Data Warehouse Service

Developer Guide

Issue 02

Date 2024-04-30

HUAWEI CLOUD COMPUTING TECHNOLOGIES CO., LTD.

Trademarks and Permissions


and other Huawei trademarks are the property of Huawei Technologies Co., Ltd.
All other trademarks and trade names mentioned in this document are the property of their respective holders.

Notice

The purchased products, services and features are stipulated by the contract made between Huawei Cloud and the customer. All or part of the products, services and features described in this document may not be within the purchase scope or the usage scope. Unless otherwise specified in the contract, all statements, information, and recommendations in this document are provided "AS IS" without warranties, guarantees or representations of any kind, either express or implied.

The information in this document is subject to change without notice. Every effort has been made in the preparation of this document to ensure accuracy of the contents, but all statements, information, and recommendations in this document do not constitute a warranty of any kind, express or implied.

Huawei Cloud Computing Technologies Co., Ltd.

Address: Huawei Cloud Data Center Jiaoxinggong Road
Qianzhong Avenue
Gui'an New District
Gui Zhou 550029
People's Republic of China

Website: https://www.huaweicloud.com/intl/en-us/

Contents

1 Welcome

1.1 Target Readers

This document is intended for database designers, application developers, and database administrators, and provides information required for designing, building, querying and maintaining data warehouses.

As a database administrator or application developer, you need to be familiar with:

- Knowledge about OSs, which is the basis for everything.
- SQL syntax, which is the necessary skill for database operation.

Statement

When writing documents, the writers of GaussDB(DWS) try their best to provide guidance from the perspective of commercial use, application scenarios, and task completion. Even so, references to PostgreSQL content may still exist in the document. For this type of content, the following PostgreSQL Copyright is applicable:

Postgres-XC is Copyright © 1996-2013 by the PostgreSQL Global Development Group.

PostgreSQL is Copyright © 1996-2013 by the PostgreSQL Global Development Group.

Postgres95 is Copyright © 1994-5 by the Regents of the University of California.

IN NO EVENT SHALL THE UNIVERSITY OF CALIFORNIA BE LIABLE TO ANY PARTY FOR DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING LOST PROFITS, ARISING OUT OF THE USE OF THIS SOFTWARE AND ITS DOCUMENTATION, EVEN IF THE UNIVERSITY OF CALIFORNIA HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

1.2 Reading Guide

If you are a new GaussDB(DWS) user, you are advised to read the following contents first:

- Sections describing the features, functions, and application scenarios of GaussDB(DWS).
- "Getting Started": guides you through creating a data warehouse cluster, creating a database table, uploading data, and testing queries.

If you intend to or are migrating applications from other data warehouses to GaussDB(DWS), you might want to know how GaussDB(DWS) differs from them.

You can find useful information from the following table for GaussDB(DWS) database application development.

If you want to...	Query Suggestions
Quickly get started with GaussDB(DWS).	Deploy a cluster, connect to the database, and perform some queries by following the instructions provided in **Getting Started**. When you are ready to construct a database, load data to tables and compile the query content to operate the data in the data warehouse. Then, you can return to the *Data Warehouse Service Database Developer Guide*.
Understand the internal architecture of a GaussDB(DWS) data warehouse.	To know more about GaussDB(DWS), go to the GaussDB(DWS) home page.

If you want to...	Query Suggestions
Learn how to design tables to achieve the excellent performance.	**Development and Design Proposal** introduces the design specifications that should be complied with during the development of database applications. Modeling compliant with these specifications fits the distributed processing architecture of GaussDB(DWS) and provides efficient SQL code. To facilitate service execution through optimization, you can refer to **Query Performance Optimization**. Successful performance optimization depends more on database administrators' experience and judgment than on instructions and explanation. However, **Query Performance Optimization** still tries to systematically illustrate the performance optimization methods for application development personnel and new GaussDB(DWS) database administrators.
Load data.	**Importing Data**describes how to import data to GaussDB(DWS). **Excellent Practices for Data Import** provides key points for quick data import.
Manage users, groups, and database security.	**Database Security Management** covers database security topics.
Monitor and optimize system performance.	**System Catalogs and System Views** describes the system catalogs where you can query the database status and monitor the query content and process. You can learn how to check the system running status and monitoring metrics on the GaussDB(DWS) console by referring to **Management Guide**.

1.3 Prerequisites

Complete the following tasks before you perform operations described in this document:

- Create a GaussDB(DWS) cluster.
- Install an SQL client.
- Connect the SQL client to the default database of the cluster.

For details about the preceding tasks, see **Getting Started**.

2 System Overview

2.1 HA Transaction Processing

GaussDB(DWS) manages cluster transactions, the basis of HA and failovers. This ensures speedy fault recovery, guarantees the Atomicity, Consistency, Isolation, Durability (ACID) properties for transactions and after a recovery, and enables concurrent control.

Fault Rectification

GaussDB(DWS) provides an HA mechanism to reduce the service interