its bytes instead of characters. Unexpected result will occur in tail after the truncation. If you want correct truncation result, you are advised to adopt encoding set such as UTF8, which has no character data crossing the truncation position.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that overlong strings are truncated.
- **off** indicates that overlong strings are not truncated.

**Default value**: **off**

## nls_timestamp_format

**Parameter description:** Specifies the default timestamp format.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: a string

**Default value**: **DD-Mon-YYYY HH:MI:SS.FF AM**

### max_function_args

**Parameter description**: Specifies the maximum number of parameters allowed for a function.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: an integer.

**Default value**: **8192**

### convert_string_to_digit

**Parameter description:** Specifies the implicit conversion priority, which determines whether to preferentially convert strings into numbers.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that strings are preferentially converted into numbers.
- **off** indicates that strings are not preferentially converted into numbers.

**Default value**: **on**

NOTICE

Adjusting this parameter will change the internal data type conversion rule and cause unexpected behavior. Exercise caution when performing this operation.

## 19.17 Fault Tolerance

This section describes parameters used for controlling how the server processes an error occurring in the database system.

### exit_on_error

**Parameter description:** If this function is enabled, errors of the ERROR level will be upgraded to PANIC errors, and core stacks will be generated. It is mainly used to locate problems and test services.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-2.

**Value range**: Boolean

- **on** indicates that errors of the ERROR level will be upgraded to PANIC errors.
- **off** indicates that errors of the ERROR level will not be upgraded.

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**Default value**: **off**

## restart_after_crash

**Parameter description**: If this parameter is set to **on** and a backend process crashes, GaussDB automatically reinitializes the backend process.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-2.

**Value range**: Boolean

- **on** maximizes the availability of the database.

  In some circumstances (for example, when a management tool, such as xCAT, is used to manage GaussDB), setting this parameter to **on** maximizes the availability of the database.
- **off** indicates that a management tool is enabled to obtain control permission and take proper measures when a backend process crashes.

**Default value**: **on**

## omit_encoding_error

**Parameter description**: If this parameter is set to **on** and the client character set of the database is encoded in UTF-8 format, character encoding conversion errors will be recorded in logs. Additionally, converted characters that have conversion errors will be ignored and replaced with question marks (?).

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-2.

**Value range**: Boolean

- **on** indicates that characters that have conversion errors will be ignored and replaced with question marks (?), and error information will be recorded in logs.
- **off** indicates that characters that have conversion errors cannot be converted and error information will be directly displayed.

**Default value**: **off**

NOTE

If this parameter is modified by running the **gs_guc reload** command and the connection of a session on the current node is not from the client but from another node in the cluster to which the node belongs, this parameter does not take effect immediately on the session after the **gs_guc reload** command is executed. The setting takes effect only after the connection node is disconnected and then reconnected.

## max_query_retry_times

The current feature is a lab feature. Contact Huawei technical support before using it.

**Parameter description**: Specifies the maximum number of retry attempts when an SQL statement error occurs. Currently, the error types that support retries are

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**Connection reset by peer**, **Lock wait timeout**, and **Connection timed out**. For details about complete error types, see "Cluster HA > Automatic Retry upon SQL Statement Execution Errors" in the *GaussDB Kernel Troubleshooting*. If it is set to **0**, the retry function is disabled.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 20

**Default value**: **0**

## cn_send_buffer_size

**Parameter description**: Specifies the size of the data buffer used for data transmission on data on CNs.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 8 to 128. The unit is KB.

**Default value**: **8KB**

## max_cn_temp_file_size

**Parameter description**: Specifies the maximum number of temporary files that can be used by the CN during automatic SQL statement retries. The value **0** indicates that no temporary file is used.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 10485760. The unit is KB.

**Default value**: **5GB**

## retry_ecode_list

**Parameter description**: Specifies the list of SQL error types that support automatic retries.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

**Default value**: **YY001 YY002 YY003 YY004 YY005 YY006 YY007 YY008 YY009 YY010 YY011 YY012 YY013 YY014 YY015 53200 08006 08000 57P01 XX003 XX009 YY016**

## data_sync_retry

**Parameter description**: Specifies whether to keep running the database when updated data fails to be written into disks by using the **fsync** function. In some OSs, no error is reported even if **fsync** fails after the second attempt. As a result, data is lost.

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This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that the database keeps running and **fsync** is executed again after **fsync** fails.
- **off** indicates that a PANIC-level error is reported and the database is stopped after **fsync** fails.

**Default value**: **off**

### remote_read_mode

**Parameter description**: Specifies whether to enable the remote read function. This function allows pages on the standby server to be read when reading pages on the primary server fails.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values

- **off** indicates that the remote read function is disabled.
- **non_authentication** indicates that the remote read function is enabled but certificate authentication is not required.
- **authentication** indicates that the remote read function is enabled and certificate authentication is required.

**Default value**: **authentication**

## 19.18 Connection Pool Parameters

When a connection pool is used to access the database, database connections are established and then stored in the memory as objects during system running. When you need to access the database, no new connection is established. Instead, an existing idle connection is selected from the connection pool. After you finish accessing the database, the database does not disable the connection but puts it back into the connection pool. The connection can be used for the next access request.

### pooler_port

**Parameter description**: Specifies the O&M management port of internal tools, such as cm_agent and cm_ctl. This port is used by the initial user or system administrator to connect to the database through the client.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: the value of the GUC parameter **port** of a CN or DN plus 1

**Default value**: the default value of the GUC parameter **port** of a CN or DN plus 1. The default value of this parameter is **8001** for CNs and **40001** for DNs.

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## pooler_maximum_idle_time

**Parameter description**: Specifies the maximum amount of time that the connections can remain idle in a pool before being removed. After that, the automatic connection clearing mechanism is triggered to reduce the number of connections on each node to the value of **minimum_pool_size**.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 2147483647. The smallest unit is s.

**Default value**: **10min** (600 seconds)

## minimum_pool_size

**Parameter description**: Specifies the minimum number of remaining connections in the pool on each node after the automatic connection clearing is triggered. If this parameter is set to **0**, the automatic connection clearing is disabled.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 65535

**Default value**: **50**

## max_pool_size

**Parameter description**: Specifies the maximum number of connections between a CN's connection pool and another CN/DN.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 65535

**Default value**:

- Independent deployment:

  32768 (60-core CPU/480 GB memory); 16384 (32-core CPU/256 GB memory); 8192 (16-core CPU/128 GB memory); 4096 (8-core CPU/64 GB memory); 2048 (4-core CPU/32 GB memory); 1000 (4-core CPU/16 GB memory)

- Finance edition (standard):

  32000 (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, and 80-core CPU/640 GB memory); 16000 (72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 8000 (32-core CPU/256 GB memory); 4000 (16-core CPU/128 GB memory); 2000 (8-core CPU/64 GB memory)

- Enterprise edition:

  CN: 5000 (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 4000 (96-core CPU/768 GB memory); 3000 (80-core CPU/640 GB memory); 2048 (80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, 60-core CPU/480 GB

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memory, and 32-core CPU/256 GB memory); 1024 (16-core CPU/128 GB memory and 8-core CPU/64 GB memory)

DN: 20000 (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, and 96-core CPU/1024 GB memory); 15000 (96-core CPU/768 GB memory and 80-core CPU/640 GB memory); 10000 (80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); 5000 (32-core CPU/256 GB memory); 2000 (16-core CPU/128 GB memory); 1024 (8-core CPU/64 GB memory)

- Finance edition (data computing):

  CN: 3000 (96-core CPU/768 GB memory); 2048 (72-core CPU/576 GB memory and 64-core CPU/512 GB memory); 1024 (32-core CPU/256 GB memory)

  DN: 2048 (96-core CPU/768 GB memory, 72-core CPU/576 GB memory, and 64-core CPU/512 GB memory); 1024 (32-core CPU/256 GB memory)

## persistent_datanode_connections

**Parameter description**: Specifies whether to release the connection for the current session.

This parameter is a BACKEND parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **off** indicates that the connection for the current session will be released.
- **on** indicates that the connection for the current session will not be released.

**NOTICE**

After this parameter is set to **on**, a session may hold a connection but does not run a query. As a result, other query requests fail to be connected. To fix this problem, the number of sessions must be less than or equal to **max_active_statements**.

**Default value**: **off**

## max_coordinators

**Parameter description**: Specifies the maximum number of CNs in a cluster. If scale-out is required, ensure that the value of this parameter is greater than the number of CNs in the target cluster. Otherwise, the scale-out will fail.

This parameter is a POSTMASTER parameter. You are not advised to modify it. If you need to modify it, set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 2 to 1024. The minimum value cannot be less than the actual number of CNs in the cluster.

**Default value**: **128**

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## max_datanodes

**Parameter description**: Specifies the maximum number of DNs in a cluster. If scale-out is required, ensure that the value of this parameter is greater than the total number of DNs in the target cluster. Otherwise, the scale-out will fail.

This parameter is a POSTMASTER parameter. You are not advised to modify it. If you need to modify it, set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 2 to 65535. The minimum value cannot be less than the actual number of DNs in the cluster.

**Default value**: **256**

## cache_connection

**Parameter description**: Specifies whether to reclaim the connections of a connection pool.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that the connections of a connection pool will be reclaimed.
- **off** indicates that the connections of a connection pool will not be reclaimed.

**Default value**: **on**

## enable_force_reuse_connections

**Parameter description**: Specifies whether a session forcibly reuses a new connection.

This parameter is a BACKEND parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that the new connection is forcibly used.
- **off** indicates that the current connection is used.

**Default value**: **off**

## pooler_connect_max_loops

**Parameter description**: Specifies whether to enable the connection retries to enhance stability of setting up connections in primary/standby switchover scenarios. If a service fails to connect to the primary server, it will retry by attempting to connect to the standby server. If the standby server is successfully promoted to primary, the retry attempt will succeed. This parameter specifies the total number of retry attempts. If this parameter is set to **0**, retries are disabled. The service only establishes a connection to the primary server.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 20

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**Default value**: **1**

## pooler_connect_interval_time

**Parameter description**: Specifies the interval between retries when **pooler_connect_max_loops** is set to a value greater than 1. You are advised to set this parameter to a value slightly greater than the time required for primary/standby switchover in the current cluster.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 7200. The smallest unit is s.

**Default value**: **15s**

## pooler_timeout

**Parameter description**: Specifies the timeout period of communication between each connection in a CN's connection pool and another CN/DN.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 7200. The smallest unit is s.

**Default value**: **10min**

## pooler_connect_timeout

**Parameter description**: Specifies the timeout period of connecting a CN's connection pool to another CN/DN in the same cluster.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 7200. The smallest unit is s.

**Default value**: **1min**

## pooler_cancel_timeout

**Parameter description**: Specifies the timeout period of canceling a connection by a CN's connection pool during error processing. If similar timeout occurs when an exception of the subtransaction or stored procedure is captured, the transaction containing the subtransaction or the stored procedure rolls back. If the source data from the COPY FROM operation is not consistent with that of the table structure in the target table, and the parameter value is not **0**, an error is reported.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 7200. The smallest unit is s. **0** (not recommended) indicates that the timeout is disabled.

**Default value**: **15s**

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# 19.19 Cluster Transaction Parameters

This section describes the settings and value ranges of transaction parameters for the cluster.

## transaction_isolation

**Parameter description:** specifies the isolation level of the current transaction.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string of case-sensitive characters. The values include:

- **serializable**: This value is equivalent to REPEATABLE READ in GaussDB.
- **read committed** indicates that only the data in committed transactions will be read.
- **repeatable read** indicates that only the data committed before transaction start is read. Uncommitted data or data committed in other concurrent transactions cannot be read.
- **read uncommitted** indicates that data is readable at any time.
- **default**: The value is the same as that of **default_transaction_isolation**.

**Default value: read committed**

## transaction_read_only

**Parameter description**: Specifies whether the current transaction is a read-only transaction.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that the current transaction is a read-only transaction.
- **off** indicates that the current transaction can be a read/write transaction.

**Default value**: **off**

## xc_maintenance_mode

**Parameter description**: Specifies whether the system is in maintenance mode.

This parameter is a SUSET parameter. Set it based on method 3 in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that the system is in maintenance mode.
- **off** indicates that the system is not in maintenance mode.

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NOTICE

Exercise caution when setting this parameter to **on** to avoid data inconsistencies in the cluster.

**Default value**: **off**

## allow_concurrent_tuple_update

**Parameter description**: Specifies whether to allow concurrent update.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that concurrent update is allowed.
- **off** indicates that concurrent update is disallowed.

**Default value**: **on**

## gtm_host

**Parameter description**: Specifies the IP address of the primary GTM process. This parameter is visible only to the sysadmin user.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

**Default value**: IP address of the primary GTM

## gtm_port

**Parameter description**: Specifies the listening port of the primary GTM process. This parameter is visible only to the sysadmin user.

This parameter is a POSTMASTER parameter.

NOTE

This parameter is specified in the configuration file during installation. Do not modify this parameter unless absolutely necessary. Otherwise, database communication will be affected.

**Value range:** an integer ranging from 1 to 65535

**Default value**: specified during installation

## gtm_host1

**Parameter description**: Specifies the IP address of the standby GTM process. This parameter is visible only to the sysadmin user.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

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**Value range**: a string

**Default value**: IP address of the standby GTM

## gtm_port1

**Parameter description**: Specifies the listening port of the standby GTM process. This parameter is visible only to the sysadmin user.

This parameter is a POSTMASTER parameter.

NOTE

This parameter is specified in the configuration file during installation. Do not modify this parameter unless absolutely necessary. Otherwise, database communication will be affected.

**Value range:** an integer ranging from 1 to 65535

**Default value**: The value is specified during installation if the standby GTM 1 is deployed. Otherwise, the value is **6665**.

## pgxc_node_name

**Parameter description**: Specifies the name of a node.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

When a standby node requests to replicate logs on the primary node, if the **application_name** parameter is not set, the **pgxc_node_name** parameter is used as the name of the streaming replication slot of the standby node on the primary node. The streaming replication slot is named in the following format: Value of this parameter_IP address of the standby node_Port number of the standby node. The IP address and port number of the standby node are obtained from the IP address and port number of the standby node specified by the **replconninfo** parameter. The maximum length of a streaming replication slot name is 61 characters. If the length of the concatenated string exceeds 61 characters, the truncated **pgxc_node_name** will be used for concatenation to ensure that the length of the streaming replication slot name is less than or equal to 61 characters.

CAUTION

After this parameter is modified, the cluster will fail to be connected. You are advised not to modify this parameter.

**Value range**: a string

**Default value**: current node name

## gtm_backup_barrier

**Parameter description**: Specifies whether to create a restoration point for the GTM starting point.

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This parameter is a SUSET parameter. Set it based on instructions provided in Table 11-2.

**Value range**: Boolean

- **on** indicates that a restoration point will be created for the GTM starting point.
- **off** indicates that a restoration point will not be created for the GTM starting point.

**Default value**: **off**

## gtm_conn_check_interval

**Parameter description**: Sets the intervals between two consecutive performed checks performed by the CN on the connections between local threads and the primary GTM.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-2.

**Value range**: an integer ranging from 0 to 2147483. The unit is s.

**Default value**: **10s**

## transaction_deferrable

**Parameter description**: Specifies whether to delay the execution of a read-only serial transaction without incurring an execution failure. Assume this parameter is set to **on**. When the server detects that the tuples read by a read-only transaction are being modified by other transactions, it delays the execution of the read-only transaction until the other transactions finish modifying the tuples. This parameter is reserved and does not take effect in this version. Similar to this parameter, the **default_transaction_deferrable** parameter is used to specify whether to allow delayed execution of a transaction.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-2.

**Value range**: Boolean

- **on** indicates that the execution of a read-only serial transaction can be delayed.
- **off** indicates that the execution of a read-only serial transaction cannot be delayed.

**Default value**: **off**

## enable_show_any_tuples

**Parameter description:** This parameter is available only in a read-only transaction and is used for analysis. When this parameter is set to **on** or **true**, all versions of tuples in the table are displayed.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-2.

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**Value range**: Boolean

- **on** or **true** indicates that all versions of tuples in the table are displayed.
- **off** or **false** indicates that no versions of tuples in the table are displayed.

**Default value**: **off**

## gtm_connect_timeout

**Parameter description**: Specifies the GTM connection timeout. If the connection time of the GTM exceeds its value, the connection times out and exits.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 2147483647. The unit is s.

**Default value**: **2s**

## gtm_connect_retries

**Parameter description**: Specifies the number of GTM reconnection attempts.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 2147483647

**Default value**: **30**

## gtm_rw_timeout

**Parameter description**: Specifies the GTM response timeout. If the time spent waiting for GTM responses exceeds its value, the operation times out and exits.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 2147483647. The unit is s.

**Default value**: **1min**

## enable_redistribute

**Parameter description**: Specifies whether unmatched nodes are redistributed.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that unmatched nodes are redistributed.
- **off** indicates that unmatched nodes are not redistributed.

**Default value**: **off**

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## replication_type

**Parameter description**: Specifies whether the current HA mode is primary/standby/secondary, one primary multiple standbys, or single primary.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

This parameter is used for CM deployment. Do not set it.

**Value range**: 0 to 2

- **0**: indicates that the HA nodes consist of a primary, a standby, and a secondary node.
- **1** Indicates that the one-primary-multiple-standby mode is used, covering all scenarios. This mode is recommended.
- **2** Indicates the single primary mode. In this mode, the standby node cannot be expanded.

**Default value**: **1**

## enable_gtm_free

**Parameter description**: Specifies whether the GTM-Free mode is enabled. In large concurrency scenarios, the snapshots delivered by the GTM increase in number and size. The network between the GTM and the CN becomes the performance bottleneck. The GTM-Free mode is used to eliminate the bottleneck. In this mode, the CN communicates with DNs instead of the GTM. The CN sends queries to each DN, which locally generates snapshots and xids, ensuring external write consistency but not external read consistency.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**CAUTION**

When the GTM-Free mode is used, you are advised to set **application_type** to **perfect_sharding_type** so that you can find SQL statements that may cause data inconsistency. Otherwise, the system does not intercept statements that may cause data inconsistency.

**Value range**: Boolean

- **on** indicates that the GTM-FREE mode is enabled and the cluster ensures eventual read consistency.
- **off** indicates that the GTM-FREE mode is disabled.

**Default value**: **off**

## enable_twophase_commit

**Parameter description**: Specifies whether to enable distributed two-phase commit in the GTM-Free mode adopted to address the replacement issues of SDS

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in the cloud database. This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that distributed two-phase commit is allowed in the GTM-Free mode.
- **off** indicates that distributed two-phase commit is not allowed in the GTM-Free mode.

**Default value**: **on**

## application_type

**Parameter description**: valid only when **enable_gtm_free** is set to **on**. This parameter specifies the service type of a user. This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**. This parameter cannot be set using **gs_guc**. Only the following ways are allowed:

1. Use the **gsql** client to perform session-level configuration.
2. When JDBC is used to connect to the database, set the **ApplicationType** parameter for the connection string.

**Value range**: enumerated values

- **not_perfect_sharding_type** indicates a service across nodes. If this value is used, statements across nodes can be executed.
- **perfect_sharding_type** indicates a service on a single node. If this value is used and the SQL statement involves multiple nodes, an error is reported. The corresponding SQL statement is recorded in the system log.
  - If this value is used, you can run the **/*+ multinode */ hint** command to allow SQL statements to be executed on multiple nodes. The multinode hint can be added after the select, insert, update, delete, and merge keywords.

## gtm_host2

**Parameter description**: Specifies the host name or IP address of the standby GTM 2 if the standby GTM 2 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

**Default value**: the IP address of the standby GTM 2 if the standby GTM 2 is deployed. Otherwise, the value is **""**.

## gtm_host3

**Parameter description**: Specifies the host name or IP address of the standby GTM 3 if the standby GTM 3 is deployed. This parameter is visible only to the sysadmin user.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

**Default value**: the IP address of the standby GTM 3 if the standby GTM 3 is deployed. Otherwise, the value is **""**.

## gtm_host4

**Parameter description**: Specifies the host name or IP address of the standby GTM 4 if the standby GTM 4 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

**Default value**: the IP address of the standby GTM 4 if the standby GTM 4 is deployed. Otherwise, the value is **""**.

## gtm_host5

**Parameter description**: Specifies the host name or IP address of the standby GTM 5 if the standby GTM 5 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

**Default value**: the IP address of the standby GTM 5 if the standby GTM 5 is deployed. Otherwise, the value is **""**.

## gtm_host6

**Parameter description**: Specifies the host name or IP address of the standby GTM 6 if the standby GTM 6 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: a string

**Default value**: the IP address of the standby GTM 6 if the standby GTM 6 is deployed. Otherwise, the value is **""**.

## gtm_host7

**Parameter description**: Specifies the host name or IP address of the standby GTM 7 if the standby GTM 7 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

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**Value range**: a string

**Default value**: the IP address of the standby GTM 7 if the standby GTM 7 is deployed. Otherwise, the value is **""**.

## gtm_port2

**Parameter description**: Specifies the listening port of the standby GTM 2 if the standby GTM 2 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 65535

**Default value**: The value is specified during installation if the standby GTM 2 is deployed. Otherwise, the value is **6666**.

## gtm_port3

**Parameter description**: Specifies the listening port of the standby GTM 3 if the standby GTM 3 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 65535

**Default value**: The value is specified during installation if the standby GTM 3 is deployed. Otherwise, the value is **6666**.

## gtm_port4

**Parameter description**: Specifies the listening port of the standby GTM 4 if the standby GTM 4 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 65535

**Default value**: The value is specified during installation if the standby GTM 4 is deployed. Otherwise, the value is **6666**.

## gtm_port5

**Parameter description**: Specifies the listening port of the standby GTM 5 if the standby GTM 5 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 65535

**Default value**: The value is specified during installation if the standby GTM 5 is deployed. Otherwise, the value is **6666**.

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### gtm_port6

**Parameter description**: Specifies the listening port of the standby GTM 6 if the standby GTM 6 is deployed. This parameter is visible only to the sysadmin user.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 65535

**Default value**: The value is specified during installation if the standby GTM 6 is deployed. Otherwise, the value is **6666**.

### gtm_port7

**Parameter description**: Specifies the listening port of the standby GTM 7 if the standby GTM 7 is deployed. This parameter is visible only to the **sysadmin** user.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 65535

**Default value**: The value is specified during installation if the standby GTM 7 is deployed. Otherwise, the value is **6666**.

### enable_defer_calculate_snapshot

**Parameter description**: Specifies the delay in calculating **xmin** and **oldestxmin**. Calculation is triggered only when 1000 transactions are executed or the interval is 1s. If this parameter is set to **on**, the overhead of calculating snapshots can be reduced in heavy-load scenarios, but the progress of **oldestxmin** is slow, affecting tuple recycling. If this parameter is set to **off**, **xmin** and **oldestxmin** can be calculated in real time, but the overhead for calculating snapshots increases.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that snapshots **xmin** and **oldestxmin** are calculated with a delay.
- **off** indicates that snapshots **xmin** and **oldestxmin** are calculated in real time.

**Default value**: **on**

## 19.20 Dual-Cluster Replication Parameters

### enable_roach_standby_cluster

**Parameter description**: Sets the instances of the standby cluster to read-only in dual-cluster mode. Only the sysadmin user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

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- **on** indicates that the read-only mode is enabled for the standby cluster.
- **off** indicates that the read-only mode is disabled for the standby cluster. In this case, the standby cluster can be read and written.

**Default value**: **off**

## enable_slot_log

**Parameter description**: Determines whether to enable primary/standby synchronization for logical replication slots.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that primary/standby synchronization is enabled for logical replication slots.
- **off** indicates that primary/standby synchronization is disabled for logical replication slots.

**Default value**: **on**

## max_changes_in_memory

**Parameter description**: Specifies the maximum number of DML statements cached in memory for a single transaction during logical decoding.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 2147483647

**Default value**: **4096**

## max_cached_tuplebufs

**Parameter description**: Specifies the upper limit of the total tuple information cached in the memory during logical decoding. You are advised to set this parameter to a value greater than or equal to twice of **max_changes_in_memory**.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: an integer ranging from 1 to 2147483647

**Default value**: **8192**

## logical_decode_options_default

**Parameter description**: Specifies the global default value for unspecified decoding options when logical decoding starts.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

Currently, the following logical decoding options are supported: **parallel-decode-num**, **parallel-queue-size**, **max-txn-in-memory**, **max-reorderbuffer-in-memory**,

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and **exclude-users**. For the meanings of the options, see **6.3.15 Example: Logic Replication Code**.

**Value range**: a string of key=value characters separated by commas (,), for example, **'parallel-decode-num=4,parallel-queue-size=128,exclude-users=userA'**. An empty string indicates that the default value hardcoded by the program is used.

**Default value**: **""**

NOTICE

The SIGHUP parameter does not affect the started logic decoding process. The options specified by this parameter are used as the default settings for subsequent logic decoding startup, and the settings specified in the startup command are preferentially used.

The **exclude-users** option is different from the logic decoding startup option. You are not allowed to specify multiple blacklisted users.

## logical_sender_timeout

**Parameter description:** Specifies the maximum waiting time for the sender to wait for the receiver to receive logical logs.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is ms.

**Default value**: **30s**

## RepOriginId

**Parameter description**: This parameter is a session-level GUC parameter. In bidirectional logical replication, set it to a non-zero value to avoid infinite data replication.

This parameter is a USERSET parameter. Set it based on **Method 3** provided in **Table 11-2**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **0**

## hadr_max_size_for_xlog_receiver

**Parameter description**: Specifies the maximum difference between the OBS logs obtained by instances in the DR cluster and the local playback logs. If the difference is greater than the value of this parameter, the instances stop obtaining OBS logs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

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**Handling suggestion**: The value of this parameter is related to the local disk size. You are advised to set this parameter to 50% of the local disk size.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **256GB**

### auto_csn_barrier

**Parameter description**: Specifies whether the barrier logging function is enabled for the primary cluster for streaming DR.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: enabled.
- **off**: disabled.

**Default value**: **off**

### stream_cluster_run_mode

**Parameter description**: Specifies whether a CN or DN belongs to the primary or standby cluster in a dual-cluster streaming DR scenario. In a single-cluster scenario, the primary cluster is selected by default.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values

- **cluster_primary** indicates that the node is in the primary cluster.
- **cluster_standby** indicates that the node is in the standby cluster.

**Default value**: **cluster_primary**

## 19.21 Developer Options

### allow_system_table_mods

**Parameter description:** Specifies whether the structure of a system catalog or the name of a system schema can be modified.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the structure of the system catalog or the name of the system schema can be modified.
- **off** indicates that the structure of the system catalog or the name of the system schema cannot be modified.

**Default value**: **off**

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> **CAUTION**
>
> You are not advised to change the default value of this parameter. If this parameter is set to **on**, system tables may be damaged and the database may fail to be started.

## allow_create_sysobject

**Parameter description:** Specifies whether objects such as functions, stored procedures, and synonyms can be created or modified in the system schema. The system schema refers to the schema provided by the database after initialization, excluding the public schema. The OID of the system schema is usually smaller than 16384.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that initial users and system administrators can create or modify objects such as functions, stored procedures, and synonyms in the system schema. For details about whether other users are allowed to create these objects, see the permission requirements of the corresponding schema.
- **off** indicates that all users are not allowed to create or modify objects such as functions, stored procedures, and synonyms in the system schema.

**Default value**: **on**

## debug_assertions

**Parameter description**: Specifies whether to enable various assertion checks. This parameter assists in debugging. If you are experiencing strange problems or crashes, set this parameter to **on** to identify programming defects. To use this parameter, the macro USE_ASSERT_CHECKING must be defined (through the configure option **--enable-cassert**) during the GaussDB compilation.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that various assertion checks are enabled.
- **off** indicates that various assertion checks are disabled.

> **NOTE**
>
> If you compile GaussDB with the assertion check enabled, this parameter is set to **on** by default.

**Default value**: **off**

## ignore_checksum_failure

**Parameter description**: Specifies whether to ignore check failures (but still generate an alarm) and continue reading data. Continuing reading data may

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result in breakdown, damaged data being transferred or stored, failure of data recovery from remote nodes, or other serious problems. You are not advised to modify the settings.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that data check errors are ignored.
- **off** indicates that data check errors are reported.

**Default value**: **off**

## ignore_system_indexes

**Parameter description**: Specifies whether to ignore system indexes when reading system tables (but still update the indexes when modifying the tables).

This parameter is a BACKEND parameter. Set it based on instructions provided in **Table 11-1**.

NOTICE

This parameter is useful for recovering data from tables whose system indexes are damaged.

**Value range**: Boolean

- **on** indicates that system indexes are ignored.
- **off** indicates that system indexes are not ignored.

**Default value**: **off**

## post_auth_delay

**Parameter description**: Specifies the delay in the connection to the server after a successful authentication. Developers can attach a debugger to the server startup process.

This parameter is a BACKEND parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer ranging from 0 to 2147. The unit is s.

**Default value**: **0**

NOTE

This parameter is used only for commissioning and fault locating. To prevent impact on service running, ensure that the default value **0** is used in the production environment. If this parameter is set to a value other than 0, the cluster status may be abnormal due to a long authentication delay.

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## pre_auth_delay

**Parameter description**: Specifies the period of delaying authentication after the connection to the server is started. Developers can attach a debugger to the authentication procedure.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 60. The unit is s.

**Default value**: **0**

NOTE

This parameter is used only for commissioning and fault locating. To prevent impact on service running, ensure that the default value **0** is used in the production environment. If this parameter is set to a value other than 0, the cluster status may be abnormal due to a long authentication delay.

## trace_notify

**Parameter description**: Specifies whether to enable the function of generating debugging output for the **LISTEN** and **NOTIFY** commands. The level of **client_min_messages** or **log_min_messages** must be **debug1** or lower so that debugging output can be recorded in the client or server logs, respectively.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the function is enabled.
- **off** indicates that the function is disabled.

**Default value**: **off**

## trace_recovery_messages

**Parameter description**: Specifies whether to enable logging of recovery-related debugging output. This parameter allows users to overwrite the normal setting of **log_min_messages**, but only for specific messages. This is intended for the use in debugging the standby server.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values. Valid values include **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, and **log**. For details about the parameter values, see **log_min_messages**.

**Default value**: **log**

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NOTE

- **log** indicates that recovery-related debugging information will not be logged.
- Except the default value **log**, each of the other values indicates that recovery-related debugging information at the specified level will also be logged. Common settings of **log_min_messages** enables logs to be unconditionally recorded into server logs.

## trace_sort

**Parameter description**: Specifies whether to print information about resource usage during sorting operations. This parameter is available only when the macro TRACE_SORT is defined during the GaussDB compilation. However, TRACE_SORT is currently defined by default.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the function is enabled.
- **off** indicates that the function is disabled.

**Default value**: **off**

## zero_damaged_pages

**Parameter description**: Specifies whether to detect a damaged page header that causes GaussDB to report an error, aborting the current transaction.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- Setting this parameter to **on** causes the system to report a warning, zero out the damaged page, and continue processing. This behavior will destroy data, including all the rows on the damaged page. However, it allows you to bypass the error and retrieve rows from any undamaged pages that may be present in the table. Therefore, it is useful for restoring data if corruption has occurred due to a hardware or software error. In most cases, you are advised not to set this parameter to **on** if you want to restore data from damaged pages.
- If this parameter is set to **off**, the system does not fill zeros in damaged pages.

**Default value**: **off**

## string_hash_compatible

**Parameter description**: Specifies whether to use the same method to calculate char-type hash values and varchar- or text-type hash values. Based on the setting of this parameter, you can determine whether a redistribution is required when a distribution column is converted from a char-type data distribution into a varchar- or text-type data distribution.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: Boolean

- **on** indicates that the same calculation method is used and a redistribution is not required.
- **off** indicates that different calculation methods are used and a redistribution is required.

NOTE

Calculation methods differ in the length of input strings used for calculating hash values. (For a char-type hash value, spaces following a string are not counted as the length. For a text- or varchar-type hash value, the spaces are counted.) The hash value affects the calculation result of queries. To avoid query errors, do not modify this parameter during database running once it is set.

**Default value**: **off**

## remotetype

**Parameter description**: Specifies the remote connection type.

This parameter is a BACKEND parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: enumerated values. Valid values are **application**, **coordinator**, **datanode**, **gtm**, **gtmproxy**, **internaltool**, and **gtmtool**.

**Default value**: **application**

## max_user_defined_exception

**Parameter description**: Specifies the maximum number of exceptions.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

Value range: an integer. Currently, only the fixed value **1000** is supported.

**Default value**: **1000**

## enable_compress_spill

**Parameter description**: Specifies whether to enable the compression function of writing data to disk.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** or **true** indicates that optimization for writing data to disk is enabled.
- **off** or **false** indicates that optimization for writing data to a disk is disabled.

**Default value**: **on**

## enable_parallel_ddl

**Parameter description**: Specifies whether multiple CNs can concurrently perform DDL operations on the same database object.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: DDL operations can be concurrently performed without distributed deadlocks.
- **off**: DDL operations cannot be concurrently performed as distributed deadlocks may occur.

**Default value**: **on**

## support_batch_bind

**Parameter description**: Specifies whether to batch bind and execute PBE statements through interfaces such as JDBC, ODBC, and libpq.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that batch binding and execution are used.
- **off** indicates that batch binding and execution are not used.

**Default value**: **on**

## numa_distribute_mode

**Parameter description**: Specifies the distribution of some shared data and threads among NUMA nodes. This parameter is used to optimize the performance of large-scale ARM servers with multiple NUMA nodes. Generally, you do not need to set this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string. The valid values are **none** and **all**.

- **none** indicates that this function is disabled.
- **all** indicates that some shared data and threads are distributed to different NUMA nodes to reduce the number of remote access times and improve performance. Currently, this function applies only to ARM servers with multiple NUMA nodes. All NUMA nodes must be available for database processes. You cannot select only some NUMA nodes.

NOTE

In the current version, **numa_distribute_mode** cannot be set to **all** on the x86 architecture.

**Default value**: **none**

## log_pagewriter

**Parameter description**: Specifies whether to display the page refresh information of a thread and details about an incremental check point after the incremental

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check point is enabled. You are not advised to set this parameter to **true** because a large amount of information will be generated.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**Default value**: **off**

## advance_xlog_file_num

**Parameter description**: Specifies the number of Xlog files that are periodically initialized in advance in the background. This parameter is used to prevent the Xlog file initialization from affecting the performance during transaction submission. However, such a fault may occur only when the system is overloaded. Therefore, you do not need to set this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 1000000. The value **0** indicates that initialization is not performed in advance. For example, the value **10** indicates that the backend thread periodically initializes 10 Xlog files in advance based on the write location of the current xlog.

**Default value**: **0**

## comm_sender_buffer_size

**Parameter description**: Specifies the size of the buffer for each interaction between CNs and DNs and between DNs in the stream plan. In some cases, different values affect the stream performance. After the value is reset, the cluster needs to be restarted for the reset to take effect. The unit is KB.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 1024

**Default value**: **8**

## default_index_kind

**Parameter description**: Controls the default behavior of creating indexes.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

Value range: an integer. Currently, only the fixed values **0**, **1**, and **2** are supported.

- **0**: The global partition index function is disabled for distributed deployment.
- **1**: A local index is created by default.
- **2**: A global index is created by default.

**Default value**: **2**

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> **CAUTION**
>
> You are advised not to change the default value of this parameter. Otherwise, the index validity may be affected.

# 19.22 Auditing

## 19.22.1 Audit Switch

### audit_enabled

**Parameter description**: Specifies whether to enable or disable the audit process. After the audit process is enabled, the auditing information written by the background process can be read from the pipe and written into audit files.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the auditing function is enabled.
- **off** indicates that the auditing function is disabled.

**Default value**: **on**

### audit_directory

**Parameter description**: Specifies the storage directory of audit files. A path relative to the **data** directory. Only the **sysadmin** user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value: pg_audit** If **om** is used for cluster deployment, audit logs are stored in *$GAUSSLOG*/**pg_audit/***Instance name*.

> **NOTICE**
>
> - You need to set different audit file directories for different CNs or DNs. Otherwise, audit logs will be abnormal.
> - If the value of **audit_directory** in the configuration file is an invalid path, the audit function cannot be used.

> **NOTE**
>
> - Valid path: Users have read and write permissions on the path.
> - Invalid path: Users do not have read or write permissions on an invalid path.

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## audit_data_format

**Parameter description**: Audits the format of log files. Currently, only the binary format is supported. Only the **sysadmin** user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **binary**

## audit_rotation_interval

**Parameter description**: Specifies the interval of creating an audit log file. If the difference between the current time and the time when the previous audit log file is created is greater than the value of **audit_rotation_interval**, a new audit log file will be generated.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 35791394. The unit is min.

**Default value: 1d**

NOTICE

Adjust this parameter only when required. Otherwise, **audit_resource_policy** may fail to take effect. To control the storage space and time of audit logs, set the **audit_resource_policy**, **audit_space_limit**, and **audit_file_remain_time** parameters.

## audit_rotation_size

**Parameter description**: Specifies the maximum capacity of an audit log file. If the total number of messages in an audit log exceeds the value of **audit_rotation_size**, the server will generate a new audit log file.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1024 to 1048576. The unit is KB.

**Default value**: **10 MB**

NOTICE

- Do not adjust this parameter unless necessary. Otherwise, **audit_resource_policy** may fail to take effect. To control the storage space and time of audit logs, set the **audit_resource_policy**, **audit_space_limit**, and **audit_file_remain_time** parameters.
- If the space occupied by a single record in an audit log file exceeds the value of this parameter, the log file is regarded as an invalid log file.

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## audit_resource_policy

**Parameter description**: Specifies the policy for determining whether audit logs are preferentially stored by space or time.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that audit logs are preferentially stored by space. A maximum of **audit_space_limit** logs can be stored.
- **off** indicates that audit logs are preferentially stored by time. A minimum duration of **audit_file_remain_time** logs must be stored.

**Default value**: **on**

## audit_file_remain_time

**Parameter description**: Specifies the minimum duration required for recording audit logs. This parameter is valid only when **audit_resource_policy** is set to **off**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 730. The unit is day. **0** indicates that the storage duration is not limited.

**Default value**: **90**

## audit_space_limit

**Parameter description**: Specifies the total disk space occupied by audit files.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1024 KB to 1024 GB. The unit is KB.

**Default value**: **1 GB**

NOTICE

- This parameter takes effect only for a single process instance folder in the **pg_audit** directory. By default, the total disk space occupied by audit files on each CN or DN is 1 GB.
- In the multi-audit thread scenario, the minimum disk space occupied by audit files is the product of values of **audit_thread_num** and **audit_rotation_size**. If the value of this parameter is too small, the disk space occupied by audit files may exceed the value of this parameter.

## audit_file_remain_threshold

**Parameter description**: Specifies the maximum number of audit files in the audit directory.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 100 to 1048576

**Default value**: **1048576**

NOTICE

- Ensure that this parameter is set to **1048576**. Do not adjust this parameter unless necessary. Otherwise, **audit_resource_policy** may fail to take effect. To control the storage space and time of audit logs, set the **audit_resource_policy**, **audit_space_limit**, and **audit_file_remain_time** parameters.
- In the multi-audit thread scenario, do not adjust this parameter unless necessary. Ensure that the value of this parameter is greater than or equal to the value of **audit_thread_num**. Otherwise, the audit function cannot be used and the database is abnormal.

### audit_thread_num

**Parameter description**: Specifies the number of audit threads.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in Table 11-1.

**Value range:** an integer ranging from 1 to 48

**Default value**: **1**

NOTICE

When **audit_dml_state** is enabled and high performance is required, you are advised to increase the value of this parameter to ensure that audit messages can be processed and recorded in a timely manner.

## 19.22.2 User and Permission Audit

### audit_login_logout

**Parameter description**: Specifies whether to audit the GaussDB user's login (including login success and failure) and logout.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 0 to 7

- **0** indicates that the function of auditing users' logins and logouts is disabled.
- **1** indicates that only successful user logins are audited.
- **2** indicates that only failed user logins are audited.

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- **3** indicates that successful and failed user logins are audited.
- **4** indicates that only user logouts are audited.
- **5** indicates that successful user logouts and logins are audited.
- **6** indicates that failed user logouts and logins are audited.
- **7** indicates that successful user logins, failed user logins, and logouts are audited.

**Default value**: **7**

## audit_database_process

**Parameter description**: Specifies whether to audit the GaussDB user's login (including login success and failure) and logout.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range: 0** or **1**

- **0** indicates that the function of auditing GaussDB start, stop, recovery, and switchover operations of a database is disabled.
- **1** indicates that the function of auditing GaussDB start, stop, recovery, and switchover operations of a database is enabled.

**Default value**: **1**

## audit_user_locked

**Parameter description**: Specifies whether to audit the GaussDB user's locking and unlocking.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range: 0** or **1**

- **0** indicates that the function of auditing user's locking and unlocking is disabled.
- **1** indicates that the function of auditing user's locking and unlocking is enabled.

**Default value**: **1**

## audit_user_violation

**Parameter description**: Specifies whether to audit the access violation operations of a user.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range: 0** or **1**

- **0** indicates that the function of auditing the access violation operations of a user is disabled.

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- **1** indicates that the function of auditing the access violation operations of a user is enabled.

**Default value**: **0**

### audit_grant_revoke

**Parameter description**: Specifies whether to audit the granting and reclaiming of the GaussDB user's permission.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range: 0** or **1**

- **0** indicates that the function of auditing the granting and reclaiming of a user's permission is disabled.
- **1** indicates that the function of auditing the granting and reclaiming of a user's permission is enabled.

**Default value**: **1**

## 19.22.3 Operation Auditing

### audit_system_object

**Parameter description**: Specifies whether to audit the CREATE, DROP, and ALTER operations on the GaussDB database object. The GaussDB database objects include databases, users, schemas, and tables. You can change the value of this parameter to audit only the operations on required database objects. In the scenario where the leader node is forcibly selected, you are advised to set **audit_system_object** to the maximum value and audit all DDL objects.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 134217727

- **0** indicates that the function of auditing the CREATE, DROP, and ALTER operations on the GaussDB database object is disabled.
- Other values indicate that the CREATE, DROP, and ALTER operations on a certain or some GaussDB database objects are audited.

**Value description:**

The value of this parameter is calculated by 27 binary bits. The 27 binary bits represent 27 types of GaussDB objects. If the corresponding binary bit is set to **0**, the CREATE, DROP, and ALTER operations on corresponding database objects are not audited. If it is set to **1**, the CREATE, DROP, and ALTER operations are audited. For details about the audit contents represented by these 27 binary bits, see **Table 19-8**.

**Default value**: **67121159**, indicating that DDL operations on databases, schemas, users, data sources, and node groups are audited.

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**Table 19-8** audit_system_object parameter description

| Binary Bit | Description | Value Range |
| --- | --- | --- |
| Bit 0 | Whether to audit the CREATE, DROP, and ALTER operations on databases. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 1 | Whether to audit the CREATE, DROP, and ALTER operations on schemas. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 2 | Whether to audit the CREATE, DROP, and ALTER operations on users and user mappings. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 3 | Whether to audit the CREATE, DROP, ALTER, and TRUNCATE operations on tables. | • **0** indicates that the CREATE, DROP, ALTER, and TRUNCATE operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, ALTER, and TRUNCATE operations on these objects are audited. |
| Bit 4 | Whether to audit the CREATE, DROP, and ALTER operations on indexes. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 5 | Whether to audit the CREATE and DROP operations on views and materialized views. | • **0** indicates that the CREATE and DROP operations on these objects are not audited.<br>• **1** indicates that the CREATE and DROP operations on these objects are audited. |

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| Binary Bit | Description | Value Range |
| --- | --- | --- |
| Bit 6 | Whether to audit the CREATE, DROP, and ALTER operations on triggers. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 7 | Whether to audit the CREATE, DROP, and ALTER operations on procedures and functions. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 8 | Whether to audit the CREATE, DROP, and ALTER operations on tablespaces. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 9 | Whether to audit the CREATE, DROP, and ALTER operations on resource pools. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 10 | Whether to audit the CREATE, DROP, and ALTER operations on workloads. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 11 | Reserved | - |
| Bit 12 | Whether to audit the CREATE, DROP, and ALTER operations on data sources. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 13 | Whether to audit the CREATE and DROP operations on node groups. | • **0** indicates that the CREATE and DROP operations on these objects are not audited.<br>• **1** indicates that the CREATE and DROP operations on these objects are audited. |

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| Binary Bit | Description | Value Range |
| --- | --- | --- |
| Bit 14 | Whether to audit the CREATE, DROP, and ALTER operations on row-level security objects. | • **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited. |
| Bit 15 | Whether to audit the CREATE, DROP, and ALTER operations on types. | • **0** indicates that the CREATE, DROP, and ALTER operations on types are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on types are audited. |
| Bit 16 | Whether to audit the CREATE, DROP, and ALTER operations on text search objects (CONFIGURATION and DICTIONARY). | • **0** indicates that the CREATE, DROP, and ALTER operations on text search objects are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on text search objects are audited. |
| Bit 17 | Whether to audit the CREATE, DROP, and ALTER operations on directories. | • **0** indicates that the CREATE, DROP, and ALTER operations on directories are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on directories are audited. |
| Bit 18 | Whether to audit the CREATE, DROP, and ALTER operations on synonyms. | • **0** indicates that the CREATE, DROP, and ALTER operations on synonyms are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on synonyms are audited. |
| Bit 19 | Whether to audit the CREATE, DROP, and ALTER operations on sequences. | • **0** indicates that the CREATE, DROP, and ALTER operations on sequences are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on sequences are audited. |
| Bit 20 | Whether to audit the CREATE and DROP operations on CMKs and CEKs. | • **0** indicates that the CREATE and DROP operations on CMKs and CEKs are not audited.<br>• **1** indicates that the CREATE and DROP operations on CMKs and CEKs are audited. |

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| Binary Bit | Description | Value Range |
| --- | --- | --- |
| Bit 21 | Whether to audit the CREATE, DROP, and ALTER operations on packages. (Currently, the operations on packages can be audited only in the centralized deployment scenario.) | • **0** indicates that the CREATE, DROP, and ALTER operations on packages are not audited.<br>• **1** indicates that the CREATE, DROP, and ALTER operations on packages are audited. |
| Bit 22 | Reserved | - |
| Bit 23 | Reserved | - |
| Bit 24 | Whether to audit the ALTER and DROP operations on the **gs_global_config** objects. | • **0** indicates that the ALTER and DROP operations on the **gs_global_config** objects are not audited.<br>• **1** indicates that the ALTER and DROP operations on the **gs_global_config** objects are audited. |
| Bit 25 | Reserved | - |
| Bit 26 | Reserved | - |

## audit_dml_state

**Parameter description**: Specifies whether to audit the INSERT, UPDATE, and DELETE operations on a specific table.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer, **0** or **1**

- **0** indicates that the function of auditing the DML operations (except SELECT) is disabled.
- **1** indicates that the function of auditing the DML operations (except SELECT) is enabled.

**Default value**: **0**

## audit_dml_state_select

**Parameter description**: Specifies whether to audit the SELECT operation.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer, **0** or **1**

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- **0** indicates that auditing the SELECT operation is disabled.
- **1** indicates that auditing the SELECT operation is enabled.

**Default value**: **0**

## audit_function_exec

**Parameter description**: Specifies whether to record the audit information during the execution of the stored procedures, anonymous blocks, or user-defined functions (excluding system functions).

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer, **0** or **1**

- **0** indicates that auditing the stored procedure or function execution is disabled.
- **1** indicates that auditing the stored procedure or function execution is enabled.

**Default value**: **0**

## audit_copy_exec

**Parameter description**: Specifies whether to audit the COPY operation.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer, **0** or **1**

- **0** indicates that auditing the COPY operation is disabled.
- **1** indicates that auditing the COPY operation is enabled.

**Default value**: **1**

## audit_set_parameter

**Parameter description**: Specifies whether to audit the SET operation.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer, **0** or **1**

- **0** indicates that auditing the SET operation is disabled.
- **1** indicates that auditing the SET operation is enabled.

**Default value**: **0**

## audit_xid_info

**Parameter description**: Specifies whether to record the transaction ID of the SQL statement in the **detail_info** column of the audit log.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range:** an integer, **0** or **1**

- **0** indicates that the function of recording transaction IDs in the audit log is disabled.
- **1** indicates that the function of recording transaction IDs in the audit log is enabled.

**Default value**: **0**

NOTICE

If this function is enabled, the **detail_info** information in the audit log starts with *xid*. For example:

```
detail_info: xid=14619 , create table t1(id int);
```

If transaction IDs do not exist, *xid* is recorded as **NA** in the audit log.

## enableSeparationOfDuty

**Parameter description**: Specifies whether the separation of duties is enabled.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the separation of duties is enabled.
- **off** indicates that the separation of duties is disabled.

**Default value**: **off**

## enable_nonsysadmin_execute_direct

**Parameter description**: Specifies whether non-system administrator and non-monitor administrator users are allowed to execute the EXECUTE DIRECT ON statement.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that any user is allowed to execute the EXECUTE DIRECT ON statement.
- **off** indicates that only the system administrator and monitor administrator are allowed to execute the EXECUTE DIRECT ON statement.

**Default value**: **off**

## enable_access_server_directory

**Parameter description**: Specifies whether to allow non-initial users to create, modify, and delete directories.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that non-initial users have the permission to create, modify, and delete directories.
- **off** indicates that non-initial users do not have the permission to create, modify, and delete directories.

**Default value**: **off**

NOTICE

To use the advanced package UTL_FILE to access files on the server, you must have the permissions on the specified directory.

For security purposes, only the initial user can create, modify, and delete directories by default.

If **enable_access_server_directory** is enabled, users with the **SYSADMIN** permission and users who inherit the **gs_role_directory_create** permission of the built-in role can create directories. A user with the **SYSADMIN** permission, the owner of a directory, a user who is granted with the **DROP** permission for the directory, or a user who inherits the **gs_role_directory_drop** permission of the built-in role can delete the directory. A user with the **SYSADMIN** permission and the owner of a directory object can change the owner of the directory, and the user must be a member of the new owning role.

# 19.23 Transaction Monitoring

The automatic rollback transaction can be monitored and its statement problems can be located by setting the transaction timeout warning. In addition, the statements with long execution time can also be monitored.

## transaction_sync_naptime

**Parameter description**: For data consistency, when the local transaction's status differs from that in the snapshot of GTM, other transactions will be blocked. You need to wait for a few minutes until the transaction status of the local host is consistent with that of the GTM. The gs_clean tool is automatically triggered for cleansing when the waiting period on the CN exceeds that of **transaction_sync_naptime**. The tool will shorten the blocking time after it completes the cleansing.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 0 to 2147483. The unit is s.

**Default value**: **30s**

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NOTE

If the value of this parameter is set to **0**, gs_clean will not be automatically invoked for the cleansing before the blocking arrives the duration. Instead, the gs_clean tool is invoked by **gs_clean_timeout**. The default value is 5 minutes.

### transaction_sync_timeout

**Parameter description**: For data consistency, when the local transaction's status differs from that in the snapshot of GTM, other transactions will be blocked. You need to wait for a few minutes until the transaction status of the local host is consistent with that of the GTM. An exception is reported when the waiting duration on the CN exceeds the value of **transaction_sync_timeout**. Roll back the transaction to avoid system blocking due to long time of process response failures (for example, sync lock).

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483. The unit is s.

**Default value**: **10min**

NOTE

- If the value is **0**, no error is reported when the blocking times out or the transaction is rolled back.
- The value of this parameter must be greater than **gs_clean_timeout**. Otherwise, unnecessary transaction rollback will probably occur due to a block timeout caused by residual transactions that have not been deleted by gs_clean on the DN.

## 19.24 CM Parameters

Modifying CM parameters affects the running mechanism of GaussDB. You are advised to ask GaussDB engineers to do it for you. For details about how to modify the CM parameters, see method 1 in **Table 11-2**.

You can view CM Agent parameters in the **cm_agent.conf** file in the CM Agent data directory and CM Server parameters in the **cm_server.conf** file in the CM Server data directory.

## 19.24.1 CM Agent Parameters

### log_dir

**Parameter description**: Specifies the directory where CM Agent logs are stored. The value can be an absolute path, or relative to the CM Agent data directory.

**Value range**: a string. Any modification of this parameter takes effect only after CM Agent is restarted. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **"log"**, indicating that CM Agent logs are generated in the CM Agent data directory.

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## log_file_size

**Parameter description**: Specifies the size of a log file. If a log file exceeds the specified size, a new one is created to record log information.

**Value range**: an integer ranging from 0 to 2047. The unit is MB. The modification of this parameter takes effect after reloading. For details about how to modify the parameter, see **Table 11-2**.

**Default value**: **16MB**

## log_min_messages

**Parameter description**: Specifies which message levels are written to the CM Agent log. A higher level covers the messages of all the lower levels. The lower the level is, the fewer messages will be written into the log.

**Value range**: enumerated type. Valid values are **debug5**, **debug1**, **log**, **warning**, **error**, and **fatal**. The modification of this parameter takes effect after reloading. For details about how to modify the parameter, see **Table 11-2**.

**Default value**: **warning**

## incremental_build

**Parameter description**: Specifies whether a standby DN is incrementally built. If this parameter is enabled, a standby DN is incrementally built.

**Value range**: Boolean. The value can be **on** or **off**. The modification of this parameter takes effect after reloading. For details about how to modify the parameter, see **Table 11-2**.

**Default value**: **on**

## alarm_component

**Parameter description**: Specifies the location of the alarm component that processes alarms.

**Value range**: a string The modification of this parameter takes effect after reloading. For details about how to modify the parameter, see **Table 11-2**.

- If **--alarm-type** in the **gs_preinstall** script is set to **5**, no third-party component is connected and alarms are written into the **system_alarm** log. In this case, the value of **alarm_component** is **/opt/huawei/snas/bin/snas_cm_cmd**.
- If **--alarm-type** in the **gs_preinstall** script is set to **1**, a third-party component is connected. In this case, the value of **alarm_component** is the absolute path of the executable program of the third-party component.

**Default value**: **/opt/huawei/snas/bin/snas_cm_cmd**

## alarm_report_interval

**Parameter description**: Specifies the interval at which an alarm is reported. For details about how to modify this parameter, see **Table 11-2**.

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**Value range**: a non-negative integer (unit: s)

**Default value**: **1**

## alarm_report_max_count

**Parameter description**: Specifies the maximum number of times an alarm is reported. For details about how to modify this parameter, see **Table 11-2**.

**Value range**: a non-negative integer

**Default value**: **1**

## agent_report_interval

**Parameter description**: Specifies the interval at which CM Agent reports the instance status.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1**

## agent_phony_dead_check_interval

**Parameter description**: Specifies the interval at which CM Agent checks whether the CN, DN, or GTM process is suspended.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value: 10**

## agent_check_interval

**Parameter description**: Specifies the interval at which the CM Agent queries the status of instances, such as the DNs, CN, and GTM.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value: 2**

## agent_heartbeat_timeout

**Parameter description**: Specifies the heartbeat timeout interval for CM Agent to connect to CM Server.

**Value range**: an integer ranging from 2 to $2^{31}$ – 1. The unit is second. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **8**

## agent_connect_timeout

**Parameter description**: Specifies the time to wait before the attempt of CM Agent to connect to CM Server times out.

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**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1**

## agent_connect_retries

**Parameter description**: Specifies the number of times CM Agent tries to connect to the CM Server.

**Value range**: an integer. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **15**

## agent_kill_instance_timeout

**Parameter description**: Specifies the interval from the time when CM Agent fails to connect to the primary CM Server to the time when CM Agent kills all instances on the node.

**Value range**: an integer. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **0**, indicating that the operation of killing all instances on the node is not initiated.

## enable_gtm_phony_dead_check

**Parameter description**: Specifies whether to enable the GTM zombie check function.

**Value range**: an integer. The value **1** indicates that the zombie check is enabled, and the value **0** indicates that the zombie check is disabled. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1**

## security_mode

**Parameter description**: Specifies whether CNs and DNs are started in secure mode. If this parameter is set to **on**, CNs and DNs are started in secure mode.

**Value range**: Boolean. The value can be **on** or **off**. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **off**

## upgrade_from

**Parameter description**: Specifies the internal version number of the cluster before an in-place upgrade. Do not modify the value of this parameter.

**Value range**: a non-negative integer For details about how to modify this parameter, see **Table 11-2**.

The recommended value range is [0,*Version number of the installation package*].

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**Default value**: **0**

## process_cpu_affinity

**Parameter description**: Specifies whether to bind a primary DN process to a CPU core before starting the process. If this parameter is set to **0**, core binding will not be performed. If it is set to another value, core binding will be performed, and the number of physical CPU cores is $2^n$. Any modification of this parameter takes effect only after the cluster and CM Agent are restarted. Only ARM is supported. For details about how to modify this parameter, see **Table 11-2**.

**Value range**: an integer ranging from 0 to 2

**Default value**: **0**

## enable_xc_maintenance_mode

**Parameter description**: Specifies whether the **pgxc_node** system catalog can be modified when the cluster is in read-only mode.

**Value range**: Boolean Any modification of this parameter takes effect only after CM Agent is restarted. For details about how to modify this parameter, see **Table 11-2**.

- **on** indicates that the **pgxc_node** system catalog can be modified.
- **off** indicates that the **pgxc_node** system catalog cannot be modified.

**Default value**: **on**

## log_threshold_check_interval

**Parameter description**: Specifies the interval for compressing and clearing logs.

**Value range**: an integer ranging from 0 to $2^{31}$ – 1. The unit is second. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1800**

## dilatation_shard_count_for_disk_capacity_alarm

**Parameter description**: Specifies the number of shards to be added in the scale-out scenario. This parameter is used to calculate the threshold for reporting a disk capacity alarm.

NOTE

The parameter value must be the same as the actual number of shards to be added.

**Value range**: an integer ranging from 0 to $2^{31}$ – 1. If this parameter is set to **0**, the disk scale-out alarm is not reported. If this parameter is set to a value greater than **0**, the disk scale-out alarm is reported and the threshold is calculated based on the number of shards specified by this parameter. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1**

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## log_max_size

**Parameter description**: Specifies the maximum size of a log file.

**Value range**: an integer ranging from 0 to $2^{31}$ – 1. The unit is MB. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **10240**

## log_max_count

**Parameter description**: Specifies the maximum number of logs that can be stored on hard disks.

**Value range**: an integer ranging from 0 to 10000. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **10000**

## log_saved_days

**Parameter description**: Specifies the number of days for storing logs.

**Value range**: an integer ranging from 0 to 1000. The unit is day. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **90**

## enable_log_compress

**Parameter description**: Specifies whether to enable log compression.

**Value range**: Boolean For details about how to modify this parameter, see **Table 11-2**.

- **on** indicates that log compression is enabled.
- **off** indicates that log compression is disabled.

**Default value**: **on**

## enable_cn_auto_repair

**Parameter description**: Specifies whether to enable automatic CN recovery.

**Value range**: Boolean For details about how to modify this parameter, see **Table 11-2**.

- **on** indicates that the automatic CN recovery is enabled. That is, after a CN is removed, the agent automatically attempts to recover the CN and add the CN back.
- **off** indicates that automatic CN recovery is disabled.

**Default value**: **on**

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## agent_backup_open

**Parameter description**: Specifies whether to enable the DR cluster. After the DR cluster is enabled, the CM runs in DR cluster mode.

**Value range:** an integer ranging from 0 to 1 Any modification of this parameter takes effect only after CM Agent is restarted. For details about how to modify this parameter, see **Table 11-2**.

- **0**: disabled.
- **1**: enabled.

**Default value**: **0**

## enable_e2e_rto

**Parameter description**: Specifies whether to enable the E2E RTO function. After this function is enabled, the hang-up detection period and network detection timeout time are shortened. The CM can reach the E2E RTO indicator (RTO for a single instance ≤ 10s; RTO for combined faults ≤ 30s).

**Value range:** an integer, **0** or **1** The value **1** indicates enabled, while the value **0** indicates disabled. For details about how to modify this parameter, see **Table 11-2**.

**Default value**:

Independent deployment: **1**

Finance edition (standard), enterprise edition, and finance edition (data computing): **0**

## enable_dcf

**Parameter description**: Specifies the status of the DCF mode.

**Value range**: Boolean Any modification of this parameter takes effect only after CM Agent is restarted. For details about how to modify this parameter, see **Table 11-2**.

- **0**: disabled.
- **1**: enabled.

**Default value**: **off**

## unix_socket_directory

**Parameter description**: Specifies the directory location of the Unix socket.

**Value range**: a string For details about how to modify this parameter, see **Table 11-2**.

**Default value: ''**

## disaster_recovery_type

**Parameter description**: Specifies the type of the DR relationship between primary and standby clusters.

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**Value range**: an integer ranging from 0 to 2 For details about how to modify this parameter, see **Table 11-2**.

- **0** indicates that no DR relationship is established.
- **1** indicates that the OBS DR relationship is established.
- **2** indicates that the streaming DR relationship is established.

**Default value**: **0**

### environment_threshold

**Parameter description**: Specifies the thresholds for the physical environment and node status monitored by the agent. If the thresholds are exceeded, logs will be printed. The thresholds include the memory usage threshold, CPU usage threshold, disk usage threshold, instance memory usage threshold, and instance thread pool usage threshold.

**Value range**: a string, in the format of (*0*, *0*, *0*, *0*). The value range for each number is [0,100]. The unit is %. Value **0** indicates that the detection is disabled. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **(0,0,0,0,0)**

## 19.24.2 CM Server Parameters

### log_dir

**Parameter description**: Specifies the directory where CM Server logs are stored. The value can be an absolute path, or relative to the CM Server data directory.

**Value range**: a string Any modification of this parameter takes effect only after the CM Server is restarted. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **"log"**, indicating that CM Server logs are generated in the CM Server data directory.

### log_file_size

**Parameter description**: Specifies the size of a log file. If a log file exceeds the specified size, a new one is created to record log information.

**Value range**: an integer ranging from 0 to 2047. The unit is MB. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **16MB**

### log_min_messages

**Parameter description**: Specifies the level of messages to be written to the CM Server log. A higher level covers the messages of all the lower levels. The lower the level is, the fewer messages will be written into the log.

**Value range**: enumerated type. Valid values are **debug5**, **debug1**, **log**, **warning**, **error**, and **fatal**. For details about how to modify this parameter, see **Table 11-2**.

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**Default value**: **warning**

## thread_count

**Parameter description**: Specifies the number of threads in the CM Server thread pool. If the value is greater than the sum of the number of cluster nodes and the number of threads for processing cm_ctl requests (if the number of cluster nodes is less than 32, one thread is used by default; otherwise, four threads are used), the value that takes effect is the sum of the number of cluster nodes and the number of threads for processing cm_ctl requests.

**Value range**: an integer ranging from 2 to 1000. Any modification of this parameter takes effect only after the CM Server is restarted. For details about how to modify this parameter, see **Table 11-2**.

**Default value: 1000**

## alarm_component

**Parameter description**: Specifies the location of the alarm component that processes alarms.

**Value range**: a string For details about how to modify this parameter, see **Table 11-2**.

- If **--alarm-type** in the **gs_preinstall** script is set to **5**, no third-party component is connected and alarms are written into the **system_alarm** log. In this case, the value of **alarm_component** is **/opt/huawei/snas/bin/snas_cm_cmd**.
- If **--alarm-type** in the **gs_preinstall** script is set to **1**, a third-party component is connected. In this case, the value of **alarm_component** is the absolute path of the executable program of the third-party component.

**Default value**: **/opt/huawei/snas/bin/snas_cm_cmd**

## instance_failover_delay_timeout

**Parameter description**: Specifies the delay in the CM Server failover when the primary CM Server breakdown is detected.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **0**

## instance_heartbeat_timeout

**Parameter description**: Specifies the time to wait before the instance heartbeat times out.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **6**

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## coordinator_heartbeat_timeout

**Parameter description**: Specifies the heartbeat timeout that triggers the automatic removal of faulty CNs. The setting of this parameter takes effect immediately, and you do not need to restart CM Server. If this parameter is set to **0**, faulty CNs are not automatically removed.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value: 25**

## cmserver_ha_connect_timeout

**Parameter description**: Specifies the time to wait before the connection between the primary and standby CM Servers times out.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **2**

## cmserver_ha_heartbeat_timeout

**Parameter description**: Specifies the time to wait before the heartbeat between the primary and standby CM Servers times out.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **6**

## phony_dead_effective_time

**Parameter description**: Specifies the maximum number of times CN, DN, or GTM processes are detected as zombie. If the number of times a process is detected as zombie is greater than the specified value, the process is considered as a zombie process and will be restarted.

**Value range**: an integer. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **5**

## enable_transaction_read_only

**Parameter description**: Specifies whether to enable the automatic threshold detection function of the CM Server disk. After this function is enabled, CM Server automatically sets the database to read-only when the disk usage is greater than the value of **datastorage_threshold_value_check**.

**Value range**: Boolean values **on**, **off**, **true**, **false**, **yes**, **no**, **1**, and **0** For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **on**

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## datastorage_threshold_check_interval

**Parameter description**: Specifies the interval for checking the disk usage. The system checks the disk usage at the interval specified by the user.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **10**

## datastorage_threshold_value_check

**Parameter description**: Specifies the usage threshold of a read-only disk in a database. When the disk usage of the data directory exceeds the specified value, the database is automatically set to read-only.

**Value range**: an integer ranging from 1 to 99, in percentage. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **85**

## max_datastorage_threshold_check

**Parameter description**: Specifies the maximum interval for checking the disk usage. After you modify the **enable_transaction_read_only** parameter, the system automatically checks whether the disk usage reaches the threshold at the specified interval.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

Default value: **43200**

## cmserver_ha_status_interval

**Parameter description**: Specifies the interval between synchronizations of primary and standby CM Server status.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1**

## cmserver_self_vote_timeout

**Parameter description**: Specifies the time to wait before the CM Server self-voting times out.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **6**

## alarm_report_interval

**Parameter description**: Specifies the interval at which an alarm is reported.

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**Value range**: a non-negative integer (unit: s) For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **3**

## alarm_report_max_count

**Parameter description**: Specifies the maximum number of times an alarm is reported.

**Value range**: a non-negative integer For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1**

## enable_az_auto_switchover

**Parameter description**: Specifies whether to enable automatic AZ switchover. If it is set to **1**, CM Server automatically switches over services among AZs. Otherwise, when a DN is faulty, services will not be automatically switched to another AZ even if the current AZ is unavailable. You can run the switchover command to manually switch services to another AZ.

**Value range**: a non-negative integer. The value **0** indicates that automatic AZ switchover is disabled, and the value **1** indicates that automatic AZ switchover is enabled. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1**

## instance_keep_heartbeat_timeout

**Parameter description**: The CM Agent periodically checks the instance status and reports the status to the CM Server. If the instance status cannot be detected for a long time and the accumulated number of times exceeds the value of this parameter, the CM Server delivers a command to the CM Agent to restart the instance.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **40**

## az_switchover_threshold

**Parameter description**: If the failure rate of a DN shard in an AZ (Number of faulty DN shards/Total number of DN shards x 100%) exceeds the specified value, automatic AZ switchover is triggered.

**Value range**: an integer ranging from 0 to 100 For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **100**

## az_check_and_arbitrate_interval

**Parameter description**: Specifies the interval for checking the AZ status. If the status of an AZ is abnormal, automatic AZ switchover is triggered.

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**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **2**

## az_connect_check_interval

**Parameter description**: Specifies the interval at which the network connection between AZs is checked.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **60**

## az_connect_check_delay_time

**Parameter description**: Specifies the delay between two retries to check the network connection between AZs.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **150**

## cmserver_demote_delay_on_etcd_fault

**Parameter description**: Specifies the interval at which CM Server switches from the primary state to the standby state due to unhealthy etcd.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **8**

## instance_phony_dead_restart_interval

**Parameter description**: Specifies the interval at which the CM Agent process restarts and kills a zombie CN, DN, or GTM instance. The interval between two consecutive kill operations cannot be less than the value of this parameter. Otherwise, the CM Agent process does not deliver commands.

**Value range**: an integer ranging from 1800 to $2^{31}$ – 1. The unit is second. For details about how to modify this parameter, see **Table 11-2**.

**Default value: 21600**

## cm_auth_method

**Parameter description**: Specifies the port authentication mode of the CM. **trust** indicates that port authentication is not configured. **gss** indicates that Kerberos port authentication is used. Note that you can change the value to **gss** only after the Kerberos server and client are successfully installed. Otherwise, the CM cannot communicate properly, affecting the cluster status.

**Value range**: **gss** or **trust**. For details about how to modify this parameter, see **Table 11-2**.

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**Default value**: **trust**

## cm_krb_server_keyfile

**Parameter description**: Specifies the location of the key file on the Kerberos server. The value must be an absolute path. The file is usually stored in the *${GAUSSHOME}*/**kerberos** directory and ends with keytab. The file name is the same as the name of the user who runs the cluster. This parameter is used together with **cm_auth_method**. If the **cm_auth_method** parameter is changed to **gss**, **cm_krb_server_keyfile** must also be configured as the correct path. Otherwise, the cluster status will be affected.

**Value range**: a string. For details about how to modify the parameter, see **Table 11-2**.

**Default value**: *${GAUSSHOME}*/**kerberos/***{Username}*.**keytab**. The default value cannot take effect and is used only as a prompt.

## cm_server_arbitrate_delay_base_time_out

**Parameter description**: Specifies the basic delay duration for CM Server arbitration. If the primary CM Server is disconnected, the arbitration starts to be timed. If the disconnection duration exceeds the arbitration delay duration, a new primary CM Server will be selected. The arbitration delay duration is determined by the basic delay duration, the node index (server ID), and the incremental delay duration. The formula is as follows: Arbitration delay duration = Basic delay duration + Node index x Incremental delay duration

**Value range**: an integer. The unit is s. The index should be larger than 0. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **10**

## cm_server_arbitrate_delay_incrememtal_time_out

**Parameter description**: Specifies the incremental delay duration for CM Server arbitration. If the primary CM Server is disconnected, the arbitration starts to be timed. If the disconnection duration exceeds the arbitration delay duration, a new primary CM Server will be selected. The arbitration delay duration is determined by the basic delay duration, the node index (server ID), and the incremental delay duration. The formula is as follows: Arbitration delay duration = Basic delay duration + Node index x Incremental delay duration

**Value range**: an integer. The unit is s. The index should be larger than 0. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **3**

## force_promote

**Parameter description**: Specifies whether CM Server enables the forcible startup logic (that is, when the cluster status is unknown, ensure that the basic functions of the cluster are available at the cost of partial data loss). The value **0** indicates that forcible startup is disabled, and the value **1** indicates that forcible startup is enabled. This parameter applies to CNs and DNs.

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**Value range: 0** or **1**. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **0**

## switch_rto

**Parameter description**: Specifies the delay for the forcible startup of CM Server. When **force_promote** is set to **1** and a shard in the cluster does not have primary CM Server, the system starts timing. After the delay, the forcible startup logic starts to be executed.

**Value range**: an integer ranging from 0 to 2147483647. The unit is second. The minimum value that takes effect is 60. If this parameter is set to a value less than 60, 60s is used. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **600**

## backup_open

**Parameter description**: Specifies whether to enable the DR cluster. After the DR cluster is enabled, the CM runs in DR cluster mode.

**Value range:** an integer, **0** or **1**. Any modification of this parameter takes effect only after the CM Server is restarted. This parameter cannot be enabled for non-DR clusters. For details about how to modify this parameter, see **Table 11-2**.

- **0**: disabled.
- **1**: enabled.

**Default value**: **0**

## enable_e2e_rto

**Parameter description**: Specifies whether to enable the E2E RTO function. After this function is enabled, the hang-up detection period and network detection timeout time are shortened. The CM can reach the E2E RTO indicator (RTO for a single instance ≤ 10s; RTO for combined faults ≤ 30s).

**Value range:** an integer, **0** or **1**. The value **1** indicates enabled, while the value **0** indicates disabled. For details about how to modify this parameter, see **Table 11-2**.

**Default value**:

Independent deployment: **1**

Finance edition (standard), enterprise edition, and finance edition (data computing): **0**

## cluster_starting_aribt_delay

**Parameter description**: Specifies the time that CM Server waits for the static primary DN to be promoted to primary during cluster startup.

**Value range**: an integer. The unit is s. For details about how to modify this parameter, see **Table 11-2**.

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**Default value**: **180**

## enable_dcf

**Parameter description**: Specifies the status of the DCF mode.

**Value range**: Boolean Any modification of this parameter takes effect only after the CM Server is restarted. For details about how to modify this parameter, see **Table 11-2**.

- **0**: disabled.
- **1**: enabled.

**Default value**: **off**

## ddb_type

**Parameter description**: Specifies whether to switch between ETCD and DCC modes.

**Value range**: an integer. **0**: ETCD; **1**: DCC. Any modification of this parameter takes effect only after the CM Server is restarted. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **0**

## enable_ssl

**Parameter description**: Specifies whether to enable SSL.

**Value range**: Boolean After this function is enabled, the SSL certificate is used to encrypt communication. Any modification of this parameter takes effect only after a restart. For details about how to modify this parameter, see **Table 11-2**.

**Default value**:

- **on** indicates that SSL is enabled.
- **off** indicates that SSL is disabled.
- **Default value**: **off**

> **NOTICE**
>
> To ensure security, you are not advised to disable it. After this function is disabled, the CM does not use encrypted communication and all information is transmitted in plaintext, which may bring security risks such as eavesdropping, tampering, and spoofing.

## ssl_cert_expire_alert_threshold

**Parameter description**: Specifies the SSL certificate expiration alerting time.

**Value range**: an integer. The unit is day. If the certificate expiration time is less than the value of this parameter, an alarm indicating that the certificate is about

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to expire is reported. Any modification of this parameter takes effect only after a restart. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **90**

## ssl_cert_expire_check_interval

**Parameter description**: Specifies the period for checking whether the SSL certificate expires.

**Value range**: an integer. The unit is s. Any modification of this parameter takes effect only after a restart. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **86400**

## ddb_log_level

**Parameter description**: Sets the DDB log level.

To disable the log function, set this parameter to **NONE**, which cannot be used together with the following log levels:

To enable the log function, set this parameter to one or a combination of the following log levels: **RUN_ERR|RUN_WAR|RUN_INF|DEBUG_ERR|DEBUG_WAR|DEBUG_INF|TRACE|PROFILE|OPER**. If two or more log levels are used together, separate them with vertical bars (|). The log level cannot be set to an empty string.

**Value range**: a string containing one or a combination of the following log levels: **RUN_ERR|RUN_WAR|RUN_INF|DEBUG_ERR|DEBUG_WAR|DEBUG_INF|TRACE|PROFILE|OPER**. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **RUN_ERR|RUN_WAR|DEBUG_ERR|OPER|RUN_INF|PROFILE**

## ddb_log_backup_file_count

**Parameter description**: Specifies the maximum number of log files that can be saved.

**Value range**: an integer, in the range [1,100]. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **10**

## ddb_max_log_file_size

**Parameter description**: Specifies the maximum number of bytes in a log.

**Value range**: a string, in the range [1MB,1000MB]. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **10MB**

## ddb_log_suppress_enable

**Parameter description**: Specifies whether to enable the log suppression function.

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**Value range**: an integer. **0**: disabled; **1**: enabled. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **1**

### ddb_election_timeout

**Parameter description**: Specifies the DCC election timeout period.

**Value range**: an integer, in the range [1,600], in seconds. For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **3**

### delay_arbitrate_timeout

**Parameter description**: Specifies the waiting time for a node in the same AZ as the primary DN to be promoted to primary after redo replay.

**Value range**: an integer, in the range [0,21474836] (unit: second). For details about how to modify this parameter, see **Table 11-2**.

**Default value**: **0**

### install_type

**Parameter description**: Specifies the settings related to the DR cluster to distinguish the cluster type.

**Value range**: an integer ranging from 0 to 2 Any modification of this parameter takes effect only after the CM Server is restarted. This parameter cannot be enabled for non-DR clusters. For details about how to modify this parameter, see **Table 11-1**.

**Default value**: **0**

- **0** indicates the cluster for which no DR relationship is established.
- **1** indicates a Dorado-based cluster.
- **2** indicates a streaming-based cluster.

## 19.25 GTM Parameters

GTM parameters can be set in the **gtm.conf** file or using gs_guc.

### nodename

**Parameter description**: Specifies the name of the primary or standby GTM.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, which complies with the identifier naming convention

**Default value**: **NULL**

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## port

**Parameter description**: Specifies the host port number listened by the primary or standby GTM.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The recommended value range is 1024 to 65535.

**Default value**: **6666**

## log_file

**Parameter description**: Specifies a log file name.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, which complies with the identifier naming convention

**Default value**: **gtm-***%Y-%m-%d_%H%M%S*.**log**

## active_host

**Parameter description**: Specifies the IP address of a target GTM. For the primary GTM, it is the IP address of the standby GTM; for the standby GTM, it is the IP address of the primary GTM.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, which complies with the identifier naming convention

**Default value**: **NULL**

## local_host

**Parameter description**: Specifies the HA local address. Set this parameter based on the cluster configuration file. You do not need to manually set this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, which complies with the identifier naming convention.

**Default value**: **NULL**

## active_port

**Parameter description**: Specifies the port number of the target GTM server.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The recommended value range is 1024 to 65535.

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NOTE

This parameter is specified in the configuration file during installation. Do not modify this parameter unless absolutely necessary. Otherwise, database communication will be affected.

**Default value**: **0**

## local_port

**Parameter description**: Specifies the local port for HA.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The recommended value range is 1024 to 65535.

NOTE

This parameter is specified in the configuration file during installation. Do not modify this parameter unless absolutely necessary. Otherwise, database communication will be affected.

**Default value**: **0**

## standby_connection_timeout

**Parameter description**: Specifies the timeout interval between the primary and standby GTMs. A larger value enhances the fault tolerance capability of the network between the primary and standby GTMs, but increases the duration for reporting disconnection between them.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 5 to 2147483647. The unit is s.

**Default value**: **5**

## keepalives_count

**Parameter description**: Specifies the number of keepalived signals that can be waited before the GTM server is disconnected from the client if the OS supports the **TCP_KEEPCNT** socket parameter. This parameter takes effect only on the standby GTM.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **0**, indicating that the connection is immediately broken if no keepalived signal from the client is received by the GTM.

## keepalives_idle

**Parameter description**: Specifies the interval for sending keepalived signals.

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This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is s.

**Default value**: **0**

## keepalives_interval

**Parameter description**: Specifies the response time before retransmission on an OS that supports the **TCP_KEEPINTVL** socket option.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647. The unit is s.

**Default value**: **0**

## synchronous_backup

**Parameter description**: Specifies whether to enable synchronization for backing up data to the standby GTM.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: **off**, **on**, or **auto**

- **on**: Synchronization is enabled.
- **off**: Synchronization is disabled.
- **auto**: Automatic synchronization is enabled.

**Default value**: **auto**

## query_memory_limit

**Parameter description**: Specifies the limit of memory available for queries. This parameter applies only to the default resource group. For other resource groups, the memory available for queries is not limited.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a floating point number ranging from **0.0** to **1.0**

**Default value**: **0.25**

## wlm_max_mem

**Parameter description**: Specifies the maximum memory for GTM execution.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 512 to 2147483647. The unit is MB.

**Default value**: **2048**

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## config_file

**Parameter description**: Specifies the name of a GTM configuration file. Only the sysadmin user can access this parameter.

**Value range**: a string Set it based on instructions provided in **Table 11-1**.

**Default value**: **gtm.conf**

## data_dir

**Parameter description**: Specifies the GTM data file directory.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **NULL**

## listen_addresses

**Parameter description**: Specifies the TCP/IP address of the client for a server to listen on.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**:

- Host name or IP address. Multiple values are separated with commas (,).
- An asterisk (*), indicating all IP addresses.
- If the parameter is not specified, the server does not listen on any IP address. In this case, only Unix domain sockets can be used for database connections.

**Default value**: *

## log_directory

**Parameter description**: Specifies the directory for storing log files when **logging_collector** is set to **on**. The value can be an absolute path, or relative to the data directory.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

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NOTICE

- If the value of **log_directory** in the configuration file is an invalid path (that is, the user does not have the permission to read or write this path), the cluster cannot be restarted.
- If the value of **log_directory** is changed to a valid path (that is, the user has the permission to read and write this path), logs are generated in the new path. If the specified path is invalid, log files are generated in the last valid path and the database running is not affected. The invalid value is still written into the configuration file.

**Value range**: a string

**Default value**: **gtm_log**, indicating that server logs will be generated in the **gtm_log/** directory under the data directory.

## log_min_messages

**Parameter description**: Specifies which level of messages will be written into server logs. Each level covers all the levels following it. The lower the level is, the fewer messages will be written into the log.

NOTICE

If the values of **client_min_messages** and **log_min_messages** are the same, they indicate different levels.

**Valid values**: enumerated values. Valid values are **debug**, **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error**, **fatal**, and **panic**. For details about the parameters, see **Table 19-2**.

**Default value**: **warning**

## alarm_component

**Parameter description**: Certain alarms are suppressed during alarm reporting. That is, the same alarm will not be repeatedly reported by an instance within the period specified by **alarm_report_interval**. Its default value is **10s**. In this case, the parameter specifies the location of the alarm component that is used to process alarm information.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

- If **--alarm-type** in the **gs_preinstall** script is set to **5**, no third-party component is connected and alarms are written into the **system_alarm** log. In this case, the value of **alarm_component** is **/opt/huawei/snas/bin/snas_cm_cmd**.
- If **--alarm-type** in the **gs_preinstall** script is set to **1**, a third-party component is connected. In this case, the value of **alarm_component** is the absolute path of the executable program of the third-party component.

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**Default value**: **/opt/huawei/snas/bin/snas_cm_cmd**

## alarm_report_interval

**Parameter description**: Specifies the interval at which an alarm is reported.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a non-negative integer (unit: s)

**Default value: 10**

## standby_only

**Parameter description**: Specifies whether to forcibly synchronize information to standby nodes. In one primary+multiple standbys mode, information is only forcibly synchronized to the ETCD.

**Value range**: **0** or **1**. Set this parameter based on instructions provided in **Table 11-1**.

- **0**: Information is not forcibly synchronized to standby nodes.
- **1**: Information is forcibly synchronized to standby nodes.

**Default value**: **0**

## gtm_max_trans

**Parameter description**: Specifies the maximum number of connections accepted by the GTM. You are not advised to change the value. If you have to, set this parameter to a value no less than the maximum number of connections plus 100.

**Value range**: an integer ranging from 256 to 200000. Set it based on instructions provided in **Table 11-1**.

**Default value**: **8192**

## enable_connect_control

**Parameter description**: Specifies whether the GTM verifies that a connection IP address is within the cluster.

**Value range**: Boolean. Set it based on instructions provided in **Table 11-1**.

- **true**: The GTM checks whether a connection IP address is within the cluster. If it is not, the access is rejected.
- **false**: The GTM does not check whether a connection IP address is within the cluster.

**Default value**: **true**

## gtm_authentication_type

**Parameter description**: Specifies the port authentication mode of the GTM. **trust** indicates that port authentication is not configured. **gss** indicates that Kerberos

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port authentication is used. Note that you can change the value to **gss** only after the Kerberos server and client are successfully installed. Otherwise, the GTM cannot communicate properly, affecting the cluster status.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: **gss** or **trust**.

**Default value**: **trust**

## gtm_krb_server_keyfile

**Parameter description**: Specifies the location of the key file on the Kerberos server. The value must be an absolute path. The file is usually stored in the *${GAUSSHOME}*/**kerberos** directory and ends with keytab. The file name is the same as the name of the user who runs the cluster. This parameter is used together with **gtm_authentication_type**. If **gtm_authentication_type** is changed to **gss**, **gtm_krb_server_keyfile** must be configured as the correct path. Otherwise, the cluster status will be affected.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **''**

## gtm_option

**Parameter description**: Specifies the GTM mode, which must be set to the same value on all GTMs, CNs, and DNs. There are three GTM modes: GTM, GTM-Lite, and GTM-FREE. For details, see **GTM Modes**. The GTM and GTM-Lite modes take effect only when the **enable_gtm_free** parameter is set to **off**. The current version does not support switching between different GTM modes for installed clusters.

**Value range**: an integer ranging from 0 to 2. The value **0** indicates the GTM mode, the value **1** indicates the GTM-Lite mode, and the value **2** indicates the GTM-FREE mode. Set it based on instructions provided in **Table 11-1**.

**Default value**: **1**

## csn_sync_interval

**Parameter description**: Specifies the interval for synchronizing CSN between the primary and standby GTMs, in unit of s.

**Value range**: an integer ranging from 1 to 2147483647. Set it based on instructions provided in **Table 11-1**.

**Default value**: **1**

## restore_duration

**Parameter description**: Specifies the pre-allocation interval of XID or CSN on the GTM.

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**Value range**: an integer ranging from 1000000 to 2147483647. Set it based on instructions provided in **Table 11-1**.

**Default value**: **1000000**

### gtm_enable_threadpool

**Parameter description**: Specifies whether to enable the GTM thread pool function. The setting takes effect only after the GTM is restarted.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**Default value**: **true**

### gtm_num_threads

**Parameter description**: Specifies the number of work threads in the thread pool when the thread pool function **gtm_enable_threadpool** is enabled.

The value is related to the size of **gtm_max_trans** and cannot exceed the result of (Value of **gtm_max_trans** – 1 – Number of auxiliary threads). The number of auxiliary threads is **2** in the current version.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 16384

**Default value**: **1024**

## 19.26 Upgrade Parameters

### IsInplaceUpgrade

**Parameter description**: Specifies whether an upgrade is ongoing. This parameter is an upgrade parameter and cannot be modified. Only the sysadmin user can access the parameter.

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates an upgrade is ongoing.
- **off** indicates no upgrade is ongoing.

**Default value**: **off**

### inplace_upgrade_next_system_object_oids

**Parameter description**: Indicates the OID of a new system object during the in-place upgrade. This parameter is used for upgrade and cannot be modified by users.

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This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: empty

### upgrade_mode

**Parameter description**: Specifies the upgrade mode. This parameter is used for upgrade. You are advised not to modify it.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: an integer ranging from 0 to 2147483647

- **0**: indicates that the local upgrade and the minor version gray upgrade are not in progress.
- **1**: indicates that the upgrade is in progress. The upgrade command is executed and takes effect after the check is completed.
- **2**: indicates that the major version gray upgrade is in progress. The upgrade command is executed and takes effect after the check is completed.

**Default value**: **0**

NOTE

Execute the precommand on new packages, switch to the cluster user, and use the **source** command to invalidate environment variables. Run the **gs_upgradectl -t chose-strategy** command to check whether the upgrade is a major version upgrade or minor version upgrade.

If "Upgrade strategy: large-binary-upgrade" is returned, the major version is upgraded.

If "Upgrade strategy: small-binary-upgrade" is returned, the minor version is upgraded.

## 19.27 Miscellaneous Parameters

### server_version

**Parameter description**: Specifies the server version number.

This parameter is a fixed INTERNAL parameter and cannot be modified. This parameter is inherited from the PostgreSQL kernel, indicating that the current database kernel is compatible with PostgreSQL's **server_version**. This parameter is reserved to ensure the ecosystem compatibility of the northbound external tool APIs (which will be queried when the tool is connected). This parameter is not recommended. You can use the **opengauss_version()** function to obtain the kernel version.

**Value range**: a string

**Default value**: **9.2.4**

### server_version_num

**Parameter description**: Specifies the server version number.

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This parameter is a fixed INTERNAL parameter and cannot be modified. This parameter is inherited from the PostgreSQL kernel, indicating that the current database kernel is compatible with PostgreSQL's **server_version_num**. This parameter is reserved to ensure the ecosystem compatibility of the northbound external tool APIs (which will be queried when the tool is connected).

**Value range**: an integer

**Default value**: **90204**

## block_size

**Parameter description**: Specifies the block size of the current database.

This parameter is a fixed INTERNAL parameter and cannot be modified. This parameter is inherited from the PostgreSQL kernel, indicating that the current database kernel is compatible with PostgreSQL's **server_version_num**. This parameter is reserved to ensure the ecosystem compatibility of the northbound external tool APIs.

**Default value**: **8192**

## segment_size

**Parameter description**: Specifies the segment file size of the current database.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Default value**: **1 GB**

## max_index_keys

**Parameter description**: Specifies the maximum number of index keys supported by the current database.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Default value**: **32**

## integer_datetimes

**Parameter description**: Specifies whether the date and time are in the 64-bit integer format.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: Boolean

- **on** indicates that the 64-bit integer format is used.
- **off** indicates that the 64-bit integer format is not used.

**Default value**: **on**

## enable_cluster_resize

**Parameter description:** If an SQL statement involves tables belonging to different groups, you can enable this parameter to push the execution plan of the statement to improve performance.

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This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the execution plan of the statement can be pushed.
- **off** indicates that the execution plan of the statement cannot be pushed.

**Default value**: **off**

NOTE

This parameter is used for internal O&M. Do not set it to **on** unless absolutely necessary.

## lc_collate

**Parameter description:** Specifies the locale in which sorting of textual data is done.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Default value**: Determined by the configuration set during the cluster installation and deployment.

## lc_ctype

**Parameter description**: Specifies the locale that determines character classifications. For example, it specifies what a letter and its upper-case equivalent are.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Default value**: Determined by the configuration set during the cluster installation and deployment.

## max_identifier_length

**Parameter description**: Specifies the maximum identifier length.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: an integer

**Default value**: **63**

## server_encoding

**Parameter description**: Specifies the database encoding (character set).

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Default value**: Determined when the database is created.

## enable_upgrade_merge_lock_mode

**Parameter description**: If this parameter is set to **on**, the delta merge operation internally increases the lock level, and errors can be prevented when update and delete operations are performed at the same time.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- If this parameter is set to **on**, the delta merge operation internally increases the lock level. In this way, when the **DELTAMERGE** operation is concurrently performed with the **UPDATE** or **DELETE** operation, one operation can be performed only after the previous one is complete.
- If this parameter is set to **off** and the **DELTAMERGE** operation is concurrently performed with the **UPDATE** or **DELETE** operation to the data in a row in the delta table of the table, errors will be reported during the later operation, and the operation will stop.

**Default value**: **off**

## transparent_encrypted_string

**Parameter description**: Specifies a sample string that is transparently encrypted. Its value is generated by encrypting **TRANS_ENCRYPT_SAMPLE_STRING** using a database secret key. The ciphertext is used to check whether the DEK obtained during secondary startup is correct. If the DEK is incorrect, CNs and DNs reject the startup. This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**. This parameter applies only to the DWS scenario in the current version.

**Value range**: a string. An empty string indicates that the entire cluster is encrypted.

**Default value**: empty

NOTE

Do not set this parameter manually. Otherwise, the cluster may become faulty.

## transparent_encrypt_kms_url

**Parameter description**: Specifies the URL for obtaining the database secret key to be transparently encrypted. It must contain only the characters specified in RFC3986, and the maximum length is 2047 bytes. The format is **kms://** *Protocol*@*KMS host name 1*;*KMS host name 2*:*KMS port number*/**kms**, for example, **kms://https@linux175:29800/**. This parameter applies only to the DWS scenario in the current version.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: empty

## transparent_encrypt_kms_region

**Parameter description**: Specifies the deployment region of the entire cluster. It must contain only the characters specified in RFC3986, and the maximum length is 2047 bytes. This parameter applies only to the DWS scenario in the current version.

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This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: empty

### datanode_heartbeat_interval

**Parameter description**: Specifies the interval at which heartbeat messages are sent between heartbeat threads. You are advised to set this parameter to a value no more than wal_receiver_timeout/2.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1000 to 60000. The unit is ms.

Default value: **1s**

### dfs_partition_directory_length

**Parameter description**: Specifies the maximum directory name length for the partition directory of a table partitioned by VALUE in the HDFS.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: 92 to 7999

**Default value**: **512**

### max_concurrent_autonomous_transactions

**Parameter description**: Specifies the maximum number of autonomous transaction connections, that is, the maximum number of concurrent autonomous transactions executed at the same time. If this parameter is set to **0**, autonomous transactions cannot be executed.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: 0–1024

**Default value: 10**

### mot_config_file

This parameter is unavailable in a distributed system.

## 19.28 Wait Event

### enable_instr_track_wait

**Parameter description**: Specifies whether to enable real-time collection of wait event information.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the function of collecting wait event information is enabled.
- **off** indicates that the function of collecting wait event information is disabled.

**Default value**: **on**

# 19.29 Query

## instr_unique_sql_count

**Parameter description**: Specifies the maximum number of unique SQL records to be collected. The value **0** indicates that the function of collecting Unique SQL information is disabled.

If the value is changed from a larger one to a smaller one, unique SQL statistics will be reset and re-collected (the standby node does not support this function). There is no impact if the value is changed from a smaller one to a larger one.

When the number of unique SQL records generated in the system is greater than the value of **instr_unique_sql_count**, the extra unique SQL records are not collected.

In the x86-based centralized deployment scenario, the hardware configuration specifications are 32U 256 GB memory. When the Benchmark SQL 5.0 tool is used to test performance, the performance fluctuates by about 3% by enabling or disabling this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 0 to 2147483647

**Default value**: **200000**

## instr_unique_sql_track_type

**Parameter description**: Specifies which SQL statements are recorded in unique SQL.

This parameter is an INTERNAL parameter. Set it based on instructions provided in Table 11-1.

**Value range**: enumerated values

**top**: Only top-level SQL statements are recorded.

**Default value**: **top**

## unique_sql_retention_time

**Parameter description**: Specifies the memory cleanup interval for the unique SQL hash table. The default value is 30 minutes.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 3650

**Default value**: **30min**

## enable_instr_rt_percentile

**Parameter description**: Specifies whether to enable the function of calculating the response time of 80% and 95% SQL statements in the system.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the function of calculating the response time of 80% and 95% SQL statements is enabled.
- **off** indicates that the function of calculating the response time of 80% and 95% SQL statements is disabled.

**Default value**: **on**

## percentile

**Parameter description**: Specifies the percentage of SQL statements whose response time is to be calculated by the background calculation thread.

This parameter is an INTERNAL parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **"80,95"**

## instr_rt_percentile_interval

**Parameter description**: Specifies the interval at which the background calculation thread calculates the SQL response time.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 3600. The unit is s.

**Default value**: **10s**

## enable_instr_cpu_timer

**Parameter description**: Specifies whether to capture the CPU time consumed during SQL statement execution.

In the x86-based centralized deployment scenario, the hardware configuration specifications are 32U 256 GB memory. When the Benchmark SQL 5.0 tool is used to test performance, the performance fluctuates by about 3.5% by enabling or disabling this parameter.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the CPU time consumed during SQL statement execution is captured.
- **off** indicates that the CPU time consumed during SQL statement execution is not captured.

**Default value**: **on**

## enable_slow_query_log (Discarded)

**Parameter description:** Specifies whether to write the slow query information to the log file. This parameter is discarded in this version.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on**: indicates that slow query information needs to be written into log files.
- **off**: indicates that slow query information does not need to be written into log files.

**Default value**: **on**

## query_log_file (Discarded)

**Parameter description**: Specifies the name of a slow query log file on the server. If **enable_slow_query_log** is set to **ON**, slow query records are written into log files. Only the **sysadmin** user can access this parameter. Generally, log file names are generated in strftime mode. Therefore, the system time can be used to define log file names, which are implemented using the escape character %. This function has been discarded in this version.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

NOTICE

You are advised to use escape character % to specify the log file names for efficient management of log files.

**Value range**: a string

**Default value: slow_query_log-%Y-%m-%d_%H%M%S.log**

## query_log_directory (Discarded)

**Parameter description**: Specifies the directory for storing low query log files when **enable_slow_query_log** is set to **on**. Only the **sysadmin** user can access this parameter. It can be an absolute path or a relative path (relative to the data directory), which has been discarded in this version.

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This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**NOTICE**

If this parameter is set to an invalid path, the cluster cannot be started.

**NOTE**

Valid path: You have read and write permissions on the path.

Invalid path: You do not have read or write permission on the path.

**Value range**: a string

**Default value**: specified during installation

## asp_log_directory

**Parameter description**: Specifies the directory for storing ASP log files on the server when **asp_flush_mode** is set to **all** or **file**. The value can be an absolute path, or relative to the data directory. Only the **sysadmin** user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**NOTICE**

If this parameter is set to an invalid path, the cluster cannot be started.

**NOTE**

- Valid path: Users have read and write permissions on the path.
- Invalid path: Users do not have read or write permissions on an invalid path.

**Value range**: a string

**Default value**: specified during installation

## perf_directory

**Parameter description**: Specifies the directory of the output file of the performance view dotting task. Only the **sysadmin** user can access this parameter. The value can be an absolute path, or relative to the data directory.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**NOTE**

- Valid path: Users have read and write permissions on the path.
- Invalid path: Users do not have read or write permissions on an invalid path.

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**Value range**: a string

**Default value**: specified during installation

## enable_stmt_track

**Parameter description**: Specifies whether to enable the full/slow SQL statement feature.

In the x86-based centralized deployment scenario, the hardware configuration specifications are 32U 256 GB memory. When the Benchmark SQL 5.0 tool is used to test performance, the performance fluctuates by about 1.2% by enabling or disabling this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: Full/Slow SQL capture is enabled.
- **off**: Full/Slow SQL capture is disabled.

**Default value**: **on**

## track_stmt_parameter

**Parameter description**: After **track_stmt_parameter** is enabled, the executed statements recorded in **statement_history** are not normalized. The complete SQL statement information can be displayed to help the database administrator locate faults. For a simple query, the complete statement information is displayed. For a PBE statement, the complete statement information and information about each variable value are displayed. The format is query string; parameters: $1=value1,$2=value2, .... This parameter is used to display full SQL information for users and is not controlled by the **track_activity_query_size** parameter. When the SQL bypass logic is used for PBE statements, parameters are directly delivered to DNs. Therefore, the number of complete statements cannot be obtained by querying **statement_history** on CNs. In addition, DNs do not have query character strings. Therefore, complete statement information cannot be obtained by querying **statement_history** on DNs.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on**: The function of displaying complete SQL statement information is enabled.
- **off**: The function of displaying complete SQL statement information is disabled.

Default value: **off**

## track_stmt_session_slot

**Parameter description**: Specifies the maximum number of full/slow SQL statements that can be cached in a session. If the number of full/slow SQL

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statements exceeds this value, new statements will not be traced until the flush thread flushes the cached statements to the disk to reserve free space.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 2147483647

**Default value: 1000**

## track_stmt_details_size

**Parameter description**: Specifies the maximum size (in bytes) of execution events that can be collected by a single statement.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 100000000

**Default value**: **4096**

## track_stmt_retention_time

**Parameter description**: Specifies the retention period of full/slow SQL statement records. This parameter is a combination of parameters. This parameter is read every 60 seconds and records older than the retention period are deleted. Only the **sysadmin** user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

This parameter consists of two parts in the format of 'full sql retention time, slow sql retention time'.

- **full sql retention time** indicates the retention period of full SQL statements. The value ranges from 0 to 86400.
- **slow sql retention time** indicates the retention period of slow SQL statements. The value ranges from 0 to 604800.

**Default value**: **3600,604800**

## track_stmt_stat_level

**Parameter description**: Controls the level of statement execution tracing.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**. Letters are case insensitive. If the full SQL function is enabled, the performance will be affected and a large amount of disk space may be occupied.

**Value range**: a string

This parameter consists of two parts in the format of 'full sql stat level, slow sql stat level'.

- The first part indicates the tracing level of full SQL statements. The value can be **OFF**, **L0**, **L1**, or **L2**.

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- The second part indicates the tracing level of slow SQL statements. The value can be **OFF**, **L0**, **L1**, or **L2**.

  NOTE

  If the tracing level of full SQL statements is not **OFF**, the current SQL statement tracing level is the higher level (L2 > L1 > L0) of the full SQL statements and slow SQL statements. For details about the levels, see **Table 15-109**.

**Default value**: **OFF,L0**

# 19.30 System Performance Snapshot

## enable_wdr_snapshot

**Parameter description**: Specifies whether to enable the database monitoring snapshot function.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the database monitoring snapshot function is enabled.
- **off** indicates that the database monitoring snapshot function is disabled.

**Default value**: **on**

## wdr_snapshot_retention_days

**Parameter description**: Specifies the number of days database monitoring snapshots are retained. If the number of days that the snapshots are retained exceeds the value of this parameter, the system deletes the snapshots with the smallest ID at an interval specified by **wdr_snapshot_interval**.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 8. The unit is day.

**Default value**: **8**

## wdr_snapshot_query_timeout

**Parameter description**: Specifies the execution timeout for the SQL statements associated with database monitoring snapshot operations. If the SQL statement execution is not complete and a result is not returned within the specified time, the snapshot operation fails.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 100 to 2147483647. The unit is s.

**Default value**: **100s**

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## wdr_snapshot_interval

**Parameter description**: Specifies the interval at which the backend thread Snapshot automatically performs snapshot operations on the database monitoring data.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 10 to 60. The unit is min.

**Default value**: **1h**

## enable_asp

**Parameter description:** Specifies whether to enable the active session profile function.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on**: The function is enabled.
- **off**: The function is disabled.

**Default value**: **on**

## asp_sample_num

**Parameter description**: Specifies the maximum number of samples allowed in the LOCAL_ACTIVE_SESSION view. Only the sysadmin user can access this parameter.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 10000 to 100000

**Default value**: **100000**

## asp_sample_interval

**Parameter description**: Specifies the sampling interval.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 10. The unit is s.

**Default value**: **1s**

## asp_flush_rate

**Parameter description**: When the number of samples reaches the value of **asp_sample_num**, the samples in the memory are updated to the disk based on a certain proportion. **asp_flush_rate** indicates the update proportion. If this parameter is set to **10**, it indicates that the update ratio is 10:1.

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This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 1 to 10

**Default value**: **10**

### asp_flush_mode

**Parameter description**: Specifies the mode for the ASP to update data to the disk. The value can be **file** (default value), **table** (system catalog), or **all** (system catalog and file). Only the sysadmin user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: a string, which can be **table**, **file**, or **all**

**Default value**: **table**

### asp_retention_days

**Parameter description**: Specifies the maximum number of days for reserving ASP samples when they are written to the system catalog.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 1 to 7. The unit is day.

**Default value**: **2**

### asp_log_filename

**Parameter description**: Specifies the file name format when writing files using ASP. Only the sysadmin user can access this parameter.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: a string

**Default value**: **asp-%Y-%m-%d_%H%M%S.log**

## 19.31 Security Configuration

### enable_security_policy

**Parameter description**: Specifies whether the unified audit and dynamic data masking policies take effect.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

**on**: The security policy is enabled.

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**off**: The security policy is disabled.

**Default value**: **off**

## use_elastic_search

**Parameter description**: Specifies whether to send unified audit logs to Elasticsearch. If **enable_security_policy** and this parameter are enabled, unified audit logs are sent to Elasticsearch through HTTP or HTTPS (used by default). After this parameter is enabled, ensure that the Elasticsearch service corresponding to **elastic_search_ip_addr** can be properly connected. Otherwise, the process fails to be started.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

**on**: Unified audit logs are sent to Elasticsearch.

**off**: Unified audit logs are not sent to Elasticsearch.

**Default value**: **off**

## elastic_search_ip_addr

**Parameter description**: Specifies the IP address of the Elasticsearch system.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **'https:127.0.0.1'**

## is_sysadmin

**Parameter description**: Specifies whether the current user is an initial user.

This parameter is a fixed INTERNAL parameter and cannot be modified.

**Value range**: Boolean

**on** indicates that the user is an initial user.

**off** indicates that the user is not an initial user.

**Default value**: **off**

## enable_tde

**Parameter description**: Specifies whether to enable the TDE function. Set this parameter to **on** before creating an encrypted table. If this parameter is set to **off**, new encrypted tables cannot be created. The created encrypted table is decrypted only when data is read and is not encrypted when the data is written.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: Boolean

**on**: The TDE function is enabled.

**off**: The TDE function is disabled.

**Default value**: **off**

### tde_cmk_id

**Parameter description**: Specifies the CMK ID of the cluster used by the TDE function. The ID is generated by KMS. The CMK of the cluster is used to encrypt the DEK. When the DEK needs to be decrypted, a request packet needs to be sent to KMS. The DEK ciphertext and the ID of the corresponding CMK are sent to KMS.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string

**Default value**: **""**

## 19.32 HyperLogLog

### hll_default_log2m

**Parameter description**: Specifies the number of buckets for HLL data. The number of buckets affects the precision of distinct values calculated by HLL. The more buckets there are, the smaller the deviation is. The deviation range is as follows: $[-1.04/2^{log2m*1/2}, +1.04/2^{log2m*1/2}]$

This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 10 to 16

**Default value**: **14**

### hll_default_log2explicit

**Parameter description**: Specifies the default threshold for switching from the explicit mode to the sparse mode.

This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 12 The value **0** indicates that the explicit mode is skipped. The value 1 to 12 indicates that the mode is switched when the number of distinct values reaches $2^{hll\_default\_log2explicit}$.

**Default value**: **10**

### hll_default_log2sparse

**Parameter description**: Specifies the default threshold for switching from the **sparse** mode to the **full** mode.

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This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 0 to 14 The value **0** indicates that the explicit mode is skipped. The value 1 to 14 indicates that the mode is switched when the number of distinct values reaches $2^{hll\_default\_log2sparse}$.

**Default value**: **12**

## hll_duplicate_check

**Parameter description**: Specifies whether duplicatecheck is enabled by default.

This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: **0** or **1** **0**: disabled; **1**: enabled

**Default value**: **0**

## hll_default_regwidth (Discarded)

**Parameter description**: Specifies the number of bits in each bucket for HLL data. A larger value indicates more memory occupied by HLL. **hll_default_regwidth** and **hll_default_log2m** determine the maximum number of distinct values that can be calculated by HLL. Currently, **regwidth** is set to a fixed value and is no longer used.

This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 1 to 5

**Default value**: **5**

## hll_default_expthresh (Discarded)

**Parameter description**: Specifies the default threshold for switching from the **explicit** mode to the **sparse** mode. Currently, the **hll_default_log2explicit** parameter is used to replace the similar function.

This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 7 **–1** indicates the auto mode; **0** indicates that the **explicit** mode is skipped; a value from 1 to 7 indicates that the mode is switched when the number of distinct values reaches $2^{hll\_default\_expthresh}$.

**Default value**: **–1**

## hll_default_sparseon (Discarded)

**Parameter description**: Specifies whether to enable the **sparse** mode by default. Currently, the **hll_default_log2sparse** parameter is used to replace the similar function. When **hll_default_log2sparse** is set to **0**, the **sparse** mode is disabled.

This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: **0** or **1** **0** indicates that the **sparse** mode is disabled by default. **1** indicates that the **sparse** mode is enabled by default.

**Default value**: **1**

### hll_max_sparse (Discarded)

**Parameter description**: Specifies the size of **max_sparse**. Currently, the **hll_default_log2sparse** parameter is used to replace the similar function.

This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from –1 to 2147483647

**Default value**: **–1**

### enable_compress_hll (Discarded)

**Parameter description**: Specifies whether to enable memory optimization for HLL. Currently, the HLL memory has been optimized, and this parameter is no longer used.

This parameter is a **USERSET** parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** or **true** indicates that memory optimization is enabled.
- **off** or **false** indicates that memory optimization is disabled.

**Default value**: **off**

## 19.33 User-defined Functions

### udf_memory_limit

**Parameter description**: Specifies the maximum physical memory that can be used when CNs and DNs execute UDFs. This parameter does not take effect in the current version. Use **FencedUDFMemoryLimit** and **UDFWorkerMemHardLimit** to control virtual memory used by fenced udf worker.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: an integer ranging from 200 x 1024 to 2147483647. The unit is KB.

**Default value**: **200 MB**

### FencedUDFMemoryLimit

**Parameter description**: Specifies the virtual memory used by each fenced udf worker process.

This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-1**.

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**Value range**: an integer ranging from 0 KB to 2147483647 KB. The unit can also be MB or GB. **0** indicates that the memory is not limited.

**Default value**: **0**

### UDFWorkerMemHardLimit

**Parameter description**: Specifies the maximum value of **fencedUDFMemoryLimit**.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

Value range: an integer ranging from 0KB to 2147483647KB. The unit can also be MB or GB.

**Default value**: **1GB**

### pljava_vmoptions

**Parameter description**: Specifies the startup parameters for JVMs used by the PL/Java function. Only the sysadmin user can access this parameter. (The current feature is a lab feature. Contact Huawei engineers for technical support before using it.)

This parameter is a SUSET parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, supporting:

- JDK8 JVM startup parameters. For details, see JDK **official** descriptions.
- JDK8 JVM system attributes (starting with **–D**, for example, **–Djava.ext.dirs**). For details, see JDK **official** descriptions.
- User-defined parameters (starting with **–D**, for example, **–Duser.defined.option**).

NOTICE

If **pljava_vmoptions** is set to a value beyond the value range, an error will be reported when PL/Java functions are used.

**Default value:** empty

## 19.34 Collaborative Analysis

Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

### enable_agg_pushdown_for_ca

**Parameter description**: In collaborative analysis, this parameter specifies whether to convert the Agg operator above the ForeignScan operator into a remote SQL statement and send it to a remote cluster.

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This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the Agg operator above ForeignScan is converted into a remote SQL statement.
- **off** indicates that only the ForeignScan operator is converted to a remote SQL statement.

**Default value**: **on**

# 19.35 Acceleration Cluster

Due to specification changes, the current version no longer supports the current feature. Do not use this feature.

## show_acce_estimate_detail

**Parameter description**: When the cluster is accelerated (**acceleration_with_compute_pool** is set to **on**), this parameter specifies whether the **EXPLAIN** statement displays the evaluation information about execution plan pushed down to the accelerated cluster. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.) The evaluation information is generally used by O&M personnel during maintenance, and it may affect the output display of the **EXPLAIN** statement. Therefore, this parameter is disabled by default. The evaluation information is displayed only if the **verbose** option of the **EXPLAIN** statement is enabled.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the evaluation information is displayed in the output of the **EXPLAIN** statement.
- **off** indicates that the evaluation information is not displayed in the output of the **EXPLAIN** statement.

**Default value**: **off**

## acceleration_with_compute_pool

**Parameter description**: Specifies whether to use the computing resource pool for acceleration when an OBS is queried. (Due to specification changes, the current version no longer supports the current feature. Do not use this feature.)

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the query covering OBS is accelerated based on the cost when the computing resource pool is available.

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- **off** indicates that no query is accelerated using the computing resource pool.

**Default value**: **off**

### max_resource_package

**Parameter description**: Specifies the upper limit of the concurrent task threads for accelerating each cluster each DN.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: 0 to 2147483647

**Default value**: **0**

## 19.36 Scheduled Task

### job_queue_processes

**Parameter description:** Specifies the number of jobs that can be concurrently executed. This parameter is a POSTMASTER parameter. You can set it using **gs_guc**, and you need to restart **gaussdb** to make the setting take effect.

This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: 0 to 1000

Function:

- Setting **job_queue_processes** to **0** indicates that the scheduled job function is disabled and that no job will be executed. (Enabling scheduled jobs may affect the system performance. At sites where this function is not required, you are advised to disable it.)
- Setting **job_queue_processes** to a value that is greater than **0** indicates that the scheduled job function is enabled and this value is the maximum number of jobs that can be concurrently processed.

After the scheduled job function is enabled, the job_scheduler thread polls the **pg_job** system catalog at a scheduled interval. The scheduled job check is performed every second by default.

Too many concurrent jobs consume many system resources, so you need to set the number of concurrent jobs to be processed. If the current number of concurrent jobs reaches the value of **job_queue_processes** and some of them expire, these jobs will be postponed to the next polling period. Therefore, you are advised to set the polling interval (the **Interval** parameter of the **submit** interface) based on the execution duration of each job to avoid the problem that jobs in the next polling period cannot be properly processed because of overlong job execution time.

Note: If the number of concurrent jobs is large and the value is too small, these jobs will wait in queues. However, a large parameter value leads to large resource consumption. You are advised to set this parameter to **100** and change it based on the system resource condition.

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**Default value**: **10**

### enable_prevent_job_task_startup

**Parameter description**: Specifies whether to start the job thread.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the job thread is not started.
- **off** indicates that the job thread is started.

**Default value**: **off**

## 19.37 Thread Pool

The current feature is a lab feature. Contact Huawei technical support before using it.

### enable_thread_pool

**Parameter description**: Specifies whether to enable the thread pool function. This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the thread pool function is enabled.
- **off** indicates that the thread pool function is disabled.

**Default value**: **on**

### thread_pool_attr

**Parameter description**: Specifies the detailed attributes of the thread pool function. This parameter is valid only when **enable_thread_pool** is set to **on**. Only the sysadmin user can access this parameter. This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, consisting of one or more characters.

This parameter consists of three parts: thread_num, group_num, and cpubind_info. The meanings of the three parts are as follows:

- **thread_num** indicates the total number of threads in the thread pool. The value ranges from 0 to 4096. The value **0** indicates that the database automatically configures the number of threads in the thread pool based on the number of CPU cores. If the value is greater than **0**, the number of threads in the thread pool is the same as the value of **thread_num**. You are advised to set the thread pool size based on the hardware configuration. The formula is as follows: Value of **thread_num** = Number of CPU cores x 3–5. The maximum value of **thread_num** is **4096**.

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- **group_num** indicates the number of thread groups in the thread pool. The value ranges from 0 to 64. The value **0** indicates that the database automatically configures the number of thread groups in the thread pool based on the number of NUMA groups. If the value is greater than **0**, the number of thread groups in the thread pool is the same as the value of **group_num**.
- **cpubind_info** indicates whether the thread pool is bound to a core. The available configuration modes are as follows: 1. '(nobind)': The thread is not bound to a core. 2. '(allbind)': Use all CPU cores that can be queried in the current system to bind threads. 3. **'(nodebind: 1, 2)'**: Use the CPU cores in NUMA groups 1 and 2 to bind threads. 4. **'(cpubind: 0-30)'**: Use CPU cores 0 to 30 to bind threads. 5. **'(numabind: 0-30)'**: Use CPU cores 0 to 30 in the NUMA group to bind threads. This parameter is case-insensitive.

**Default value**:

- Independent deployment: '1024,2,(nobind)' (60-core CPU/480 GB memory and 32-core CPU/256 GB memory); '512,2,(nobind)' (16-core CPU/128 GB memory); '256,2,(nobind)'(8-core CPU/64 GB memory); '128,2,(nobind)' (4-core CPU/32 GB memory); '64,2,(nobind)' (4-core CPU/16 GB memory)
- Finance edition (standard):

  CN: '768,2,(nobind)' (128-core CPU/1024 GB memory and 104-core CPU/1024 GB memory); '684,2,(nobind)' (96-core CPU/1024 GB memory and 96-core CPU/768 GB memory); '512,2,(nobind)' (80-core CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); '256,2,(nobind)' (32-core CPU/256 GB memory); '128,2,(nobind)' (16-core CPU/128 GB memory); '64,2,(nobind)' (8-core CPU/64 GB memory)

  DN: '4096,2,(nobind)' (128-core CPU/1024 GB memory, 104-core CPU/1024 GB memory, 96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); '2048,2,(nobind)' (32-core CPU/256 GB memory); '1024,2,(nobind)' (16-core CPU/128 GB memory); '512,2,(nobind)' (8-core CPU/64 GB memory)
- Enterprise edition:

  CN: '768,2,(nobind)' (128-core CPU/1024 GB memory and 104-core CPU/1024 GB memory); '512,2,(nobind)' (96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); '256,2,(nobind)' (32-core CPU/256 GB memory); '128,2,(nobind)' (16-core CPU/128 GB memory); '64,2,(nobind)' (8-core CPU/64 GB memory)

  DN: '1536,2,(nobind)' (128-core CPU/1024 GB memory and 104-core CPU/1024 GB memory); '1024,2,(nobind)' (96-core CPU/1024 GB memory, 96-core CPU/768 GB memory, 80-core CPU/640 GB memory, 80-core CPU/512 GB memory, 72-core CPU/576 GB memory, 64-core CPU/512 GB memory, and 60-core CPU/480 GB memory); '512,2,(nobind)' (32-core CPU/256 GB memory); '256,2,(nobind)' (16-core CPU/128 GB memory); '128,2,(nobind)' (8-core CPU/64 GB memory)
- Finance edition (data computing):

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CN: 2 GB (96-core CPU/768 GB memory); '256,2,(nobind) (72-core CPU/576 GB memory); '128,2,(nobind) (64-core CPU/512 GB memory); '64,2,(nobind) (32-core CPU/256 GB memory)

DN: '2048,2,(nobind) (96-core CPU/768 GB memory); '1024,2,(nobind) (72-core CPU/576 GB memory); '512,2,(nobind) (64-core CPU/512 GB memory); '256,2,(nobind)(32-core CPU/256 GB memory)

## thread_pool_stream_attr

**Parameter description**: Specifies the detailed attributes of the stream thread pool function. This parameter is valid only when **enable_thread_pool** is set to **on** and only takes effect on DNs. Only the **sysadmin** user can access this parameter. This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, consisting of one or more characters.

This parameter consists of four parts: 'stream_thread_num, stream_proc_ratio ,group_num ,cpubind_info'. The meanings of the four parts are as follows:

- **stream_thread_num** indicates the total number of threads in the stream thread pool. The value ranges from 0 to 4096. The value **0** indicates that the database automatically configures the number of threads in the thread pool based on the number of CPU cores. If the value is greater than **0**, the number of threads in the thread pool is the same as the value of **stream_thread_num**. You are advised to set the thread pool size based on the hardware configuration. The formula is as follows: Value of **stream_thread_num** = Number of CPU cores x 3–5. The maximum value of **stream_thread_num** is **4096**.
- **stream_proc_ratio** indicates the ratio of proc resources reserved for stream threads. The value is a floating point number. The default value is **0.2**. The reserved proc resources are calculated as follows: Value of **stream_proc_ratio** x Value of **stream_thread_num**.
- **group_num** indicates the number of thread groups in the thread pool. The value ranges from 0 to 64. The value **0** indicates that the database automatically configures the number of thread groups in the thread pool based on the number of NUMA groups. If the value is greater than **0**, the number of thread groups in the thread pool is the same as the value of **group_num**. The value of **group_num** in **thread_pool_stream_attr** must be the same as that in **thread_pool_attr**. If they are set to different values, the value of **group_num** in **thread_pool_attr** is used.
- **cpubind_info** indicates whether the thread pool is bound to a core. The available configuration modes are as follows: 1. '(nobind)': The thread is not bound to a core. 2. '(allbind)': Use all CPU cores that can be queried in the current system to bind threads. 3. **'(nodebind: 1, 2)'**: Use the CPU cores in NUMA groups 1 and 2 to bind threads. 4. **'(cpubind: 0-30)'**: Use CPU cores 0 to 30 to bind threads. 5. **'(numabind: 0-30)'**: Use CPU cores 0 to 30 in the NUMA group to bind threads. This parameter is case-insensitive. The value of **cpubind_info** in **thread_pool_stream_attr** must be the same as that in **thread_pool_attr**. If they are set to different values, the value of **cpubind_info** in **thread_pool_attr** is used.

**Default value**:

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**stream_thread_num**: **16**

**stream_proc_ratio**: **0.2**

**group_num** and **cpubind_info**: For details, see **thread_pool_attr**.

## resilience_threadpool_reject_cond

**Parameter description**: Specifies the percentage of accumulated sessions in the thread pool for escape from overload. This parameter takes effect only when the GUC parameters **enable_thread_pool** and **use_workload_manager** are enabled. This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: a string, consisting of one or more characters.

This parameter consists of **recover_threadpool_percent** and **overload_threadpool_percent**. The meanings of the two parts are as follows:

- **recover_threadpool_percent**: Percentage of the number of sessions that are recovered to the normal state in the initial number of threads in the thread pool. When the number of accessed sessions is less than the initial number of threads in the thread pool multiplied by the value of this parameter, the escape from overload function is disabled and new connections are allowed. The value ranges from 0 to **INT_MAX**. The value indicates a percentage.
- **overload_threadpool_percent**: Percentage of the number of accessed sessions to the initial number of threads in the thread pool when the thread pool is overloaded. If the number of accessed sessions is greater than the initial number of threads in the thread pool multiplied by the value of this parameter, the current thread pool is overloaded. In this case, the escape from overload function is enabled to kill sessions and forbid new connections to access the thread pool. The value ranges from 0 to **INT_MAX**. The value indicates a percentage.

**Default value**: **'0,0'**, indicating that the thread pool escape function is disabled.

**Example:**

```
resilience_threadpool_reject_cond = '100,200'
```

When the number of stacked sessions exceeds 200% of the initial number of threads in the thread pool, new connections are forbidden and stacked sessions are killed. When the number of stacked sessions is less than 100% of the initial number of threads in the thread pool, new connections are allowed.

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NOTICE

- The number of stacked sessions can be obtained by querying the number of data records in the **pg_stat_activity** view. A few backend threads need to be filtered out. The initial number of threads in the thread pool can be obtained by querying the **thread_pool_attr** parameter.
- If this parameter is set to a small value, the thread pool escape from overload process is frequently triggered. As a result, ongoing sessions are forcibly logged out, and new connections fail to be connected for a short period of time. Therefore, exercise caution when setting this parameter based on the actual thread pool usage.
- If the **use_workload_manager** parameter is disabled and the **bypass_workload_manager** parameter is enabled, this parameter also takes effect. The **bypass_workload_manager** parameter is of the SIGHUP type; therefore, after the reload mode is set, you need to restart the database for the setting to take effect.
- The values of **recover_threadpool_percent** and **overload_threadpool_percent** can be **0** at the same time. In addition, the value of **recover_threadpool_percent** must be smaller than that of **overload_threadpool_percent**. Otherwise, the setting does not take effect.

# 19.38 Full Text Search

## ngram_gram_size

**Parameter description**: Specifies the length of the ngram parser segmentation.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: an integer ranging from 1 to 4

**Default value**: **2**

## ngram_grapsymbol_ignore

**Parameter description**: Specifies whether the ngram parser ignores graphical characters.

This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on**: The ngram parser ignores graphical characters.
- **off**: The ngram parser does not ignore graphical characters.

**Default value**: **off**

## ngram_punctuation_ignore

**Parameter description**: Specifies whether the ngram parser ignores punctuations.

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This parameter is a USERSET parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on**: The ngram parser ignores punctuations.
- **off**: The ngram parser does not ignore punctuations.

**Default value**: **on**

# 19.39 Backup and Restoration

## operation_mode

**Parameter description**: Specifies whether the system enters the backup and restoration mode.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on** indicates that the system is in the backup and restoration mode.
- **off** indicates that the system is not in the backup and restoration mode.

**Default value**: **off**

## enable_cbm_tracking

**Parameter description**: Specifies whether to enable cbm tracking. To perform full or incremental backup for the cluster by using Roach, set this parameter to **on**. Otherwise, the backup will fail.

This parameter is a SIGHUP parameter. Set it based on instructions provided in Table 11-1.

**Value range**: Boolean

- **on**: The cbm tracking is enabled.
- **off**: The cbm tracking is disabled.

**Default value**: **off**

# 19.40 AI Features

## enable_hypo_index

**Parameter description**: Specifies whether the database optimizer considers the created virtual index when executing the **EXPLAIN** statement. By executing **EXPLAIN** on a specific query statement, you can evaluate whether the index can improve the execution efficiency of the query statement based on the execution plan provided by the optimizer.

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This parameter is a USERSET parameter. Set it based on instructions provided in **Table 11-2**.

**Value range**: Boolean

- **on** indicates that a virtual index is created during **EXPLAIN** execution.
- **off** indicates that no virtual index is created during **EXPLAIN** execution.

**Default value**: **off**

# 19.41 Global SysCache Parameters

## enable_global_syscache

**Parameter description**: Specifies whether to enable the global system cache function. This parameter is a POSTMASTER parameter. Set it based on instructions provided in **Table 11-1**.

**Value range**: Boolean

- **on** indicates that the global system cache function is enabled.
- **off** indicates that the global system cache function is disabled.

**Default value**: **on**

You are advised to use this parameter together with the thread pool parameter. After this parameter is enabled, you are advised to set **wal_level** of the standby node to **hot_standby** or higher if you need to access the standby node.

## global_syscache_threshold

**Parameter description**: Specifies the maximum memory usage of the global system cache.

This parameter is a SIGHUP parameter. Set it based on instructions provided in **Table 11-1**.

The **enable_global_syscache** parameter must be enabled.

**Value range**: an integer ranging from 16384 to 1073741824. The unit is KB.

**Default value**: **163840**

Recommended calculation formula: The smaller value of the number of hot databases and the number of threads x Memory size allocated to each database, that is, **global_syscache_threshold** = **min(count(hot dbs)**,**count(threads))** x **memofdb**.

The number of hot databases refers to the number of frequently accessed databases. In thread pool mode, the number of threads is the sum of the number of threads in the thread pool and the number of background threads. In non-thread pool mode, the number of hot databases is used.

**memofdb** indicates the average memory allocated to each database. The background noise memory of each database is 2 MB. Each time a table or index is added, 11 KB memory is added.

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If this parameter is set to a small value, memory is frequently evicted, and a large number of memory fragments cannot be recycled. As a result, memory control fails.

# 19.42 Reserved Parameters

NOTE

The following parameters are reserved and do not take effect in this version.

acce_min_datasize_per_thread

cstore_insert_mode

dfs_partition_directory_length

enable_fstream

enable_hdfs_predicate_pushdown

enable_orc_cache

schedule_splits_threshold

enable_constraint_optimization

enable_hadoop_env

enable_hypo_index

undo_space_limit_size

undo_limit_size_per_transaction

undo_zone_count

ustore_attr

enable_ustore

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# 20 Error Log Reference

## 20.1 Kernel Error Information

ERRMSG: "unsupported syntax: ENCRYPTED WITH in this operation"

SQLSTATE: 42601

CAUSE: "client encryption feature is not supported this operation."

ACTION: "Check client encryption feature whether supported this operation."

ERRMSG: "invalid grant operation"

SQLSTATE: 0LP01

CAUSE: "Grant options cannnot be granted to public."

ACTION: "Grant grant options to roles."

ERRMSG: "unrecognized object kind: %d"

SQLSTATE: XX004

CAUSE: "The object type is not supported for GRANT/REVOKE."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "unrecognized GrantStmt.targtype: %d"

SQLSTATE: XX004

CAUSE: "The target type is not supported for GRANT/REVOKE."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported target types."

ERRMSG: "invalid grant operation"

SQLSTATE: 0LP01

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CAUSE: "Grant to public operation is forbidden in security mode."

ACTION: "Don't grant to public in security mode."

ERRMSG: "unrecognized object type"

SQLSTATE: XX004

CAUSE: "The object type is not supported for GRANT/REVOKE."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "invalid grant/revoke operation"

SQLSTATE: 0LP01

CAUSE: "Column privileges are only valid for relations in GRANT/REVOKE."

ACTION: "Use the column privileges only for relations."

ERRMSG: "invalid AccessPriv node"

SQLSTATE: 0LP01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "unrecognized GrantStmt.objtype: %d"

SQLSTATE: XX004

CAUSE: "The object type is not supported for GRANT/REVOKE."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "undefined client master key"

SQLSTATE: 42705

CAUSE: "The client master key does not exist."

ACTION: "Check whether the client master key exists."

ERRMSG: "undefined column encryption key"

SQLSTATE: 42705

CAUSE: "The column encryption key does not exist."

ACTION: "Check whether the column encryption key exists."

ERRMSG: "large object %u does not exist"

SQLSTATE: 42704

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CAUSE: "The large object does not exist."

ACTION: "Check whether the large object exists."

ERRMSG: "redundant options"

SQLSTATE: 42601

CAUSE: "The syntax 'schemas' is redundant in ALTER DEFAULT PRIVILEGES statement."

ACTION: "Check ALTER DEFAULT PRIVILEGES syntax."

ERRMSG: "redundant options"

SQLSTATE: 42601

CAUSE: "The syntax 'roles' is redundant in ALTER DEFAULT PRIVILEGES statement."

ACTION: "Check ALTER DEFAULT PRIVILEGES syntax."

ERRMSG: "option '%s' not recognized"

SQLSTATE: 42601

CAUSE: "The option in ALTER DEFAULT PRIVILEGES statement is not supported."

ACTION: "Check ALTER DEFAULT PRIVILEGES syntax."

ERRMSG: "unrecognized GrantStmt.objtype: %d"

SQLSTATE: XX004

CAUSE: "The object type is not supported for ALTER DEFAULT PRIVILEGES."

ACTION: "Check ALTER DEFAULT PRIVILEGES syntax to obtain the supported object types."

ERRMSG: "invalid alter default privileges operation"

SQLSTATE: 0LP01

CAUSE: "Default privileges cannot be set for columns."

ACTION: "Check ALTER DEFAULT PRIVILEGES syntax."

ERRMSG: "unrecognized objtype: %d"

SQLSTATE: XX004

CAUSE: "The object type is not supported for default privileges."

ACTION: "Check ALTER DEFAULT PRIVILEGES syntax to obtain the supported object types."

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ERRMSG: "could not find tuple for default ACL %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "unexpected default ACL type: %d"

SQLSTATE: 0LP01

CAUSE: "The object type is not supported for default privilege."

ACTION: "Check ALTER DEFAULT PRIVILEGES syntax to obtain the supported object types."

ERRMSG: "invalid object id"

SQLSTATE: 0LP01

CAUSE: "The object type is not supported for GRANT/REVOKE."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "undefined column"

SQLSTATE: 42703

CAUSE: "The column of the relation does not exist."

ACTION: "Check whether the column exists."

ERRMSG: "column number out of range"

SQLSTATE: 0LP01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for attribute %d of relation %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for relation %u"

SQLSTATE: 29P01

CAUSE: "System error."

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ACTION: "Contact engineer to support."

ERRMSG: "unsupported object type"

SQLSTATE: 42809

CAUSE: "Index type is not supported for GRANT/REVOKE."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "unsupported object type"

SQLSTATE: 42809

CAUSE: "Composite type is not supported for GRANT/REVOKE."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "wrong object type"

SQLSTATE: 42809

CAUSE: "GRANT/REVOKE SEQUENCE only support sequence objects."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "invalid privilege type USAGE for table"

SQLSTATE: 0LP01

CAUSE: "GRANT/REVOKE TABLE do not support USAGE privilege."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported privilege types for tables."

ERRMSG: "invalid privilege type %s for column"

SQLSTATE: 0LP01

CAUSE: "The privilege type is not supported for column object."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported privilege types for column object."

ERRMSG: "cache lookup failed for database %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for foreign-data wrapper %u"

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SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for foreign server %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for function %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for language %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "Grant/revoke on untrusted languages if forbidden."

SQLSTATE: 0LP01

CAUSE: "Grant/revoke on untrusted languages if forbidden."

ACTION: "Support grant/revoke on trusted C languages"

ERRMSG: "Forbid grant language c to user with grant option."

SQLSTATE: 0A000

CAUSE: "Forbid grant language c to user with grant option."

ACTION: "Only support grant language c to user."

ERRMSG: "Forbid grant language c to public."

SQLSTATE: 0A000

CAUSE: "Forbid grant language c to public."

ACTION: "Grant language c to specified users."

ERRMSG: "cache lookup failed for large object %u"

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SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for namespace %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "Role %s has not privilege to grant/revoke node group %s."

SQLSTATE: 42501

CAUSE: "Role has not privilege to grant/revoke node group."

ACTION: "Must have sysadmin privilege."

ERRMSG: "Can not grant CREATE privilege on node group %u to role %u in node group %u."

SQLSTATE: 42501

CAUSE: "Role has not privilege to grant CREATE privilege node group."

ACTION: "Must have sysadmin privilege."

ERRMSG: "cache lookup failed for tablespace %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for type %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cannot set privileges of array types"

SQLSTATE: 0LP01

CAUSE: "Cannot set privileges of array types."

ACTION: "Set the privileges of the element type instead."

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ERRMSG: "wrong object type"

SQLSTATE: 42809

CAUSE: "GRANT/REVOKE DOMAIN only support domain objects."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "cache lookup failed for data source %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for client master key %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for column encryption key %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "cache lookup failed for directory %u"

SQLSTATE: 29P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "unrecognized privilege type '%s'"

SQLSTATE: 42601

CAUSE: "The privilege type is not supported."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported privilege types."

ERRMSG: "unrecognized privilege: %d"

SQLSTATE: XX004

CAUSE: "The privilege type is not supported."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported privilege types."

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ERRMSG: "unrecognized AclResult"

SQLSTATE: XX004

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "permission denied for column '%s' of relation '%s'"

SQLSTATE: 42501

CAUSE: "Insufficient privileges for the column."

ACTION: "Select the system tables to get the acl of the column."

ERRMSG: "role with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "unrecognized objkind: %d"

SQLSTATE: XX004

CAUSE: "The object type is not supported for privilege check."

ACTION: "Check GRANT/REVOKE syntax to obtain the supported object types."

ERRMSG: "attribute %d of relation with OID %u does not exist"

SQLSTATE: 42703

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "the column has been dropped"

SQLSTATE: 42703

CAUSE: "The column does not exist."

ACTION: "Check whether the column exists."

ERRMSG: "relation with OID %u does not exist"

SQLSTATE: 42P01

CAUSE: "System error."

ACTION: "Contact engineer to support."

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ERRMSG: "invalid group"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "database with OID %u does not exist"

SQLSTATE: 3D000

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "directory with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "function with OID %u does not exist"

SQLSTATE: 42883

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "client master key with OID %u does not exist"

SQLSTATE: 42705

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "language with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "large object %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

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ERRMSG: "schema with OID %u does not exist"

SQLSTATE: 3F001

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "node group with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "tablespace with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "foreign-data wrapper with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "foreign server with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "data source with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "type with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

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ERRMSG: "operator with OID %u does not exist"

SQLSTATE: 42883

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "column encryption key with OID %u does not exist"

SQLSTATE: 42705

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "operator class with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "operator family with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "text search dictionary with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "text search configuration with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "collation with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

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ERRMSG: "conversion with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "extension with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "synonym with OID %u does not exist"

SQLSTATE: 42704

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "package can not create the same name with schema."

SQLSTATE: 22023

CAUSE: "Package name conflict"

ACTION: "Please rename package name"

ERRMSG: "type is not exists %s."

SQLSTATE: 22023

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "This input type is not supported for tdigest_in()"

SQLSTATE: 0A000

CAUSE: "input type is not supported"

ACTION: "Check tdigest_in syntax to obtain the supported privilege types"

ERRMSG: "Failed to apply for memory"

SQLSTATE: 53200

CAUSE: "palloc failed"

ACTION: "Check memory"

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ERRMSG: "Failed to get tde info from relation '%s'."

SQLSTATE: XX005

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "SPI_connect failed: %s"

SQLSTATE: SP001

CAUSE: "System error."

ACTION: "Analyze the error message before the error"

ERRMSG: "permission denied for terminate snapshot thread"

SQLSTATE: 42501

CAUSE: "The user does not have system admin privilege"

ACTION: "Grant system admin to user"

ERRMSG: "terminate snapshot thread failed"

SQLSTATE: OP001

CAUSE: "Execution failed due to: %s"

ACTION: "check if snapshot thread exists"

ERRMSG: "terminate snapshot thread failed"

SQLSTATE: OP001

CAUSE: "restart wdr snapshot thread timeoutor The thread did not respond to the kill signal"

ACTION: "Check the wdr snapshot thread is restarted"

ERRMSG: "set lockwait_timeout failed"

SQLSTATE: XX000

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "permission denied for create WDR Snapshot"

SQLSTATE: 42501

CAUSE: "The user does not have system admin privilege"

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ACTION: "Grant system admin to user"

ERRMSG: "WDR snapshot request can not be accepted, please retry later"
SQLSTATE: OP001
CAUSE: "wdr snapshot thread does not exist"
ACTION: "Check if wdr snapshot thread exists"

ERRMSG: "Cannot respond to WDR snapshot request"
SQLSTATE: OP001
CAUSE: "Execution failed due to: %s"
ACTION: "Check if wdr snapshot thread exists"

ERRMSG: "query(%s) can not get datum values"
SQLSTATE: 22000
CAUSE: "System error."
ACTION: "Check whether the query can be executed"

ERRMSG: "create sequence failed"
SQLSTATE: 22000
CAUSE: "System error."
ACTION: "Check if sequence can be created"

ERRMSG: "update snapshot end time stamp filled"
SQLSTATE: 22000
CAUSE: "System error."
ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "query can not get datum values"
SQLSTATE: 22000
CAUSE: "System error."
ACTION: "Check whether the query can be executed"

ERRMSG: "SPI_connect failed: %s"
SQLSTATE: XX000
CAUSE: "System error."

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ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "query(%s) execute failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "clean table of snap_%s is failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "analyze table failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "insert into tables_snap_timestamp start time stamp is failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "insert data failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful and check whether the query can be executed"

ERRMSG: "update tables_snap_timestamp end time stamp is failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "clean snapshot id %lu is failed in snapshot table"

SQLSTATE: 22000

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CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful and check whether the query can be executed"

ERRMSG: "clean snapshot failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "can not create snapshot stat table"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the query can be executed"

ERRMSG: "create WDR snapshot data table failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the query can be executed"

ERRMSG: "insert into tables_snap_timestamp start time stamp failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the query can be executed"

ERRMSG: "insert into snap_%s is failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the query can be executed"

ERRMSG: "update tables_snap_timestamp end time stamp failed"

SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the query can be executed"

ERRMSG: "create index failed"

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SQLSTATE: 22000

CAUSE: "System error."

ACTION: "Check whether the query can be executed"

ERRMSG: "analyze table, connection failed: %s"

SQLSTATE: XX000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "snapshot thread SPI_connect failed: %s"

SQLSTATE: XX000

CAUSE: "System error."

ACTION: "Check whether the snapshot retry is successful"

ERRMSG: "Distributed key column can't be transformed"

SQLSTATE: 42P10

CAUSE: "There is a risk of violating uniqueness when transforming distribution columns."

ACTION: "Change transform column."

ERRMSG: "cannot convert %s to %s"

SQLSTATE: 42804

CAUSE: "There is no conversion path in pg_cast."

ACTION: "Rewrite or cast the expression."

ERRMSG: "create matview on TDE table failed"

SQLSTATE: 0A000

CAUSE: "create materialized views is not supported on TDE table"

ACTION: "check CREATE syntax about create the materialized views"

ERRMSG: "schema name can not same as package"

SQLSTATE: 22023

CAUSE: "schema name conflict"

ACTION: "rename schema name"

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ERRMSG: "Unrecognized commandType when checking read-only attribute."

SQLSTATE: XX004

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "Fail to generate subquery plan."

SQLSTATE: XX005

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "Unrecognized node type when processing qual condition."

SQLSTATE: XX004

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "Unrecognized node type when processing const parameters."

SQLSTATE: XX004

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "SELECT FOR UPDATE/SHARE is not allowed with UNION/INTERSECT/EXCEPT"

SQLSTATE: 0A000

CAUSE: "SQL uses unsupported feature."

ACTION: "Modify SQL statement according to the manual."

ERRMSG: "GROUP BY cannot be implemented."

SQLSTATE: 0A000

CAUSE: "GROUP BY uses unsupported datatypes."

ACTION: "Modify SQL statement according to the manual."

ERRMSG: "TSDB functions cannot be used if enable_tsdb is off."

SQLSTATE: D0011

CAUSE: "Functions are not loaded."

ACTION: "Turn on enable_tsdb according to manual."

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ERRMSG: "Unrecognized node type when extracting index."

SQLSTATE: XX004

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "Ordering operator cannot be identified."

SQLSTATE: 42883

CAUSE: "Grouping set columns must be able to sort their inputs."

ACTION: "Modify SQL statement according to the manual."

ERRMSG: "DISTINCT cannot be implemented."

SQLSTATE: 0A000

CAUSE: "DISTINCT uses unsupported datatypes."

ACTION: "Modify SQL statement according to the manual."

ERRMSG: "Failed to locate grouping columns."

SQLSTATE: 55000

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "Resjunk output columns are not implemented."

SQLSTATE: 20000

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "PARTITION BY cannot be implemented."

SQLSTATE: 0A000

CAUSE: "PARTITION BY uses unsupported datatypes."

ACTION: "Modify SQL statement according to the manual."

ERRMSG: "ORDER BY cannot be implemented."

SQLSTATE: 0A000

CAUSE: "ORDER BY uses unsupported datatypes."

ACTION: "Modify SQL statement according to the manual."

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ERRMSG: "Failed to deconstruct sort operators into partitioning/ordering operators."

SQLSTATE: D0011

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "OBS and HDFS foreign table can NOT be in the same plan."

SQLSTATE: XX008

CAUSE: "SQL uses unsupported feature."

ACTION: "Modify SQL statement according to the manual."

ERRMSG: "Pool size should not be zero"

SQLSTATE: 22012

CAUSE: "Compute pool configuration file contains error."

ACTION: "Please check the value of 'pl' in cp_client.conf."

ERRMSG: "Failed to get the runtime info from the compute pool."

SQLSTATE: 22004

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "Version is not compatible between local cluster and the compute pool."

SQLSTATE: XX008

CAUSE: "Compute pool is not installed appropriately."

ACTION: "Configure compute pool according to manual."

ERRMSG: "No optional index path is found."

SQLSTATE: 01000

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "MERGE INTO on replicated table does not yet support using distributed tables."

SQLSTATE: 0A000

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CAUSE: "SQL uses unsupported feature."

ACTION: "Modify SQL statement according to the manual."

ERRMSG: "Fail to find ForeignScan node!"

SQLSTATE: P0002

CAUSE: "System error."

ACTION: "Contact Huawei Engineer."

ERRMSG: "sql advisor don't support none table, temp table, system table."

SQLSTATE: 42601

CAUSE: "sql advisor don't support none table, temp table, system table."

ACTION: "check query component"

ERRMSG: "Invalid autonomous transaction return datatypes"

SQLSTATE: P0000

CAUSE: "PL/SQL uses unsupported feature."

ACTION: "Contact Huawei Engineer."

ERRMSG: "new row for relation '%s' violates check constraint '%s'"

SQLSTATE: 23514

CAUSE: "some rows copy failed"

ACTION: "check table defination"

ERRMSG: "new row for relation '%s' violates check constraint '%s'"

SQLSTATE: 23514

CAUSE: "some rows copy failed"

ACTION: "set client_min_messages = info for more details"

ERRMSG: "get gauss home path is NULL"

SQLSTATE: XX005

CAUSE: "gauss home path not set"

ACTION: "check if $GAUSSHOME is exist"

ERRMSG: "unable to open kms_iam_info.json file"

SQLSTATE: 58P03

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CAUSE: "file not exist or broken"

ACTION: "check the kms_iam_info.json file"

ERRMSG: "can not get password plaintext"

SQLSTATE: XX005

CAUSE: "file not exist or broken"

ACTION: "check the password cipher rand file"

ERRMSG: "IAM info json key is NULL"

SQLSTATE: XX005

CAUSE: "IAM info value error"

ACTION: "check tde_config kms_iam_info.json file"

ERRMSG: "get internal password is NULL"

SQLSTATE: XX005

CAUSE: "cipher rand file missing"

ACTION: "check password cipher rand file"

ERRMSG: "KMS info json key is NULL"

SQLSTATE: XX005

CAUSE: "KMS info value error"

ACTION: "check tde_config kms_iam_info.json file"

ERRMSG: "unable to get json file"

SQLSTATE: 58P03

CAUSE: "parse json file failed"

ACTION: "check the kms_iam_info.json file format"

ERRMSG: "get JSON tree is NULL"

SQLSTATE: XX005

CAUSE: "get KMS JSON tree failed"

ACTION: "check input prarmeter or config.ini file"

ERRMSG: "failed to get json tree"

SQLSTATE: XX005

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CAUSE: "config.ini json tree error"

ACTION: "check input prarmeter or config.ini file"

ERRMSG: "failed to set the value of json tree"

SQLSTATE: XX005

CAUSE: "config.ini json tree error"

ACTION: "check input prarmeter or config.ini file"

ERRMSG: "http request failed"

SQLSTATE: XX005

CAUSE: "http request error"

ACTION: "check KMS or IAM connect or config parameter"

ERRMSG: "get iam token or iam agency token is NULL"

SQLSTATE: XX005

CAUSE: "connect IAM failed"

ACTION: "check if your env can connect with IAM server"

ERRMSG: "KMS dek json key is NULL"

SQLSTATE: XX005

CAUSE: "KMS return value error"

ACTION: "check KMS config paramenter"

ERRMSG: "get kms dek is NULL"

SQLSTATE: XX005

CAUSE: "connect KMS failed"

ACTION: "check if your env can connect with KMS server"

ERRMSG: "get http header is NULL"

SQLSTATE: XX005

CAUSE: "http request failed"

ACTION: "check IAM config parameter"

ERRMSG: "create KMS dek failed"

SQLSTATE: XX005

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CAUSE: "KMS error"

ACTION: "check KMS connect or config parameter"

ERRMSG: "get KMS dek failed"

SQLSTATE: XX005

CAUSE: "KMS error"

ACTION: "check KMS connect or config parameter"

ERRMSG: "get KMS DEK is NULL"

SQLSTATE: XX005

CAUSE: "get KMS dek_plaintext failed"

ACTION: "check KMS network or cipher is right"

ERRMSG: "create matview with TDE failed"

SQLSTATE: 0A000

CAUSE: "TDE feature is not supported for Create materialized views"

ACTION: "check CREATE syntax about create the materialized views"

ERRMSG: "failed to add item to the index page"

SQLSTATE: XX002

CAUSE: "System error."

ACTION: "Check WARNINGS for the details."

ERRMSG: "index row size %lu exceeds maximum %lu for index '%s'"

SQLSTATE: 54000

CAUSE: "Values larger than 1/3 of a buffer page cannot be indexed."

ACTION: "Consider a function index of an MD5 hash of the value, or use full text indexing."

ERRMSG: "fail to insert a tuple to an orderd index, the ordered tuple list is corrupted"

SQLSTATE: XX002

CAUSE: "System error."

ACTION: "Contact engineer to support."

ERRMSG: "Tag field is too long."

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SQLSTATE: 54000

CAUSE: "Tag buffer overflow."

ACTION: "Shorten tag Key."

# 20.2 CM Error Information

ERRMSG: "Fail to access the cluster static config file."

SQLSTATE: c3000

CAUSE: "The cluster static config file is not generated or is manually deleted."

ACTION: "Please check the cluster static config file."

ERRMSG: "Fail to open the cluster static file."

SQLSTATE: c3000

CAUSE: "The cluster static config file is not generated or is manually deleted."

ACTION: "Please check the cluster static config file."

ERRMSG: "Fail to read the cluster static file."

SQLSTATE: c3001

CAUSE: "The cluster static file permission is insufficient."

ACTION: "Please check the cluster static config file."

ERRMSG: "Failed to read the static config file."

SQLSTATE: c1000

CAUSE: "out of memeory."

ACTION: "Please check the system memory and try again."

ERRMSG: "Could not find the current node in the cluster by the node id %u."

SQLSTATE: c3002

CAUSE: "The static config file probably contained content error."

ACTION: "Please check static config file."

ERRMSG: "Failed to open the logic config file."

SQLSTATE: c3000

CAUSE: "The logic config file is not generated or is manually deleted."

ACTION: "Please check the cluster static config file."

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ERRMSG: "Fail to read the logic static config file."

SQLSTATE: c3001

CAUSE: "The logic static config file permission is insufficient."

ACTION: "Please check the logic static config file."

ERRMSG: "Failed to open or read the static config file."

SQLSTATE: c1000

CAUSE: "out of memeory."

ACTION: "Please check the system memory and try again."

ERRMSG: "Failed to open the log file '%s'."

SQLSTATE: c3000

CAUSE: "Log file not found."

ACTION: "Please check the log file."

ERRMSG: "Failed to open the log file '%s'."

SQLSTATE: c3000

CAUSE: "The log file permission is insufficient."

ACTION: "please check the log file."

ERRMSG: "Failed to open the dynamic config file '%s'."

SQLSTATE: c3000

CAUSE: "The dynamic config file permission is insufficient."

ACTION: "Please check the dynamic config file."

ERRMSG: "Failed to malloc memory, size = %lu."

SQLSTATE: c1000

CAUSE: "out of memeory."

ACTION: "Please check the system memory and try again."

ERRMSG: "unrecognized AZ name '%s'."

SQLSTATE: c3000

CAUSE: "The parameter(%s) entered by the user is incorrect."

ACTION: "Please check the parameter entered by the user and try again."

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ERRMSG: "unrecognized minorityAz name '%s'."

SQLSTATE: c3000

CAUSE: "The parameter(%s) entered by the user is incorrect."

ACTION: "Please check the parameter entered by the user and try again."

ERRMSG: "Get GAUSSHOME failed."

SQLSTATE: c3000

CAUSE: "The environment variable('GAUSSHOME') is incorrectly configured."

ACTION: "Please check the environment variable('GAUSSHOME')."

ERRMSG: "Get current user name failed."

SQLSTATE: c3000

CAUSE: "N/A"

ACTION: "Please check the environment."

ERRMSG: "-B option must be specified."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-T option must be specified.\n"

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "can't stop one node or instance with -m normal."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "can't stop one node or instance with -m resume."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

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ERRMSG: "can't stop one availability zone with -m resume."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "log level or cm server arbitration mode must be specified."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "log level or cm server arbitration mode need not be specified."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-R is needed."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-D is needed."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-n and -R are needed."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-n and -D are needed."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

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ERRMSG: "no operation specified."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "no cm directory specified."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "Please check the usage of switchover."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-n and -z cannot be specified at the same time."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-m cannot be specified at the same time with -n or -z."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-n node(%d) is invalid."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-n node is needed."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

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ERRMSG: "%s: -C is needed."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-z value must be 'ALL' when query mppdb cluster."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-v is needed."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-C is needed."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-Cv is needed."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-L value must be 'ALL' when query logic cluster."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "unrecognized LC name '%s'."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

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ERRMSG: "-n is needed."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "There is no '%s' information in cluster."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-D path is too long.\n"

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-D path is invalid."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-n node(%s) is invalid."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-R only support when the cluster is single-inst."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "-t time is invalid."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

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ERRMSG: "-votenum is invalid."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "unrecognized build mode."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "unrecognized build mode '%s'."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "too many command-line arguments (first is '%s')."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "unrecognized operation mode '%s'."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "no cm directory specified."

SQLSTATE: c3000

CAUSE: "%s: The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "Failed to malloc memory."

SQLSTATE: c1000

CAUSE: "out of memeory."

ACTION: "Please check the system memory and try again."

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ERRMSG: "Failed to open etcd: %s."

SQLSTATE: c4000

CAUSE: "Etcd is abnoraml."

ACTION: "Please check the Cluster Status and try again."

ERRMSG: "[PATCH-ERROR] hotpatch command or path set error."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "no standby datanode in single node cluster."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "restart logic cluster failed."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "restart logic cluster failed"

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

ERRMSG: "The option parameter is not specified."

SQLSTATE: c3000

CAUSE: "The cmdline entered by the user is incorrect."

ACTION: "Please check the cmdline entered by the user(%s)."

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# 21 API Reference

## 21.1 JDBC Interface Reference

The JDBC interface is a set of API methods provided to users. This chapter describes its common interfaces. For other interfaces, see information in JDK1.6 (software package) and JDBC4.0.

### 21.1.1 java.sql.Connection

This section describes **java.sql.Connection**, the interface for connecting to a database.

**Table 21-1** Support status for java.sql.Connection

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| abort(Executor executor) | void | Yes |
| clearWarnings() | void | Yes |
| close() | void | Yes |
| commit() | void | Yes |
| createArrayOf(String typeName, Object[] elements) | Array | Yes |
| createBlob() | Blob | Yes |
| createClob() | Clob | Yes |
| createSQLXML() | SQLXML | Yes |
| createStatement() | Statement | Yes |
| createStatement(int resultSetType, int resultSetConcurrency) | Statement | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| createStatement(int resultSetType, int resultSetConcurrency, int resultSetHoldability) | Statement | Yes |
| getAutoCommit() | Boolean | Yes |
| getCatalog() | String | Yes |
| getClientInfo() | Properties | Yes |
| getClientInfo(String name) | String | Yes |
| getHoldability() | int | Yes |
| getMetaData() | DatabaseMetaData | Yes |
| getNetworkTimeout() | int | Yes |
| getSchema() | String | Yes |
| getTransactionIsolation() | int | Yes |
| getTypeMap() | Map<String,Class<?>> | Yes |
| getWarnings() | SQLWarning | Yes |
| isClosed() | Boolean | Yes |
| isReadOnly() | Boolean | Yes |
| isValid(int timeout) | boolean | Yes |
| nativeSQL(String sql) | String | Yes |
| prepareCall(String sql) | CallableStatement | Yes |
| prepareCall(String sql, int resultSetType, int resultSetConcurrency) | CallableStatement | Yes |
| prepareCall(String sql, int resultSetType, int resultSetConcurrency, int resultSetHoldability) | CallableStatement | Yes |
| prepareStatement(String sql) | PreparedStatement | Yes |
| prepareStatement(String sql, int autoGeneratedKeys) | PreparedStatement | Yes |
| prepareStatement(String sql, int[] columnIndexes) | PreparedStatement | Yes |
| prepareStatement(String sql, int resultSetType, int resultSetConcurrency) | PreparedStatement | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| prepareStatement(String sql, int resultSetType, int resultSetConcurrency, int resultSetHoldability) | PreparedStatement | Yes |
| prepareStatement(String sql, String[] columnNames) | PreparedStatement | Yes |
| releaseSavepoint(Savepoint savepoint) | void | Yes |
| rollback() | void | Yes |
| rollback(Savepoint savepoint) | void | Yes |
| setAutoCommit(boolean autoCommit) | void | Yes |
| setClientInfo(Properties properties) | void | Yes |
| setClientInfo(String name,String value) | void | Yes |
| setHoldability(int holdability) | void | Yes |
| setNetworkTimeout (Executor executor, int milliseconds) | void | Yes |
| setReadOnly(boolean readOnly) | void | Yes |
| setSavepoint() | Savepoint | Yes |
| setSavepoint(String name) | Savepoint | Yes |
| setSchema(String schema) | void | Yes |
| setTransactionIsolation(int level) | void | Yes |
| setTypeMap(Map<String, Class<?>> map) | void | Yes |

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NOTICE

The AutoCommit mode is used by default within the interface. If you disable it by running **setAutoCommit(false)**, all the statements executed later will be packaged in explicit transactions, and you cannot execute statements that cannot be executed within transactions.

## 21.1.2 java.sql.CallableStatement

This section describes **java.sql.CallableStatement**, the interface for executing the stored procedure.

**Table 21-2** Support status for java.sql.CallableStatement

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getArray(int parameterIndex) | Array | Yes |
| getBigDecimal(int parameterIndex) | BigDecimal | Yes |
| getBlob(int parameterIndex) | Blob | Yes |
| getBoolean(int parameterIndex) | boolean | Yes |
| getByte(int parameterIndex) | byte | Yes |
| getBytes(int parameterIndex) | byte[] | Yes |
| getClob(int parameterIndex) | Clob | Yes |
| getDate(int parameterIndex) | Date | Yes |
| getDate(int parameterIndex, Calendar cal) | Date | Yes |
| getDouble(int parameterIndex) | double | Yes |
| getFloat(int parameterIndex) | float | Yes |
| getInt(int parameterIndex) | int | Yes |
| getLong(int parameterIndex) | long | Yes |
| getObject(int parameterIndex) | Object | Yes |
| getObject(int parameterIndex, Class<T> type) | Object | Yes |
| getShort(int parameterIndex) | short | Yes |
| getSQLXML(int parameterIndex) | SQLXML | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getString(int parameterIndex) | String | Yes |
| getNString(int parameterIndex) | String | Yes |
| getTime(int parameterIndex) | Time | Yes |
| getTime(int parameterIndex, Calendar cal) | Time | Yes |
| getTimestamp(int parameterIndex) | Timestamp | Yes |
| getTimestamp(int parameterIndex, Calendar cal) | Timestamp | Yes |
| registerOutParameter(int parameterIndex, int type) | void | Yes |
| registerOutParameter(int parameterIndex, int sqlType, int type) | void | Yes |
| wasNull() | Boolean | Yes |

NOTE

- The batch operation of statements containing OUT parameter is not allowed.
- The following methods are inherited from java.sql.Statement: close, execute, executeQuery, executeUpdate, getConnection, getResultSet, getUpdateCount, isClosed, setMaxRows, and setFetchSize.
- The following methods are inherited from java.sql.PreparedStatement: addBatch, clearParameters, execute, executeQuery, executeUpdate, getMetaData, setBigDecimal, setBoolean, setByte, setBytes, setDate, setDouble, setFloat, setInt, setLong, setNull, setObject, setString, setTime, and setTimestamp.
- The **registerOutParameter(int parameterIndex, int sqlType, int type)** method is used only to register the composite data type.

## 21.1.3 java.sql.DatabaseMetaData

This section describes **java.sql.DatabaseMetaData**, the interface for defining database objects.

**Table 21-3** Support status for java.sql.DatabaseMetaData

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| allProceduresAreCallable() | boolean | Yes |
| allTablesAreSelectable() | boolean | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| autoCommitFailureClosesAll-ResultSets() | boolean | Yes |
| dataDefinitionCausesTran-sactionCommit() | boolean | Yes |
| dataDefinitionIgnoredIn-Transactions() | boolean | Yes |
| deletesAreDetected(int type) | boolean | Yes |
| doesMaxRowSizeInclude-Blobs() | boolean | Yes |
| generatedKeyAlwaysRe-turned() | boolean | Yes |
| getBestRowIdentifier(String catalog, String schema, String table, int scope, boolean nullable) | ResultSet | Yes |
| getCatalogs() | ResultSet | Yes |
| getCatalogSeparator() | String | Yes |
| getCatalogTerm() | String | Yes |
| getClientInfoProperties() | ResultSet | Yes |
| getColumnPrivileges(String catalog, String schema, String table, String columnNamePattern) | ResultSet | Yes |
| getConnection() | Connection | Yes |
| getCrossReference(String parentCatalog, String parentSchema, String parentTable, String foreignCatalog, String foreignSchema, String foreignTable) | ResultSet | Yes |
| getDefaultTransactionIsola-tion() | int | Yes |
| getExportedKeys(String catalog, String schema, String table) | ResultSet | Yes |
| getExtraNameCharacters() | String | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getFunctionColumns(String catalog, String schemaPattern, String functionNamePattern, String columnNamePattern) | ResultSet | Yes |
| getFunctions(String catalog, String schemaPattern, String functionNamePattern) | ResultSet | Yes |
| getIdentifierQuoteString() | String | Yes |
| getImportedKeys(String catalog, String schema, String table) | ResultSet | Yes |
| getIndexInfo(String catalog, String schema, String table, boolean unique, boolean approximate) | ResultSet | Yes |
| getMaxBinaryLiteralLength() | int | Yes |
| getMaxCatalogName-Length() | int | Yes |
| getMaxCharLiteralLength() | int | Yes |
| getMaxColumnName-Length() | int | Yes |
| getMaxColumnsInGroupBy() | int | Yes |
| getMaxColumnsInIndex() | int | Yes |
| getMaxColumnsInOrderBy() | int | Yes |
| getMaxColumnsInSelect() | int | Yes |
| getMaxColumnsInTable() | int | Yes |
| getMaxConnections() | int | Yes |
| getMaxCursorNameLength() | int | Yes |
| getMaxIndexLength() | int | Yes |
| getMaxLogicalLobSize() | default long | Yes |
| getMaxProcedureName-Length() | int | Yes |
| getMaxRowSize() | int | Yes |
| getMaxSchemaName-Length() | int | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getMaxStatementLength() | int | Yes |
| getMaxStatements() | int | Yes |
| getMaxTableNameLength() | int | Yes |
| getMaxTablesInSelect() | int | Yes |
| getMaxUserNameLength() | int | Yes |
| getNumericFunctions() | String | Yes |
| getPrimaryKeys(String catalog, String schema, String table) | ResultSet | Yes |
| getPartitionTablePrimary-Keys(String catalog, String schema, String table) | ResultSet | Yes |
| getProcedureColumns(String catalog, String schemaPattern, String procedureNamePattern, String columnNamePattern) | ResultSet | Yes |
| getProcedures(String catalog, String schemaPattern, String procedureNamePattern) | ResultSet | Yes |
| getProcedureTerm() | String | Yes |
| getSchemas() | ResultSet | Yes |
| getSchemas(String catalog, String schemaPattern) | ResultSet | Yes |
| getSchemaTerm() | String | Yes |
| getSearchStringEscape() | String | Yes |
| getSQLKeywords() | String | Yes |
| getSQLStateType() | int | Yes |
| getStringFunctions() | String | Yes |
| getSystemFunctions() | String | Yes |
| getTablePrivileges(String catalog, String schemaPattern, String tableNamePattern) | ResultSet | Yes |
| getTimeDateFunctions() | String | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getTypeInfo() | ResultSet | Yes |
| getUDTs(String catalog, String schemaPattern, String typeNamePattern, int[] types) | ResultSet | Yes |
| getURL() | String | Yes |
| getVersionColumns(String catalog, String schema, String table) | ResultSet | Yes |
| insertsAreDetected(int type) | boolean | Yes |
| locatorsUpdateCopy() | boolean | Yes |
| othersDeletesAreVisible(int type) | boolean | Yes |
| othersInsertsAreVisible(int type) | boolean | Yes |
| othersUpdatesAreVisible(int type) | boolean | Yes |
| ownDeletesAreVisible(int type) | boolean | Yes |
| ownInsertsAreVisible(int type) | boolean | Yes |
| ownUpdatesAreVisible(int type) | boolean | Yes |
| storesLowerCaseIdentifiers() | Boolean | Yes |
| storesMixedCaseIdentifiers() | boolean | Yes |
| storesUpperCaseIdentifiers() | Boolean | Yes |
| supportsBatchUpdates() | boolean | Yes |
| supportsCatalogsInDataManipulation() | boolean | Yes |
| supportsCatalogsInIndexDefinitions() | boolean | Yes |
| supportsCatalogsInPrivilegeDefinitions() | boolean | Yes |
| supportsCatalogsInProcedureCalls() | boolean | Yes |
| supportsCatalogsInTableDefinitions() | boolean | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| supportsCorrelatedSubqueries() | boolean | Yes |
| supportsDataDefinitionAndDataManipulationTransactions() | boolean | Yes |
| supportsDataManipulationTransactionsOnly() | boolean | Yes |
| supportsGetGeneratedKeys() | boolean | Yes |
| supportsMixedCaseIdentifiers() | Boolean | Yes |
| supportsMultipleOpenResults() | boolean | Yes |
| supportsNamedParameters() | boolean | Yes |
| supportsOpenCursorsAcrossCommit() | boolean | Yes |
| supportsOpenCursorsAcrossRollback() | boolean | Yes |
| supportsOpenStatementsAcrossCommit() | boolean | Yes |
| supportsOpenStatementsAcrossRollback() | boolean | Yes |
| supportsPositionedDelete() | boolean | Yes |
| supportsPositionedUpdate() | boolean | Yes |
| supportsRefCursors() | boolean | Yes |
| supportsResultSetConcurrency(int type, int concurrency) | boolean | Yes |
| supportsResultSetType(int type) | boolean | Yes |
| supportsSchemasInIndexDefinitions() | boolean | Yes |
| supportsSchemasInPrivilegeDefinitions() | boolean | Yes |
| supportsSchemasInProcedureCalls() | boolean | Yes |
| supportsSchemasInTableDefinitions() | boolean | Yes |
| supportsSelectForUpdate() | boolean | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| supportsStatementPooling() | boolean | Yes |
| supportsStoredFunctionsUsingCallSyntax() | boolean | Yes |
| supportsStoredProcedures() | boolean | Yes |
| supportsSubqueriesInComparisons() | boolean | Yes |
| supportsSubqueriesInExists() | boolean | Yes |
| supportsSubqueriesInIns() | boolean | Yes |
| supportsSubqueriesInQuantifieds() | boolean | Yes |
| supportsTransactionIsolationLevel(int level) | boolean | Yes |
| supportsTransactions() | boolean | Yes |
| supportsUnion() | boolean | Yes |
| supportsUnionAll() | boolean | Yes |
| updatesAreDetected(int type) | boolean | Yes |
| getTables(String catalog, String schemaPattern, String tableNamePattern, String[] types) | ResultSet | Yes |
| getColumns(String catalog, String schemaPattern, String tableNamePattern, String columnNamePattern) | ResultSet | Yes |
| getTableTypes() | ResultSet | Yes |
| getUserName() | String | Yes |
| isReadOnly() | Boolean | Yes |
| nullsAreSortedHigh() | Boolean | Yes |
| nullsAreSortedLow() | Boolean | Yes |
| nullsAreSortedAtStart() | Boolean | Yes |
| nullsAreSortedAtEnd() | Boolean | Yes |
| getDatabaseProductName() | String | Yes |
| getDatabaseProductVersion() | String | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getDriverName() | String | Yes |
| getDriverVersion() | String | Yes |
| getDriverMajorVersion() | int | Yes |
| getDriverMinorVersion() | int | Yes |
| usesLocalFiles() | Boolean | Yes |
| usesLocalFilePerTable() | Boolean | Yes |
| supportsMixedCaseIdentifiers() | Boolean | Yes |
| storesUpperCaseIdentifiers() | Boolean | Yes |
| storesLowerCaseIdentifiers() | Boolean | Yes |
| supportsMixedCaseQuotedIdentifiers() | Boolean | Yes |
| storesUpperCaseQuotedIdentifiers() | Boolean | Yes |
| storesLowerCaseQuotedIdentifiers() | Boolean | Yes |
| storesMixedCaseQuotedIdentifiers() | Boolean | Yes |
| supportsAlterTableWithAddColumn() | Boolean | Yes |
| supportsAlterTableWithDropColumn() | Boolean | Yes |
| supportsColumnAliasing() | Boolean | Yes |
| nullPlusNonNullIsNull() | Boolean | Yes |
| supportsConvert() | Boolean | Yes |
| supportsConvert(int fromType, int toType) | Boolean | Yes |
| supportsTableCorrelationNames() | Boolean | Yes |
| supportsDifferentTableCorrelationNames() | Boolean | Yes |
| supportsExpressionsInOrderBy() | Boolean | Yes |
| supportsOrderByUnrelated() | Boolean | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| supportsGroupBy() | Boolean | Yes |
| supportsGroupByUnrelated() | Boolean | Yes |
| supportsGroupByBeyondSelect() | Boolean | Yes |
| supportsLikeEscapeClause() | Boolean | Yes |
| supportsMultipleResultSets() | Boolean | Yes |
| supportsMultipleTransactions() | Boolean | Yes |
| supportsNonNullableColumns() | Boolean | Yes |
| supportsMinimumSQLGrammar() | Boolean | Yes |
| supportsCoreSQLGrammar() | Boolean | Yes |
| supportsExtendedSQLGrammar() | Boolean | Yes |
| supportsANSI92EntryLevelSQL() | Boolean | Yes |
| supportsANSI92IntermediateSQL() | Boolean | Yes |
| supportsANSI92FullSQL() | Boolean | Yes |
| supportsIntegrityEnhancementFacility() | Boolean | Yes |
| supportsOuterJoins() | Boolean | Yes |
| supportsFullOuterJoins() | Boolean | Yes |
| supportsLimitedOuterJoins() | Boolean | Yes |
| isCatalogAtStart() | Boolean | Yes |
| supportsSchemasInDataManipulation() | Boolean | Yes |
| supportsSavepoints() | Boolean | Yes |
| supportsResultSetHoldability(int holdability) | Boolean | Yes |
| getResultSetHoldability() | int | Yes |
| getDatabaseMajorVersion() | int | Yes |
| getDatabaseMinorVersion() | int | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getJDBCMajorVersion() | int | Yes |
| getJDBCMinorVersion() | int | Yes |

NOTE

The **getPartitionTablePrimaryKeys(String catalog, String schema, String table)** API is used to obtain the primary key column of a partitioned table that contains global indexes. The following is an example:

```
PgDatabaseMetaData dbmd = (PgDatabaseMetaData)conn.getMetaData();
dbmd.getPartitionTablePrimaryKeys("catalogName", "schemaName", "tableName");
```

## 21.1.4 java.sql.Driver

This section describes **java.sql.Driver**, the database driver interface.

**Table 21-4** Support status for java.sql.Driver

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| acceptsURL(String url) | Boolean | Yes |
| connect(String url, Properties info) | Connection | Yes |
| jdbcCompliant() | Boolean | Yes |
| getMajorVersion() | int | Yes |
| getMinorVersion() | int | Yes |
| getParentLogger() | Logger | Yes |
| getPropertyInfo(String url, Properties info) | DriverPropertyInfo[] | Yes |

## 21.1.5 java.sql.PreparedStatement

This section describes **java.sql.PreparedStatement**, the interface for preparing statements.

**Table 21-5** Support status for java.sql.PreparedStatement

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| clearParameters() | void | Yes |
| execute() | Boolean | Yes |
| executeQuery() | ResultSet | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| excuteUpdate() | int | Yes |
| executeLargeUpdate() | long | No |
| getMetaData() | ResultSetMetaData | Yes |
| getParameterMetaData() | ParameterMetaData | Yes |
| setArray(int parameterIndex, Array x) | void | Yes |
| setAsciiStream(int parameterIndex, InputStream x, int length) | void | Yes |
| setBinaryStream(int parameterIndex, InputStream x) | void | Yes |
| setBinaryStream(int parameterIndex, InputStream x, int length) | void | Yes |
| setBinaryStream(int parameterIndex, InputStream x, long length) | void | Yes |
| setBlob(int parameterIndex, InputStream inputStream) | void | Yes |
| setBlob(int parameterIndex, InputStream inputStream, long length) | void | Yes |
| setBlob(int parameterIndex, Blob x) | void | Yes |
| setCharacterStream(int parameterIndex, Reader reader) | void | Yes |
| setCharacterStream(int parameterIndex, Reader reader, int length) | void | Yes |
| setClob(int parameterIndex, Reader reader) | void | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| setClob(int parameterIndex, Reader reader, long length) | void | Yes |
| setClob(int parameterIndex, Clob x) | void | Yes |
| setDate(int parameterIndex, Date x, Calendar cal) | void | Yes |
| setNull(int parameterIndex, int sqlType) | void | Yes |
| setNull(int parameterIndex, int sqlType, String typeName) | void | Yes |
| setObject(int parameterIndex, Object x) | void | Yes |
| setObject(int parameterIndex, Object x, int targetSqlType) | void | Yes |
| setObject(int parameterIndex, Object x, int targetSqlType, int scaleOrLength) | void | Yes |
| setSQLXML(int parameterIndex, SQLXML xmlObject) | void | Yes |
| setTime(int parameterIndex, Time x) | void | Yes |
| setTime(int parameterIndex, Time x, Calendar cal) | void | Yes |
| setTimestamp(int parameterIndex, Timestamp x) | void | Yes |
| setTimestamp(int parameterIndex, Timestamp x, Calendar cal) | void | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| setUnicodeStream(int parameterIndex, InputStream x, int length) | void | Yes |
| setURL(int parameterIndex, URL x) | void | Yes |
| setBoolean(int parameterIndex, boolean x) | void | Yes |
| setBigDecimal(int parameterIndex, BigDecimal x) | void | Yes |
| setByte(int parameterIndex, byte x) | void | Yes |
| setBytes(int parameterIndex, byte[] x) | void | Yes |
| setDate(int parameterIndex, Date x) | void | Yes |
| setDouble(int parameterIndex, double x) | void | Yes |
| setFloat(int parameterIndex, float x) | void | Yes |
| setInt(int parameterIndex, int x) | void | Yes |
| setLong(int parameterIndex, long x) | void | Yes |
| setShort(int parameterIndex, short x) | void | Yes |
| setString(int parameterIndex, String x) | void | Yes |
| setNString(int parameterIndex, String x) | void | Yes |
| addBatch() | void | Yes |
| executeBatch() | int[] | Yes |

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NOTE

- Execute **addBatch()** and **execute()** only after running **clearBatch()**.
- Batch is not cleared by calling **executeBatch()**. Clear batch by explicitly calling **clearBatch()**.
- After bounded variables of a batch are added, if you want to reuse these values, you do not need to use **set*()** again. Instead, add a batch.
- The following methods are inherited from **java.sql.Statement**: **close**, **execute**, **executeQuery**, **executeUpdate**, **getConnection**, **getResultSet**, **getUpdateCount**, **isClosed**, **setMaxRows**, and **setFetchSize**.
- The **executeLargeUpdate()** method can only be used in JDBC 4.2 or later.

## 21.1.6 java.sql.ResultSet

This section describes **java.sql.ResultSet**, the interface for execution result sets.

**Table 21-6** Support status for java.sql.ResultSet

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| absolute(int row) | Boolean | Yes |
| afterLast() | void | Yes |
| beforeFirst() | void | Yes |
| cancelRowUpdates() | void | Yes |
| clearWarnings() | void | Yes |
| close() | void | Yes |
| deleteRow() | void | Yes |
| findColumn(String columnLabel) | int | Yes |
| first() | Boolean | Yes |
| getArray(int columnIndex) | Array | Yes |
| getArray(String columnLabel) | Array | Yes |
| getAsciiStream(int columnIndex) | InputStream | Yes |
| getAsciiStream(String columnLabel) | InputStream | Yes |
| getBigDecimal(int columnIndex) | BigDecimal | Yes |
| getBigDecimal(String columnLabel) | BigDecimal | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getBinaryStream(int columnIndex) | InputStream | Yes |
| getBinaryStream(String columnLabel) | InputStream | Yes |
| getBlob(int columnIndex) | Blob | Yes |
| getBlob(String columnLabel) | Blob | Yes |
| getBoolean(int columnIndex) | Boolean | Yes |
| getBoolean(String columnLabel) | Boolean | Yes |
| getByte(int columnIndex) | byte | Yes |
| getBytes(int columnIndex) | byte[] | Yes |
| getByte(String columnLabel) | byte | Yes |
| getBytes(String columnLabel) | byte[] | Yes |
| getCharacterStream(int columnIndex) | Reader | Yes |
| getCharacterStream (String columnLabel) | Reader | Yes |
| getClob(int columnIndex) | Clob | Yes |
| getClob(String columnLabel) | Clob | Yes |
| getConcurrency() | int | Yes |
| getCursorName() | String | Yes |
| getDate(int columnIndex) | Date | Yes |
| getDate(int columnIndex, Calendar cal) | Date | Yes |
| getDate(String columnLabel) | Date | Yes |
| getDate(String columnLabel, Calendar cal) | Date | Yes |
| getDouble(int columnIndex) | double | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getDouble(String columnLabel) | double | Yes |
| getFetchDirection() | int | Yes |
| getFetchSize() | int | Yes |
| getFloat(int columnIndex) | float | Yes |
| getFloat(String columnLabel) | float | Yes |
| getInt(int columnIndex) | int | Yes |
| getInt(String columnLabel) | int | Yes |
| getLong(int columnIndex) | long | Yes |
| getLong(String columnLabel) | long | Yes |
| getMetaData() | ResultSetMetaData | Yes |
| getObject(int columnIndex) | Object | Yes |
| getObject(int columnIndex, Class<T> type) | <T> T | Yes |
| getObject(int columnIndex, Map<String, Class<?>> map) | Object | Yes |
| getObject(String columnLabel) | Object | Yes |
| getObject(String columnLabel, Class<T> type) | <T> T | Yes |
| getObject(String columnLabel, Map<String, Class<?>> map) | Object | Yes |
| getRow() | int | Yes |
| getShort(int columnIndex) | short | Yes |
| getShort(String columnLabel) | short | Yes |
| getSQLXML(int columnIndex) | SQLXML | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getSQLXML(String columnLabel) | SQLXML | Yes |
| getStatement() | Statement | Yes |
| getString(int columnIndex) | String | Yes |
| getString(String columnLabel) | String | Yes |
| getNString(int columnIndex) | String | Yes |
| getNString(String columnLabel) | String | Yes |
| getTime(int columnIndex) | Time | Yes |
| getTime(int columnIndex, Calendar cal) | Time | Yes |
| getTime(String columnLabel) | Time | Yes |
| getTime(String columnLabel, Calendar cal) | Time | Yes |
| getTimestamp(int columnIndex) | Timestamp | Yes |
| getTimestamp(int columnIndex, Calendar cal) | Timestamp | Yes |
| getTimestamp(String columnLabel) | Timestamp | Yes |
| getTimestamp(String columnLabel, Calendar cal) | Timestamp | Yes |
| getType() | int | Yes |
| getWarnings() | SQLWarning | Yes |
| insertRow() | void | Yes |
| isAfterLast() | Boolean | Yes |
| isBeforeFirst() | Boolean | Yes |
| isClosed() | Boolean | Yes |
| isFirst() | Boolean | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| isLast() | Boolean | Yes |
| last() | Boolean | Yes |
| moveToCurrentRow() | void | Yes |
| moveToInsertRow() | void | Yes |
| next() | Boolean | Yes |
| previous() | Boolean | Yes |
| refreshRow() | void | Yes |
| relative(int rows) | Boolean | Yes |
| rowDeleted() | Boolean | Yes |
| rowInserted() | Boolean | Yes |
| rowUpdated() | Boolean | Yes |
| setFetchDirection(int direction) | void | Yes |
| setFetchSize(int rows) | void | Yes |
| updateArray(int columnIndex, Array x) | void | Yes |
| updateArray(String columnLabel, Array x) | void | Yes |
| updateAsciiStream(int columnIndex, InputStream x, int length) | void | Yes |
| updateAsciiStream(String columnLabel, InputStream x, int length) | void | Yes |
| updateBigDecimal(int columnIndex, BigDecimal x) | void | Yes |
| updateBigDecimal(String columnLabel, BigDecimal x) | void | Yes |
| updateBinaryStream(int columnIndex, InputStream x, int length) | void | Yes |
| updateBinaryStream (String columnLabel, InputStream x, int length) | void | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| updateBoolean(int columnIndex, boolean x) | void | Yes |
| updateBoolean(String columnLabel, boolean x) | void | Yes |
| updateByte(int columnIndex, byte x) | void | Yes |
| updateByte(String columnLabel, byte x) | void | Yes |
| updateBytes(int columnIndex, byte[] x) | void | Yes |
| updateBytes(String columnLabel, byte[] x) | void | Yes |
| updateCharacterStream (int columnIndex, Reader x, int length) | void | Yes |
| updateCharacterStream (String columnLabel, Reader reader, int length) | void | Yes |
| updateDate(int columnIndex, Date x) | void | Yes |
| updateDate(String columnLabel, Date x) | void | Yes |
| updateDouble(int columnIndex, double x) | void | Yes |
| updateDouble(String columnLabel, double x) | void | Yes |
| updateFloat(int columnIndex, float x) | void | Yes |
| updateFloat(String columnLabel, float x) | void | Yes |
| updateInt(int columnIndex, int x) | void | Yes |
| updateInt(String columnLabel, int x) | void | Yes |
| updateLong(int columnIndex, long x) | void | Yes |
| updateLong(String columnLabel, long x) | void | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| updateNull(int columnIndex) | void | Yes |
| updateNull(String columnLabel) | void | Yes |
| updateObject(int columnIndex, Object x) | void | Yes |
| updateObject(int columnIndex, Object x, int scaleOrLength) | void | Yes |
| updateObject(String columnLabel, Object x) | void | Yes |
| updateObject(String columnLabel, Object x, int scaleOrLength) | void | Yes |
| updateRow() | void | Yes |
| updateShort(int columnIndex, short x) | void | Yes |
| updateShort(String columnLabel, short x) | void | Yes |
| updateSQLXML(int columnIndex, SQLXML xmlObject) | void | Yes |
| updateSQLXML(String columnLabel, SQLXML xmlObject) | void | Yes |
| updateString(int columnIndex, String x) | void | Yes |
| updateString(String columnLabel, String x) | void | Yes |
| updateTime(int columnIndex, Time x) | void | Yes |
| updateTime(String columnLabel, Time x) | void | Yes |
| updateTimestamp(int columnIndex, Timestamp x) | void | Yes |
| updateTimestamp(String columnLabel, Timestamp x) | void | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| wasNull() | Boolean | Yes |

NOTE

- One Statement cannot have multiple open ResultSets.
- The cursor that is used for traversing the ResultSet cannot be open after being committed.

## 21.1.7 java.sql.ResultSetMetaData

This section describes **java.sql.ResultSetMetaData**, which provides details about ResultSet object information.

**Table 21-7** Support status for java.sql.ResultSetMetaData

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getCatalogName(int column) | String | Yes |
| getColumnClassName(int column) | String | Yes |
| getColumnCount() | int | Yes |
| getColumnDisplaySize(int column) | int | Yes |
| getColumnLabel(int column) | String | Yes |
| getColumnName(int column) | String | Yes |
| getColumnType(int column) | int | Yes |
| getColumnTypeName(int column) | String | Yes |
| getPrecision(int column) | int | Yes |
| getScale(int column) | int | Yes |
| getSchemaName(int column) | String | Yes |
| getTableName(int column) | String | Yes |
| isAutoIncrement(int column) | boolean | Yes |
| isCaseSensitive(int column) | boolean | Yes |
| isCurrency(int column) | boolean | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| isDefinitelyWritable(int column) | boolean | Yes |
| isNullable(int column) | int | Yes |
| isReadOnly(int column) | boolean | Yes |
| isSearchable(int column) | boolean | Yes |
| isSigned(int column) | boolean | Yes |
| isWritable(int column) | boolean | Yes |

## 21.1.8 java.sql.Statement

This section describes **java.sql.Statement**, the interface for executing SQL statements.

**Table 21-8** Support status for java.sql.Statement

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| addBatch(String sql) | void | Yes |
| clearBatch() | void | Yes |
| clearWarnings() | void | Yes |
| close() | void | Yes |
| closeOnCompletion() | void | Yes |
| execute(String sql) | Boolean | Yes |
| execute(String sql, int autoGeneratedKeys) | Boolean | Yes |
| execute(String sql, int[] columnIndexes) | Boolean | Yes |
| execute(String sql, String[] columnNames) | Boolean | Yes |
| executeBatch() | Boolean | Yes |
| executeQuery(String sql) | ResultSet | Yes |
| executeUpdate(String sql) | int | Yes |
| executeUpdate(String sql, int autoGeneratedKeys) | int | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| executeUpdate(String sql, int[] columnIndexes) | int | Yes |
| executeUpdate(String sql, String[] columnNames) | int | Yes |
| getConnection() | Connection | Yes |
| getFetchDirection() | int | Yes |
| getFetchSize() | int | Yes |
| getGeneratedKeys() | ResultSet | Yes |
| getMaxFieldSize() | int | Yes |
| getMaxRows() | int | Yes |
| getMoreResults() | boolean | Yes |
| getMoreResults(int current) | boolean | Yes |
| getResultSet() | ResultSet | Yes |
| getResultSetConcurrency() | int | Yes |
| getResultSetHoldability() | int | Yes |
| getResultSetType() | int | Yes |
| getQueryTimeout() | int | Yes |
| getUpdateCount() | int | Yes |
| getWarnings() | SQLWarning | Yes |
| isClosed() | Boolean | Yes |
| isCloseOnCompletion() | Boolean | Yes |
| isPoolable() | Boolean | Yes |
| setCursorName(String name) | void | Yes |
| setEscapeProcessing (boolean enable) | void | Yes |
| setFetchDirection(int direction) | void | Yes |

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| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| setMaxFieldSize(int max) | void | Yes |
| setMaxRows(int max) | void | Yes |
| setPoolable(boolean poolable) | void | Yes |
| setQueryTimeout(int seconds) | void | Yes |
| setFetchSize(int rows) | void | Yes |
| cancel() | void | Yes |
| executeLargeUpdate(String sql) | long | No |
| getLargeUpdateCount() | long | No |
| executeLargeBatch() | long | No |
| executeLargeUpdate(String sql, int autoGeneratedKeys) | long | No |
| executeLargeUpdate(String sql, int[] columnIndexes) | long | No |
| executeLargeUpdate(String sql, String[] columnNames) | long | No |

NOTE

- Using setFetchSize can reduce the memory occupied by result sets on the client. Result sets are packaged into cursors and segmented for processing, which will increase the communication traffic between the database and the client, affecting performance.
- Database cursors are valid only within their transactions. If **setFetchSize** is set, set **setAutoCommit(false)** and commit transactions on the connection to flush service data to a database.
- **LargeUpdate** methods can only be used in JDBC 4.2 or later.

## 21.1.9 javax.sql.ConnectionPoolDataSource

This section describes **javax.sql.ConnectionPoolDataSource**, the interface for data source connection pools.

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**Table 21-9** Support status for javax.sql.ConnectionPoolDataSource

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getPooledConnection() | PooledConnection | Yes |
| getPooledConnection(String user,String password) | PooledConnection | Yes |

## 21.1.10 javax.sql.DataSource

This section describes **javax.sql.DataSource**, the interface for data sources.

**Table 21-10** Support status for javax.sql.DataSource

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getConneciton() | Connection | Yes |
| getConnection(String username,String password) | Connection | Yes |
| getLoginTimeout() | int | Yes |
| getLogWriter() | PrintWriter | Yes |
| setLoginTimeout(int seconds) | void | Yes |
| setLogWriter(PrintWriter out) | void | Yes |

## 21.1.11 javax.sql.PooledConnection

This section describes **javax.sql.PooledConnection**, the connection interface created by a connection pool.

**Table 21-11** Support status for javax.sql.PooledConnection

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| addConnectionEventListener (ConnectionEventListener listener) | void | Yes |
| close() | void | Yes |
| getConnection() | Connection | Yes |
| removeConnectionEventListener (ConnectionEventListener listener) | void | Yes |

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## 21.1.12 javax.naming.Context

This section describes **javax.naming.Context**, the context interface for connection configuration.

**Table 21-12** Support status for javax.naming.Context

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| bind(Name name, Object obj) | void | Yes |
| bind(String name, Object obj) | void | Yes |
| lookup(Name name) | Object | Yes |
| lookup(String name) | Object | Yes |
| rebind(Name name, Object obj) | void | Yes |
| rebind(String name, Object obj) | void | Yes |
| rename(Name oldName, Name newName) | void | Yes |
| rename(String oldName, String newName) | void | Yes |
| unbind(Name name) | void | Yes |
| unbind(String name) | void | Yes |

## 21.1.13 javax.naming.spi.InitialContextFactory

This section describes **javax.naming.spi.InitialContextFactory**, the initial context factory interface.

**Table 21-13** Support status for javax.naming.spi.InitialContextFactory

| Method Name | Return Type | Support JDBC 4 |
| --- | --- | --- |
| getInitialContext(Hashtable<?,?> environment) | Context | Yes |

## 21.1.14 CopyManager

CopyManager is an API class provided by the JDBC driver in GaussDB. It is used to import data to GaussDB clusters in batches.

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## Inheritance Relationship of CopyManager

The CopyManager class is in the **org.postgresql.copy** package and inherits the java.lang.Object class. The declaration of the class is as follows:

```
public class CopyManager
extends Object
```

## Constructor Method

public CopyManager(BaseConnection connection)

throws SQLException

## Common Methods

**Table 21-14** Common methods of CopyManager

| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| CopyIn | copyIn(String sql) | - | SQLException |
| long | copyIn(String sql, InputStream from) | Uses **COPY FROM STDIN** to quickly load data to tables in the database from InputStream. | SQLException,IOException |
| long | copyIn(String sql, InputStream from, int bufferSize) | Uses **COPY FROM STDIN** to quickly load data to tables in the database from InputStream. | SQLException,IOException |
| long | copyIn(String sql, Reader from) | Uses **COPY FROM STDIN** to quickly load data to tables in the database from Reader. | SQLException,IOException |
| long | copyIn(String sql, Reader from, int bufferSize) | Uses **COPY FROM STDIN** to quickly load data to tables in the database from Reader. | SQLException,IOException |
| CopyOut | copyOut(String sql) | - | SQLException |

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| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| long | copyOut(String sql, OutputStream to) | Sends the result set of **COPY TO STDOUT** from the database to the OutputStream class. | SQLException,IOException |
| long | copyOut(String sql, Writer to) | Sends the result set of **COPY TO STDOUT** from the database to the Writer class. | SQLException,IOException |

## 21.1.15 PGReplicationConnection

PGReplicationConnection is an API class provided by the JDBC driver in GaussDB. It is used to implement functions related to logical replication.

### Inheritance Relationship of PGReplicationConnection

PGReplicationConnection is a logical replication interface. Its implementation class is PGReplicationConnectionImpl, which is in the **org.postgresql.replication** package. The declaration of the class is as follows:

```
public class PGReplicationConnection implements PGReplicationConnection
```

### Constructor Method

public PGReplicationConnection(BaseConnection connection)

### Common Methods

**Table 21-15** Common methods of PGReplicationConnection

| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| ChainedCreateReplicationSlotBuilder | createReplication-Slot() | Creates a logical replication slot. | - |
| void | dropReplication-Slot(String slotName) | Deletes a logical replication slot. | SQLException,IOException |
| ChainedStreamBuilder | replicationStream() | Logical replication is enabled. | - |

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# 21.1.16 PGReplicationStream

PGReplicationStream is an API class provided by the GaussDB JDBC driver. It is used to operate logical replication streams.

## Inheritance Relationship of PGReplicationStream

PGReplicationStream is a logical replication API. Its implementation class is V3PGReplicationStream, which is in the **org.postgresql.core.v3.replication** package. The declaration of the class is as follows:

```
public class V3PGReplicationStream implements PGReplicationStream
```

## Constructor

public V3PGReplicationStream(CopyDual copyDual, LogSequenceNumber startLSN, long updateIntervalMs, ReplicationType replicationType)

## Common Methods

**Table 21-16** Common methods of PGReplicationConnection

| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| void | close() | Ends the logical replication and releases resources. | SQLExceptio n |
| void | forceUpdateStatus() | Forcibly sends the LSN status received, refreshed, and applied last time to the backend. | SQLExceptio n |
| LogSequenceN umber | getLastAppliedLSN() | Obtains the LSN when the primary node replays logs last time. | - |
| LogSequenceN umber | getLastFlushedLSN() | Obtains the LSN flushed by the primary node last time, that is, the LSN pushed by the current logic decoding. | - |
| LogSequenceN umber | getLastReceiveLSN() | Obtains the LSN received last time. | - |
| boolean | isClosed() | Determines whether the replication stream is disabled. | - |

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| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| ByteBuffer | read() | Reads the next WAL record from the backend. If the data cannot be read, this method blocks the I/O read. | SQLException |
| ByteBuffer | readPending() | Reads the next WAL record from the backend. If the data cannot be read, this method does not block the I/O read. | SQLException |
| void | setAppliedLSN(LogSequenceNumber applied) | Sets the applied LSN. | - |
| void | setFlushedLSN(LogSequenceNumber flushed) | Sets the flushed LSN, which is sent to the backend at the next update to push the LSN on the server. | - |

## 21.1.17 ChainedStreamBuilder

ChainedStreamBuilder is an API class provided by the GaussDB JDBC driver. It is used to build replication streams.

### Inheritance Relationship of ChainedStreamBuilder

ChainedStreamBuilder is a logical replication API. Its implementation class is ReplicationStreamBuilder, which is in the **org.postgresql.replication.fluent** package. The declaration of the class is as follows:

```
public class ReplicationStreamBuilder implements ChainedStreamBuilder
```

### Constructor

public ReplicationStreamBuilder(final BaseConnection connection)

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## Common Methods

**Table 21-17** Common methods of ReplicationStreamBuilder

| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| ChainedLogicalStreamBuilder | logical() | Creates a logical replication stream. | - |
| ChainedPhysicalStreamBuilder | physical() | Creates a physical replication stream. | - |

# 21.1.18 ChainedCommonStreamBuilder

ChainedCommonStreamBuilder is an API class provided by the GaussDB JDBC driver. It is used to specify common parameters for logical and physical replication.

## Inheritance Relationship of ChainedCommonStreamBuilder

ChainedCommonStreamBuilder is an API for logical replication. The implementation abstract class is AbstractCreateSlotBuilder. The inheritance class is LogicalCreateSlotBuilder which is in the **org.postgresql.replication.fluent.logical** package. The declaration of this class is as follows:

```
public class LogicalCreateSlotBuilder
    extends AbstractCreateSlotBuilder<ChainedLogicalCreateSlotBuilder>
    implements ChainedLogicalCreateSlotBuilder
```

## Constructor

public LogicalCreateSlotBuilder(BaseConnection connection)

## Common Methods

**Table 21-18** Common methods of LogicalCreateSlotBuilder

| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| T | withSlotName(String slotName) | Specifies the name of a replication slot. | - |
| ChainedLogicalCreateSlotBuilder | withOutputPlugin(String outputPlugin) | Plug-in name. Currently, mppdb_decoding is supported. | - |

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| Return Value | Method | Description | throws |
| --- | --- | --- | --- |
| void | make() | Creates a slot with the specified parameters in the database. | SQLException |
| ChainedLogicalCreateSlotBuilder | self() | - | - |

# 21.2 ODBC Interface Reference

The ODBC interface is a set of API functions provided to users. This chapter describes its common interfaces. For details on other interfaces, see "ODBC Programmer's Reference" at MSDN (https://msdn.microsoft.com/en-us/library/windows/desktop/ms714177(v=vs.85).aspx).

## 21.2.1 SQLAllocEnv

In ODBC 3.x, SQLAllocEnv (an ODBC 2.x function) was deprecated and replaced by SQLAllocHandle. For details, see **SQLAllocHandle**.

## 21.2.2 SQLAllocConnect

In ODBC 3.x, SQLAllocConnect (an ODBC 2.x function) was deprecated and replaced by SQLAllocHandle. For details, see **SQLAllocHandle**.

## 21.2.3 SQLAllocHandle

### Function

SQLAllocHandle is used to allocate environment, connection, statement, or descriptor handles. This function replaces the deprecated ODBC 2.x functions SQLAllocEnv, SQLAllocConnect, and SQLAllocStmt.

### Prototype

```
SQLRETURN SQLAllocHandle(SQLSMALLINT   HandleType,
                         SQLHANDLE     InputHandle,
                         SQLHANDLE     *OutputHandlePtr);
```

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## Parameter

**Table 21-19** SQLAllocHandle parameters

| Keyword | Parameter Description |
| --- | --- |
| HandleType | Type of handle to be allocated by SQLAllocHandle. The value must be one of the following:<br>• SQL_HANDLE_ENV (environment handle)<br>• SQL_HANDLE_DBC (connection handle)<br>• SQL_HANDLE_STMT (statement handle)<br>• SQL_HANDLE_DESC (descriptor handle)<br>The handle application sequence is: **SQL_HANDLE_ENV** > **SQL_HANDLE_DBC** > **SQL_HANDLE_STMT**. The handle applied later depends on the handle applied prior to it. |
| InputHandle | Existing handle to use as a context for the new handle being allocated.<br>• If **HandleType** is **SQL_HANDLE_ENV**, this parameter is set to **SQL_NULL_HANDLE**.<br>• If **HandleType** is **SQL_HANDLE_DBC**, this parameter value must be an environment handle.<br>• If **HandleType** is **SQL_HANDLE_STMT** or **SQL_HANDLE_DESC**, this parameter value must be a connection handle. |
| OutputHandlePtr | **Output parameter**: Pointer to a buffer that stores the returned handle in the newly allocated data structure. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

## Precautions

If SQLAllocHandle returns **SQL_ERROR** when it is used to allocate a non-environment handle, it sets **OutputHandlePtr** to **SQL_NULL_HDBC**, **SQL_NULL_HSTMT**, or **SQL_NULL_HDESC**. The application can then call **SQLGetDiagRec**, with **HandleType** and **Handle** set to the value of **IntputHandle**, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

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### Example

See **Examples**.

## 21.2.4 SQLAllocStmt

In ODBC 3.x, SQLAllocStmt was deprecated and replaced by SQLAllocHandle. For details, see **SQLAllocHandle**.

## 21.2.5 SQLBindCol

### Function

SQLBindCol is used to bind columns in a result set to an application data buffer.

### Prototype

```
SQLRETURN SQLBindCol(SQLHSTMT       StatementHandle,
                     SQLUSMALLINT   ColumnNumber,
                     SQLSMALLINT    TargetType,
                     SQLPOINTER     TargetValuePtr,
                     SQLINTEGER     BufferLength,
                     SQLINTEGER     *StrLen_or_IndPtr);
```

### Parameter

**Table 21-20** SQLBindCol parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle. |
| ColumnNumber | Number of the column to be bound. The column number starts with 0 and increases in ascending order. Column 0 is the bookmark column. If no bookmark column is set, column numbers start with 1. |
| TargetType | C data type in the buffer. |
| TargetValuePtr | **Output parameter**: pointer to the buffer bound with the column. The SQLFetch function returns data in the buffer. If **TargetValuePtr** is null, **StrLen_or_IndPtr** is a valid value. |
| BufferLength | Size of the **TargetValuePtr** buffer in bytes. |
| StrLen_or_IndPtr | **Output parameter**: pointer to the length or indicator of the buffer. If **StrLen_or_IndPtr** is null, no length or indicator is used. |

### Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.

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- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

### Precautions

If SQLBindCol returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

### Example

See **Examples**.

## 21.2.6 SQLBindParameter

### Function

SQLBindParameter is used to bind parameter markers in an SQL statement to a buffer.

### Prototype

```
SQLRETURN SQLBindParameter(SQLHSTMT       StatementHandle,
                           SQLUSMALLINT   ParameterNumber,
                           SQLSMALLINT    InputOutputType,
                           SQLSMALLINT    ValuetType,
                           SQLSMALLINT    ParameterType,
                           SQLSMALLINT    ColumnSize,
                           SQLSMALLINT    DecimalDigits,
                           SQLPOINTER     ParameterValuePtr,
                           SQLINTEGER     BufferLength,
                           SQLINTEGER     *StrLen_or_IndPtr);
```

### Parameter

**Table 21-21** SQLBindParameter parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle. |
| ParameterNumber | Parameter marker number, starting with 1 and increasing in ascending order. |
| InputOutputType | Input/output type of the parameter. |
| ValueType | C data type of the parameter. |
| ParameterType | SQL data type of the parameter. |
| ColumnSize | Size of the column or expression of the corresponding parameter marker. |

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| Keyword | Parameter Description |
| --- | --- |
| DecimalDigits | Digital number of the column or expression of the corresponding parameter marker. |
| ParameterValuePtr | Pointer to the storage parameter buffer. |
| BufferLength | Size of the ParameterValuePtr buffer in bytes. |
| StrLen_or_IndPtr | Pointer to the length or indicator of the buffer. If **StrLen_or_IndPtr** is null, no length or indicator is used. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

## Precautions

If SQLBindParameter returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

## Example

See **Examples**.

# 21.2.7 SQLColAttribute

## Function

SQLColAttribute is used to return the descriptor information about a column in the result set.

## Prototype

```
SQLRETURN SQLColAttibute(SQLHSTMT        StatementHandle,
                         SQLUSMALLINT    ColumnNumber,
                         SQLUSMALLINT    FieldIdentifier,
                         SQLPOINTER      CharacterAtrributePtr,
                         SQLSMALLINT     BufferLength,
                         SQLSMALLINT     *StringLengthPtr,
                         SQLPOINTE       NumericAttributePtr);
```

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## Parameter

**Table 21-22** SQLColAttribute parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle. |
| ColumnNumber | Column number of the field to be queried, starting with 1 and increasing in ascending order. |
| FieldIdentifier | Field identifier of **ColumnNumber** in IRD. |
| CharacterAttributePtr | **Output parameter**: pointer to the buffer that returns the **FieldIdentifier** value. |
| BufferLength | • **BufferLength** indicates the length of the buffer if **FieldIdentifier** is an ODBC-defined field and **CharacterAttributePtr** points to a character string or a binary buffer.<br>• Ignore this parameter if **FieldIdentifier** is an ODBC-defined field and **CharacterAttributePtr** points to an integer. |
| StringLengthPtr | **Output parameter**: pointer to a buffer in which the total number of valid bytes (for string data) is stored in ***CharacterAttributePtr**. Ignore the value of **BufferLength** if the data is not a string. |
| NumericAttributePtr | **Output parameter**: pointer to an integer buffer in which the value of the **FieldIdentifier** field in the **ColumnNumber** row of the IRD is returned. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

## Precautions

If SQLColAttribute returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

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## Example

See **Examples**.

# 21.2.8 SQLConnect

## Function

SQLConnect is used to establish a connection between a driver and a data source. After the connection is established, the connection handle can be used to access all information about the data source, including its application operating status, transaction processing status, and error information.

## Prototype

```
SQLRETURN  SQLConnect(SQLHDBC        ConnectionHandle,
                      SQLCHAR        *ServerName,
                      SQLSMALLINT    NameLength1,
                      SQLCHAR        *UserName,
                      SQLSMALLINT    NameLength2,
                      SQLCHAR        *Authentication,
                      SQLSMALLINT    NameLength3);
```

## Parameter

**Table 21-23** SQLConnect parameters

| Keyword | Parameter Description |
| --- | --- |
| ConnectionHandle | Connection handle, obtained from SQLAllocHandle. |
| ServerName | Name of the data source to connect. |
| NameLength1 | Length of **ServerName**. |
| UserName | Username of the database in the data source. |
| NameLength2 | Length of **UserName**. |
| Authentication | User password of the database in the data source. |
| NameLength3 | Length of **Authentication**. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

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- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

### Precautions

If SQLConnect returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_DBC** and **ConnectionHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

### Example

See **Examples**.

## 21.2.9 SQLDisconnect

### Function

SQLDisconnect is used to close the connection associated with a database connection handle.

### Prototype

```
SQLRETURN SQLDisconnect(SQLHDBC     ConnectionHandle);
```

### Parameter

**Table 21-24** SQLDisconnect parameters

| Keyword | Parameter Description |
| --- | --- |
| ConnectionHandle | Connection handle, obtained from SQLAllocHandle. |

### Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

### Precautions

If SQLDisconnect returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_DBC** and **ConnectionHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

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## Example

See **Examples**.

# 21.2.10 SQLExecDirect

## Function

SQLExecDirect is used to execute a prepared SQL statement specified in this parameter. This is the fastest method for executing only one SQL statement at a time.

## Prototype

```
SQLRETURN SQLExecDirect(SQLHSTMT         StatementHandle,
                        SQLCHAR          *StatementText,
                        SQLINTEGER       TextLength);
```

## Parameter

**Table 21-25** SQLExecDirect parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle, obtained from SQLAllocHandle. |
| StatementText | SQL statement to be executed. One SQL statement can be executed at a time. |
| TextLength | Length of **StatementText**. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_NEED_DATA** indicates that parameters provided before executing the SQL statement are insufficient.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.
- **SQL_NO_DATA** indicates that the SQL statement does not return a result set.

## Precautions

If SQLExecDirect returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the

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**SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

### Example

See **Examples**.

## 21.2.11 SQLExecute

### Function

SQLExecute is used to execute a prepared SQL statement using SQLPrepare. The statement is executed using the current value of any application variables that were bound to parameter markers by SQLBindParameter.

### Prototype

```
SQLRETURN SQLExecute(SQLHSTMT    StatementHandle);
```

### Parameter

**Table 21-26** SQLExecute parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle to be executed. |

### Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_NEED_DATA** indicates that parameters provided before executing the SQL statement are insufficient.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_NO_DATA** indicates that the SQL statement does not return a result set.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

### Precautions

If SQLExecute returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

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## Example

See **Examples**.

# 21.2.12 SQLFetch

## Function

SQLFetch is used to advance the cursor to the next row of the result set and retrieve any bound columns.

## Prototype

```
SQLRETURN SQLFetch(SQLHSTMT    StatementHandle);
```

## Parameter

**Table 21-27** SQLFetch parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle, obtained from SQLAllocHandle. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_NO_DATA** indicates that the SQL statement does not return a result set.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

## Precautions

If SQLFetch returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

## Example

See **Examples**.

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## 21.2.13 SQLFreeStmt

In ODBC 3.x, SQLFreeStmt (an ODBC 2.x function) was deprecated and replaced by SQLFreeHandle. For details, see **21.2.15 SQLFreeHandle**.

## 21.2.14 SQLFreeConnect

In ODBC 3.x, SQLFreeConnect (an ODBC 2.x function) was deprecated and replaced by SQLFreeHandle. For details, see **21.2.15 SQLFreeHandle**.

## 21.2.15 SQLFreeHandle

### Function

SQLFreeHandle is used to release resources associated with a specific environment, connection, or statement handle. It replaces the ODBC 2.x functions: SQLFreeEnv, SQLFreeConnect, and SQLFreeStmt.

### Prototype

```
SQLRETURN SQLFreeHandle(SQLSMALLINT   HandleType,
                        SQLHANDLE     Handle);
```

### Parameter

**Table 21-28** SQLFreeHandle parameters

| Keyword | Parameter Description |
| --- | --- |
| HandleType | Type of handle to be freed by SQLFreeHandle. The value must be one of the following:<br>• SQL_HANDLE_ENV<br>• SQL_HANDLE_DBC<br>• SQL_HANDLE_STMT<br>• SQL_HANDLE_DESC<br>If **HandleType** is not one of the preceding values, SQLFreeHandle returns **SQL_INVALID_HANDLE**. |
| Handle | Name of the handle to be freed. |

### Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

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### Precautions

If SQLFreeHandle returns **SQL_ERROR**, the handle is still valid.

### Example

See **Examples**.

## 21.2.16 SQLFreeEnv

In ODBC 3.x, SQLFreeEnv (an ODBC 2.x function) was deprecated and replaced by SQLFreeHandle. For details, see **21.2.15 SQLFreeHandle**.

## 21.2.17 SQLPrepare

### Function

SQLPrepare is used to prepare an SQL statement to be executed.

Note that the prepared statements sent by ODBC do not support the kernel reuse plan. As a result, a new plan needs to be generated for each execution, causing high CPU usage. If services have requirements on plan reuse, you are advised to use the JDBC client.

### Prototype

```
SQLRETURN SQLPrepare(SQLHSTMT      StatementHandle,
                     SQLCHAR       *StatementText,
                     SQLINTEGER    TextLength);
```

### Parameter

**Table 21-29** SQLPrepare parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle. |
| StatementText | SQL text string. |
| TextLength | Length of **StatementText**. |

### Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

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- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

## Precautions

If SQLPrepare returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

## Example

See **Examples**.

# 21.2.18 SQLGetData

## Function

SQLGetData is used to retrieve data for a single column in the result set. It can be called for many times to retrieve data of variable lengths.

## Prototype

```
SQLRETURN SQLGetData(SQLHSTMT        StatementHandle,
                     SQLUSMALLINT    Col_or_Param_Num,
                     SQLSMALLINT     TargetType,
                     SQLPOINTER      TargetValuePtr,
                     SQLLEN          BufferLength,
                     SQLLEN          *StrLen_or_IndPtr);
```

## Parameter

**Table 21-30** SQLGetData parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle, obtained from SQLAllocHandle. |
| Col_or_Param_Num | Column number for which the data retrieval is requested. The column number starts with 1 and increases in ascending order. The number of the bookmark column is 0. |
| TargetType | C data type in the TargetValuePtr buffer. If **TargetType** is **SQL_ARD_TYPE**, the driver uses the data type of the **SQL_DESC_CONCISE_TYPE** field in ARD. If **TargetType** is **SQL_C_DEFAULT**, the driver selects a default data type according to the source SQL data type. |
| TargetValuePtr | **Output parameter**: pointer to the pointer that points to the buffer where the data is located. |
| BufferLength | Size of the **TargetValuePtr** buffer. |

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| Keyword | Parameter Description |
| --- | --- |
| StrLen_or_IndPtr | **Output parameter**: pointer to the buffer where the length or identifier value is returned. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_NO_DATA** indicates that the SQL statement does not return a result set.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

## Precautions

If SQLGetData returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

## Example

See **Examples**.

# 21.2.19 SQLGetDiagRec

## Function

SQLGetDiagRec is used to return the current values of multiple fields in a diagnostic record that contains error, warning, and status information.

## Prototype

```
SQLRETURN  SQLGetDiagRec(SQLSMALLINT    HandleType
                         SQLHANDLE      Handle,
                         SQLSMALLINT    RecNumber,
                         SQLCHAR        *SQLState,
                         SQLINTEGER     *NativeErrorPtr,
                         SQLCHAR        *MessageText,
                         SQLSMALLINT    BufferLength
                         SQLSMALLINT    *TextLengthPtr);
```

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## Parameter

**Table 21-31** SQLGetDiagRec parameters

| Keyword | Parameter Description |
| --- | --- |
| HandleType | A handle-type identifier that describes the type of handle for which diagnostics are desired. The value must be one of the following:<br>• SQL_HANDLE_ENV<br>• SQL_HANDLE_DBC<br>• SQL_HANDLE_STMT<br>• SQL_HANDLE_DESC |
| Handle | A handle for the diagnostic data structure. Its type is indicated by **HandleType**. If **HandleType** is **SQL_HANDLE_ENV**, **Handle** may be a shared or non-shared environment handle. |
| RecNumber | Status record from which the application seeks information. **RecNumber** starts with 1. |
| SQLState | **Output parameter**: pointer to a buffer that saves the 5-character **SQLSTATE** code pertaining to **RecNumber**. |
| NativeErrorPtr | **Output parameter**: pointer to a buffer that saves the native error code. |
| MessageText | Pointer to a buffer that saves text strings of diagnostic information. |
| BufferLength | Length of **MessageText**. |
| TextLengthPtr | **Output parameter**: pointer to the buffer, the total number of bytes in the returned **MessageText**. If the number of bytes available to return is greater than **BufferLength**, then the diagnostics information text in **MessageText** is truncated to **BufferLength** minus the length of the null termination character. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

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## Precautions

SQLGetDiagRec does not release diagnostic records for itself. It uses the following return values to report execution results:

- **SQL_SUCCESS** indicates that the function successfully returns diagnostic information.
- **SQL_SUCCESS_WITH_INFO** indicates that the ***MessageText** buffer is too small to hold the requested diagnostic information. No diagnostic records are generated.
- **SQL_INVALID_HANDLE** indicates that the handle indicated by **HandType** and **Handle** is an invalid handle.
- **SQL_ERROR** indicates that **RecNumber** is less than or equal to 0 or that **BufferLength** is smaller than 0.

If an ODBC function returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call SQLGetDiagRec to obtain the **SQLSTATE** value. The possible **SQLSTATE** values are listed as follows:

**Table 21-32** SQLSTATE values

| SQLSATATE | Error | Description |
| --- | --- | --- |
| HY000 | General error. | An error occurred for which there is no specific SQLSTATE. |
| HY001 | Memory allocation error. | The driver is unable to allocate memory required to support execution or completion of the function. |
| HY008 | Operation canceled. | SQLCancel is called to terminate the statement execution, but the StatementHandle function is still called. |
| HY010 | Function sequence error. | The function is called prior to sending data to data parameters or columns being executed. |
| HY013 | Memory management error. | The function fails to be called. The error may be caused by low memory conditions. |
| HYT01 | Connection timeout. | The timeout period expired before the application was able to connect to the data source. |
| IM001 | Function not supported by the driver. | The called function is not supported by the StatementHandle driver. |

## Example

See **Examples**.

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# 21.2.20 SQLSetConnectAttr

## Function

SQLSetConnectAttr is used to set connection attributes.

## Prototype

```
SQLRETURN SQLSetConnectAttr(SQLHDBC      ConnectionHandle
                        SQLINTEGER   Attribute,
                        SQLPOINTER   ValuePtr,
                        SQLINTEGER   StringLength);
```

## Parameter

**Table 21-33** SQLSetConnectAttr parameters

| Keyword | Parameter Description |
| --- | --- |
| ConnectionHandle | Connection handle. |
| Attribute | Attribute to set. |
| ValuePtr | Pointer to the **Attribute** value. **ValuePtr** depends on the **Attribute** value, and can be a 32-bit unsigned integer value or a null-terminated string. If the **ValuePtr** parameter is a driver-specific value, it may be a signed integer. |
| StringLength | If **ValuePtr** points to a string or a binary buffer, **StringLength** is the length of ***ValuePtr**. If **ValuePtr** points to an integer, **StringLength** is ignored. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

## Precautions

If SQLSetConnectAttr returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_DBC** and **ConnectionHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

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## Example

See **Examples**.

# 21.2.21 SQLSetEnvAttr

## Function

SQLSetEnvAttr is used to set environment attributes.

## Prototype

```
SQLRETURN SQLSetEnvAttr(SQLHENV      EnvironmentHandle
                        SQLINTEGER   Attribute,
                        SQLPOINTER   ValuePtr,
                        SQLINTEGER   StringLength);
```

## Parameter

**Table 21-34** SQLSetEnvAttr parameters

| Keyword | Parameter Description |
| --- | --- |
| EnvironmentHandle | Environment handle. |
| Attribute | Environment attribute to be set. The value must be one of the following:<br>• **SQL_ATTR_ODBC_VERSION**: ODBC version<br>• **SQL_CONNECTION_POOLING**: connection pool attribute<br>• **SQL_OUTPUT_NTS**: string type returned by the driver |
| ValuePtr | Pointer to the **Attribute** value. **ValuePtr** depends on the **Attribute** value, and can be a 32-bit integer value or a null-terminated string. |
| StringLength | If **ValuePtr** points to a string or a binary buffer, **StringLength** is the length of ***ValuePtr**. If **ValuePtr** points to an integer, **StringLength** is ignored. |

## Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

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### Precautions

If SQLSetEnvAttr returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_ENV** and **EnvironmentHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

### Example

See **Examples**.

## 21.2.22 SQLSetStmtAttr

### Function

SQLSetStmtAttr is used to set attributes related to a statement.

### Prototype

```
SQLRETURN SQLSetStmtAttr(SQLHSTMT      StatementHandle
                         SQLINTEGER    Attribute,
                         SQLPOINTER    ValuePtr,
                         SQLINTEGER    StringLength);
```

### Parameter

**Table 21-35** SQLSetStmtAttr parameters

| Keyword | Parameter Description |
| --- | --- |
| StatementHandle | Statement handle. |
| Attribute | Attribute to set. |
| ValuePtr | Pointer to the **Attribute** value. **ValuePtr** depends on the **Attribute** value, and can be a 32-bit unsigned integer value or a pointer to a null-terminated string, a binary buffer, or a driver-specified value. If the **ValuePtr** parameter is a driver-specific value, it may be a signed integer. |
| StringLength | If **ValuePtr** points to a string or a binary buffer, **StringLength** is the length of ***ValuePtr**. If **ValuePtr** points to an integer, **StringLength** is ignored. |

### Return Value

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates that some warning information is displayed.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.

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- **SQL_INVALID_HANDLE** indicates that invalid handles were called. This value may also be returned by other APIs.

### Precautions

If SQLSetStmtAttr returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **SQL_HANDLE_STMT** and **StatementHandle**, respectively, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

### Example

See **Examples**.

# 21.3 libpq Interface Reference

## 21.3.1 Database Connection Control Functions

Database connection control functions control the connections to GaussDB servers. An application can connect to multiple servers at a time. For example, a client connects to multiple databases. Each connection is represented by a PGconn object, which is obtained from the function PQconnectdb, PQconnectdbParams, or PQsetdbLogin. Note that these functions will always return a non-null object pointer, unless there is too little memory to allocate the PGconn object. The interface for establishing a connection is stored in the PGconn object. The PQstatus function can be called to check the return value for a successful connection.

### 21.3.1.1 PQconnectdbParams

### Function

PQconnectdbParams is used to establish a new connection with the database server.

### Prototype

```
PGconn *PQconnectdbParams(const char * const *keywords,
                          const char * const *values,
                          int expand_dbname);
```

### Parameter

**Table 21-36** PQconnectdbParams parameters

| Keyword | Parameter Description |
| --- | --- |
| keywords | An array of strings, each of which is a keyword. |
| values | Value assigned to each keyword. |

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| Keyword | Parameter Description |
| --- | --- |
| expand_dbname | When **expand_dbname** is non-zero, the **dbname** keyword value can be recognized as a connection string. Only **dbname** that first appears is expanded in this way, and any subsequent **dbname** value is treated as a database name. |

## Return Value

**PGconn *** points to the object pointer that contains a connection. The memory is applied for by the function internally.

## Precautions

This function establishes a new database connection using the parameters taken from two NULL-terminated arrays. Unlike PQsetdbLogin, the parameter set can be extended without changing the function signature. Therefore, use of this function (or its non-blocking analogs PQconnectStartParams and PQconnectPoll) is preferred for new application programming.

## Example

For details, see **6.5.3 Example**.

### 21.3.1.2 PQconnectdb

## Function

PQconnectdb is used to establish a new connection with the database server.

## Prototype

```
PGconn *PQconnectdb(const char *conninfo);
```

## Parameter

**Table 21-37** PQconnectdb parameter

| Keyword | Parameter Description |
| --- | --- |
| conninfo | Connection string. For details about the fields in the string, see **Connection Strings**. |

## Return Value

**PGconn *** points to the object pointer that contains a connection. The memory is applied for by the function internally.

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## Precautions

- This function establishes a new database connection using the parameters taken from the string **conninfo**.
- The input parameter can be empty, indicating that all default parameters can be used. It can also contain one or more parameters separated by spaces or it can contain a URL.

## Example

For details, see **6.5.3 Example**.

### 21.3.1.3 PQbackendPID

## Supplementary Explanation

After GaussDB is multi-thread refactored based on PostgreSQL, the semantic of PQbackendPID is different from that in the native PostgreSQL libpq. In GaussDB, the return value of the PQbackendPID function indicates the slot ID of the background thread, not the backend PID of the background thread. Due to the preceding difference, you are not advised to execute this function by following the PostgreSQL semantics. To obtain the backend PID of the connection, you can use the pg_backend_pid system function. In addition, other driver APIs which depend on libpq and have the same names as PostgreSQL's APIs (such as the get_backend_pid function of the Python connection driver psycopg2) also comply with the preceding rule.

### 21.3.1.4 PQsetdbLogin

## Function

PQsetdbLogin is used to establish a new connection with the database server.

## Prototype

```
PGconn *PQsetdbLogin(const char *pghost,
                     const char *pgport,
                     const char *pgoptions,
                     const char *pgtty,
                     const char *dbName,
                     const char *login,
                     const char *pwd);
```

## Parameter

**Table 21-38** PQsetdbLogin parameters

| Keyword | Parameter Description |
| --- | --- |
| pghost | Name of the host to be connected. For details, see the **host** field described in **6.5.5 Link Parameters**. |
| pgport | Port number of the host server. For details, see the **port** field described in **6.5.5 Link Parameters**. |

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| Keyword | Parameter Description |
| --- | --- |
| pgoptions | Command-line options to be sent to the server during running. For details, see the **options** field described in **6.5.5 Link Parameters**. |
| pgtty | This field can be ignored. (Previously, this field declares the output direction of server logs.) |
| dbName | Name of the database to be connected. For details, see the **dbname** field described in **6.5.5 Link Parameters**. |
| login | Username for connection. For details, see the **user** field described in **6.5.5 Link Parameters**. |
| pwd | Password used for authentication during connection. For details, see the **password** field described in **6.5.5 Link Parameters**. |

## Return Value

**PGconn *** points to the object pointer that contains a connection. The memory is applied for by the function internally.

## Precautions

- This function is the predecessor of PQconnectdb with a fixed set of parameters. When an undefined parameter is called, its default value is used. Write NULL or an empty string for any one of the fixed parameters that is to be defaulted.
- If the **dbName** value contains an = sign or a valid prefix in the connection URL, it is taken as a conninfo string and passed to PQconnectdb, and the remaining parameters are consistent with PQconnectdbParams parameters.

## Example

For details, see **6.5.3 Example**.

## 21.3.1.5 PQfinish

## Function

PQfinish is used to close the connection to the server and release the memory used by the PGconn object.

## Prototype

```
void PQfinish(PGconn *conn);
```

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## Parameter

**Table 21-39** PQfinish parameter

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |

## Precautions

If the server connection attempt fails (as indicated by PQstatus), the application should call PQfinish to release the memory used by the PGconn object. The PGconn pointer must not be used again after PQfinish has been called.

## Example

For details, see **6.5.3 Example**.

### 21.3.1.6 PQreset

## Function

PQreset is used to reset the communication port to the server.

## Prototype

```
void PQreset(PGconn *conn);
```

## Parameter

**Table 21-40** PQreset parameter

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |

## Precautions

This function will close the connection to the server and attempt to establish a new connection to the same server by using all the parameters previously used. This function is applicable to fault recovery after a connection exception occurs.

## Example

For details, see **6.5.3 Example**.

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### 21.3.1.7 PQstatus

## Function

PQstatus is used to return the connection status.

## Prototype

```
ConnStatusType PQstatus(const PGconn *conn);
```

## Parameter

**Table 21-41** PQ status parameter

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |

## Return Value

**ConnStatusType** indicates the connection status. The enumerated values are as follows:

```
CONNECTION_STARTED
Waiting for the connection to be established.

CONNECTION_MADE
Connection succeeded; waiting to send

CONNECTION_AWAITING_RESPONSE
Waiting for a response from the server.

CONNECTION_AUTH_OK
Authentication received; waiting for backend startup to complete.

CONNECTION_SSL_STARTUP
Negotiating SSL encryption.

CONNECTION_SETENV
Negotiating environment-driven parameter settings.

CONNECTION_OK
Normal connection.

CONNECTION_BAD
Failed connection.
```

## Precautions

The connection status can be one of the preceding values. After the asynchronous connection procedure is complete, only two of them, **CONNECTION_OK** and **CONNECTION_BAD**, can return. **CONNECTION_OK** indicates that the connection to the database is normal. **CONNECTION_BAD** indicates that the connection attempt fails. Generally, the **CONNECTION_OK** state remains until PQfinish is called. However, a communication failure may cause the connection status to become to **CONNECTION_BAD** before the connection procedure is complete. In

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this case, the application can attempt to call PQreset to restore the communication.

### Example

For details, see **6.5.3 Example**.

## 21.3.2 Database Statement Execution Functions

After the connection to the database server is successfully established, you can use the functions described in this section to execute SQL queries and commands.

### 21.3.2.1 PQexec

### Function

PQexec is used to submit a command to the server and wait for the result.

### Prototype

```
PGresult *PQexec(PGconn *conn, const char *command);
```

### Parameter

**Table 21-42** PQexec parameters

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |
| command | Query string to be executed. |

### Return Value

**PGresult** indicates the object pointer that contains the query result.

### Precautions

The PQresultStatus function should be called to check the return value for any errors (including the value of a null pointer, in which **PGRES_FATAL_ERROR** will be returned). The PQerrorMessage function can be called to obtain more information about such errors.

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**NOTICE**

The command string can contain multiple SQL commands separated by semicolons (;). Multiple queries sent in a PQexec call are processed in one transaction, unless there are specific BEGIN/COMMIT commands in the query string to divide the string into multiple transactions. Note that the returned PGresult structure describes only the result of the last command executed from the string. If a command fails, the string processing stops and the returned PGresult describes the error condition.

## Example

For details, see **6.5.3 Example**.

## 21.3.2.2 PQprepare

## Function

PQprepare is used to submit a request to create a prepared statement with given parameters and wait for completion.

## Prototype

```
PGresult *PQprepare(PGconn *conn,
                    const char *stmtName,
                    const char *query,
                    int nParams,
                    const Oid *paramTypes);
```

## Parameter

**Table 21-43** PQprepare parameters

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |
| stmtName | Prepared statement to be executed. |
| query | Query string to be executed. |
| nParams | Parameter quantity. |
| paramTypes | Array of the parameter type. |

## Return Value

**PGresult** indicates the object pointer that contains the query result.

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## Precautions

- PQprepare creates a prepared statement for later execution with PQexecPrepared. This function allows commands to be repeatedly executed, without being parsed and planned each time they are executed. PQprepare is supported only in protocol 3.0 or later. It will fail when protocol 2.0 is used.
- This function creates a prepared statement named **stmtName** from the query string, which must contain an SQL command. **stmtName** can be **""** to create an unnamed statement. In this case, any pre-existing unnamed statement will be automatically replaced. Otherwise, this is an error if the statement name has been defined in the current session. If any parameters are used, they are referred to in the query as $1, $2, and so on. **nParams** is the number of parameters for which types are pre-specified in the array paramTypes[]. (The array pointer can be NULL when **nParams** is **0**.) paramTypes[] specifies the data types to be assigned to the parameter symbols by OID. If **paramTypes** is NULL, or any element in the array is **0**, the server assigns a data type to the parameter symbol in the same way as it does for an untyped literal string. In addition, the query can use parameter symbols whose numbers are greater than **nParams**. Data types of these symbols will also be inferred.

**NOTICE**

You can also execute the SQLPREPARE statement to create a prepared statement that is used with PQexecPrepared. Although there is no libpq function of deleting a prepared statement, the SQL DEALLOCATE statement can be used for this purpose.

## Example

For details, see **6.5.3 Example**.

## 21.3.2.3 PQresultStatus

## Function

PQresultStatus is used to return the result status of a command.

## Prototype

```
ExecStatusType PQresultStatus(const PGresult *res);
```

## Parameter

**Table 21-44** PQresultStatus parameter

| Keyword | Parameter Description |
| --- | --- |
| res | Object pointer that contains the query result. |

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## Return Value

**PQresultStatus** indicates the command execution status. The enumerated values are as follows:

```
PQresultStatus can return one of the following values:
PGRES_EMPTY_QUERY
The string sent to the server was empty.

PGRES_COMMAND_OK
A command that does not return data was successfully executed.

PGRES_TUPLES_OK
A query (such as SELECT or SHOW) that returns data was successfully executed.

PGRES_COPY_OUT
Copy Out (from the server) data transfer started.

PGRES_COPY_IN
Copy In (to the server) data transfer started.

PGRES_BAD_RESPONSE
The response from the server cannot be understood.

PGRES_NONFATAL_ERROR
A non-fatal error (notification or warning) occurred.

PGRES_FATAL_ERROR
A fatal error occurred.

PGRES_COPY_BOTH
Copy In/Out (to and from the server) data transfer started. This state occurs only in streaming replication.

PGRES_SINGLE_TUPLE
PGresult contains a result tuple from the current command. This state occurs in a single-row query.
```

## Precautions

- Note that the SELECT command that happens to retrieve zero rows still returns **PGRES_TUPLES_OK**. **PGRES_COMMAND_OK** is used for commands that can never return rows (such as INSERT or UPDATE, without return clauses). The result status **PGRES_EMPTY_QUERY** might indicate a bug in the client software.
- The result status P**GRES_NONFATAL_ERROR** will never be returned directly by PQexec or other query execution functions. Instead, such results will be passed to the notice processor.

## Example

For details, see **6.5.3 Example**.

## 21.3.2.4 PQclear

## Function

PQclear is used to release the storage associated with PGresult. Any query result should be released by PQclear when it is no longer needed.

## Prototype

```
void PQclear(PGresult *res);
```

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### Parameter

**Table 21-45** PQclear parameter

| Keyword | Parameter Description |
| --- | --- |
| res | Object pointer that contains the query result. |

### Precautions

PGresult is not automatically released. That is, it does not disappear when a new query is submitted or even if you close the connection. To delete it, you must call PQclear. Otherwise, memory leakage occurs.

### Example

For details, see **6.5.3 Example**.

## 21.3.3 Functions for Asynchronous Command Processing

The PQexec function is adequate for committing commands in common, synchronous applications. However, it has several defects, which may be important to some users:

- PQexec waits for the end of the command, but the application may have other work to do (for example, maintaining a user interface). In this case, PQexec would not want to be blocked to wait for the response.
- As the client application is suspended while waiting for the result, it is difficult for the application to determine whether to cancel the ongoing command.
- PQexec can return only one PGresult structure. If the committed command string contains multiple SQL commands, all the PGresult structures except the last PGresult are discarded by PQexec.
- PQexec always collects the entire result of the command and caches it in a PGresult. Although this mode simplifies the error handling logic for applications, it is impractical for results that contain multiple rows.

Applications that do not want to be restricted by these limitations can use the following functions built from PQexec: PQsendQuery and PQgetResult. The functions PQsendQueryParams, PQsendPrepare, and PQsendQueryPrepared can also be used with PQgetResult.

### 21.3.3.1 PQsendQuery

### Function

PQsendQuery is used to submit a command to the server without waiting for the result. If the query is successful, **1** is returned. Otherwise, **0** is returned.

### Prototype

```
int PQsendQuery(PGconn *conn, const char *command);
```

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## Parameter

**Table 21-46** PQsendQuery parameters

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |
| command | Query string to be executed. |

## Return Value

**int** indicates the execution result. **1** indicates successful execution and **0** indicates an execution failure. The failure cause is stored in **conn->errorMessage**.

## Precautions

After PQsendQuery is successfully called, call PQgetResult one or more times to obtain the results. PQsendQuery cannot be called again (on the same connection) until PQgetResult returns a null pointer, indicating that the command execution is complete.

## Example

For details, see **6.5.3 Example**.

## 21.3.3.2 PQsendQueryParams

## Function

PQsendQueryParams is used to submit a command and separate parameters to the server without waiting for the result.

## Prototype

```
int PQsendQueryParams(PGconn *conn,
                      const char *command,
                      int nParams,
                      const Oid *paramTypes,
                      const char * const *paramValues,
                      const int *paramLengths,
                      const int *paramFormats,
                      int resultFormat);
```

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## Parameter

**Table 21-47** PQsendQueryParams parameters

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |
| command | Query string to be executed. |
| nParams | Parameter quantity. |
| paramTypes | Parameter type. |
| paramValues | Parameter value. |
| paramLengths | Parameter length. |
| paramFormats | Parameter format. |
| resultFormat | Result format. |

## Return Value

**int** indicates the execution result. **1** indicates successful execution and **0** indicates an execution failure. The failure cause is stored in **conn->errorMessage**.

## Precautions

PQsendQueryParams is equivalent to PQsendQuery. The only difference is that query parameters can be specified separately from the query string. PQsendQueryParams parameters are handled in the same way as PQexecParams parameters. Like PQexecParams, PQsendQueryParams cannot work on connections using protocol v2.0 and it allows only one command in the query string.

## Example

For details, see **6.5.3 Example**.

## 21.3.3.3 PQsendPrepare

## Function

PQsendPrepare is used to send a request to create a prepared statement with given parameters, without waiting for completion.

## Prototype

```
int PQsendPrepare(PGconn *conn,
                  const char *stmtName,
                  const char *query,
                  int nParams,
                  const Oid *paramTypes);
```

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## Parameter

**Table 21-48** PQsendPrepare parameters

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |
| stmtName | Prepared statement to be executed. |
| query | Query string to be executed. |
| nParams | Parameter quantity. |
| paramTypes | Array of the parameter type. |

## Return Value

**int** indicates the execution result. **1** indicates successful execution and **0** indicates an execution failure. The failure cause is stored in **conn->errorMessage**.

## Precautions

PQsendPrepare is an asynchronous version of PQprepare. If it can dispatch a request, **1** is returned. Otherwise, **0** is returned. After a successful calling of PQsendPrepare, call PQgetResult to check whether the server successfully created the prepared statement. PQsendPrepare parameters are handled in the same way as PQprepare parameters. Like PQprepare, PQsendPrepare cannot work on connections using protocol v2.0.

## Example

For details, see **6.5.3 Example**.

## 21.3.3.4 PQsendQueryPrepared

## Function

PQsendQueryPrepared is used to send a request to execute a prepared statement with given parameters, without waiting for the result.

## Prototype

```
int PQsendQueryPrepared(PGconn *conn,
                        const char *stmtName,
                        int nParams,
                        const char * const *paramValues,
                        const int *paramLengths,
                        const int *paramFormats,
                        int resultFormat);
```

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## Parameter

**Table 21-49** PQsendQueryPrepared parameters

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |
| stmtName | Prepared statement to be executed. |
| nParams | Parameter type. |
| paramValues | Parameter value. |
| paramLengths | Parameter length. |
| paramFormats | Parameter format. |
| resultFormat | Result format. |

## Return Value

**int** indicates the execution result. **1** indicates successful execution and **0** indicates an execution failure. The failure cause is stored in **conn->errorMessage**.

## Precautions

PQsendQueryPrepared is similar to PQsendQueryParams, but the command to be executed is specified by naming a previously-prepared statement, instead of providing a query string. PQsendQueryPrepared parameters are handled in the same way as PQexecPrepared parameters. Like PQexecPrepared, PQsendQueryPrepared cannot work on connections using protocol v2.0.

## Example

For details, see **6.5.3 Example**.

## 21.3.3.5 PQflush

## Function

PQflush is used to try to flush any queued output data to the server.

## Prototype

```
int PQflush(PGconn *conn);
```

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### Parameter

**Table 21-50** PQflush parameter

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |

### Return Value

**int** indicates the operation result. If the operation is successful (or the send queue is empty), **0** is returned. If the operation fails, **-1** is returned. If all data in the send queue fails to be sent, **1** is returned. (This case occurs only when the connection is non-blocking.) The failure cause is stored in **conn->error_message**.

### Precautions

Call PQflush after sending any command or data over a non-blocking connection. If **1** is returned, wait for the socket to become read- or write-ready. If the socket becomes write-ready, call PQflush again. If the socket becomes read-ready, call PQconsumeInput and then call PQflush again. Repeat the operation until the value **0** is returned for PQflush. (It is necessary to check for read-ready and drain the input using PQconsumeInput. This is because the server can block trying to send us data, for example, notification messages, and will not read our data until we read it.) Once PQflush returns **0**, wait for the socket to be read-ready and then read the response as described above.

### Example

For details, see **6.5.3 Example**.

## 21.3.4 Functions for Canceling Queries in Progress

A client application can use the functions described in this section to cancel a command that is still being processed by the server.

### 21.3.4.1 PQgetCancel

### Function

PQgetCancel is used to create a data structure that contains the information required to cancel a command issued through a specific database connection.

### Prototype

```
PGcancel *PQgetCancel(PGconn *conn);
```

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## Parameter

**Table 21-51** PQgetCancel parameter

| Keyword | Parameter Description |
| --- | --- |
| conn | Points to the object pointer that contains the connection information. |

## Return Value

**PGcancel** points to the object pointer that contains the cancel information.

## Precautions

PQgetCancel creates a PGcancel object for a given PGconn connection object. If the given connection object (**conn**) is NULL or an invalid connection, PQgetCancel will return NULL. The PGcancel object is an opaque structure that cannot be directly accessed by applications. It can be transferred only to PQcancel or PQfreeCancel.

## Example

For details, see **6.5.3 Example**.

### 21.3.4.2 PQfreeCancel

## Function

PQfreeCancel is used to release the data structure created by PQgetCancel.

## Prototype

```
void PQfreeCancel(PGcancel *cancel);
```

## Parameter

**Table 21-52** PQfreeCancel parameter

| Keyword | Parameter Description |
| --- | --- |
| cancel | Points to the object pointer that contains the cancel information. |

## Precautions

PQfreeCancel releases a data object previously created by PQgetCancel.

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## Example

For details, see **6.5.3 Example**.

## 21.3.4.3 PQcancel

## Function

PQcancel is used to request the server to abandon processing of the current command.

## Prototype

```
int PQcancel(PGcancel *cancel, char *errbuf, int errbufsize);
```

## Parameter

**Table 21-53** PQcancel parameters

| Keyword | Parameter Description |
| --- | --- |
| cancel | Points to the object pointer that contains the cancel information. |
| errbuf | Buffer for storing error information. |
| errbufsize | Size of the buffer for storing error information. |

## Return Value

**int** indicates the execution result. **1** indicates successful execution and **0** indicates an execution failure. The failure cause is stored in **errbuf**.

## Precautions

- Successful sending does not guarantee that the request will have any effect. If the cancellation is valid, the current command is terminated early and an error is returned. If the cancellation fails (for example, because the server has processed the command), no result is returned.
- If **errbuf** is a local variable in a signal handler, you can safely call PQcancel from the signal handler. For PQcancel, the PGcancel object is read-only, so it can also be called from a thread that is separate from the thread that is operating the PGconn object.

## Example

For details, see **6.5.3 Example**.

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# 21.4 Psycopg API Reference

Psycopg APIs are a set of methods provided for users. This section describes some common APIs.

## 21.4.1 psycopg2.connect()

### Function

This method creates a database session and returns a new connection object.

### Prototype

```
conn=psycopg2.connect(dbname="test",user="postgres",password="secret",host="127.0.0.1",port="5432")
```

### Parameter

**Table 21-54** psycopg2.connect parameters

| Keyword | Description |
| --- | --- |
| dbname | Database name. |
| user | Username. |
| password | Password. |
| host | Database IP address. The default type is UNIX socket. |
| port | Connection port number. The default value is **5432**. |
| sslmode | SSL mode, which is used for SSL connection. |
| sslcert | Path of the client certificate, which is used for SSL connection. |
| sslkey | Path of the client key, which is used for SSL connection. |
| sslrootcert | Path of the root certificate, which is used for SSL connection. |
| hostaddr | IP address of the database |
| connect_timeout | Client connection timeout interval |
| client_encoding | Encoding format of the client |
| application_name | Value of **application_name**. |
| fallback_application_name | Rollback value of **application_name**. |

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| Keyword | Description |
| --- | --- |
| keepalives | Determines whether to enable the TCP connection on the client. The default value is **1**, indicating that the TCP connection is enabled. The value **0** indicates that the TCP connection is disabled. If the UNIX domain socket connection is used, ignore this parameter. |
| options | Specifies the command line options sent to the server when the connection starts. |
| keepalives_idle | Describes inactivity before keepalive messages are sent to the server. If **keepalive** is disabled, ignore this parameter. |
| keepalives_interval | Determines whether keepalive messages that are not confirmed by the server need to be resent. If **keepalive** is disabled, ignore this parameter. |
| keepalives_count | Specifies the number of TCP connections that may be lost before the client is disconnected from the server. |
| replication | Ensures that the connection uses the replication protocol instead of the common protocol. |
| requiressl | Supports the SSL mode. |
| sslcompression | Specifies the SSL compression. If this parameter is set to **1**, the data sent through the SSL connection is compressed. If this parameter is set to **0**, the compression is disabled. If no SSL connection is established, ignore this parameter. |
| sslcrl | Specifies the path of the certificate revocation list (CRL), which is used to check whether the SSL server certificate is available. |
| requirepeer | Specifies the OS username of the server. |

### Return Value

Connection object (for connecting to the PostgreSQL DB instance).

### Example

For details, see **6.6.9 Example: Common Operations**.

## 21.4.2 connection.cursor()

### Function

This method returns a new cursor object.

### Prototype

```
cursor(name=None, cursor_factory=None, scrollable=None, withhold=False)
```

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### Parameter

**Table 21-55** connection.cursor parameters

| Keyword | Description |
| --- | --- |
| name | Cursor name. The default value is **None**. |
| cursor_factory | Creates a non-standard cursor. The default value is **None**. |
| scrollable | Sets the SCROLL option. The default value is **None**. |
| withhold | Sets the HOLD option. The default value is **False**. |

### Return Value

Cursor object (used for cusors that are programmed using Python in the entire database)

### Example

For details, see **6.6.9 Example: Common Operations**.

## 21.4.3 cursor.execute(query,vars_list)

### Function

This method executes the parameterized SQL statements (that is, placeholders instead of SQL literals). The psycopg2 module supports placeholders marked with **%s**.

### Prototype

```
curosr.execute(query,vars_list)
```

### Parameters

**Table 21-56** curosr.execute parameters

| Keyword | Description |
| --- | --- |
| query | SQL statement to be executed. |
| vars_list | Variable list, which matches the **%s** placeholder in the query. |

### Return Value

None

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### Example

For details, see **6.6.9 Example: Common Operations**.

## 21.4.4 curosr.executemany(query,vars_list)

### Function

This method executes an SQL command against all parameter sequences or mappings found in the sequence SQL.

### Prototype

```
curosr.executemany(query,vars_list)
```

### Parameter

**Table 21-57** curosr.executemany parameters

| Keyword | Description |
| --- | --- |
| query | SQL statement that you want to execute. |
| vars_list | Variable list, which matches the **%s** placeholder in the query. |

### Return Value

None

### Example

For details, see **6.6.9 Example: Common Operations**.

## 21.4.5 connection.commit()

### Function

This method commits the currently pending transaction to the database.

**CAUTION**

By default, Psycopg opens a transaction before executing the first command. If **commit()** is not called, the effect of any data operation will be lost.

### Prototype

```
connection.commit()
```

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### Parameter

None

### Return Value

None

### Example

For details, see **6.6.9 Example: Common Operations**.

## 21.4.6 connection.rollback()

### Function

This method rolls back the current pending transaction.

> **CAUTION**
>
> If you close the connection using **close()** but do not commit the change using **commit()**, an implicit rollback will be performed.

### Prototype

```
connection.rollback()
```

### Parameter

None

### Return Value

None

### Example

For details, see **6.6.9 Example: Common Operations**.

## 21.4.7 cursor.fetchone()

### Function

This method extracts the next row of the query result set and returns a tuple.

### Prototype

```
cursor.fetchone()
```

### Parameter

None

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### Return Value

A single tuple is the first result in the result set. If no more data is available, **None** is returned.

### Example

For details, see **6.6.9 Example: Common Operations**.

## 21.4.8 cursor.fetchall()

### Function

This method gets all the (remaining) rows of the query result and returns them as a list of tuples.

### Prototype

```
cursor.fetchall()
```

### Parameter

None

### Return Value

Tuple list, which contains all results of the result set. An empty list is returned when no rows are available.

### Example

For details, see **6.6.9 Example: Common Operations**.

## 21.4.9 cursor.close()

### Function

This method closes the cursor of the current connection.

### Prototype

```
cursor.close()
```

### Parameter

None

### Return Value

None

### Example

For details, see **6.6.9 Example: Common Operations**.

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# 21.4.10 connection.close()

## Function

This method closes the database connection.

> **CAUTION**
>
> This method closes the database connection and does not automatically call **commit()**. If you just close the database connection without calling **commit()** first, changes will be lost.

## Prototype

```
connection.close()
```

## Parameter

None

## Return Value

None

## Example

For details, see **6.6.9 Example: Common Operations**.

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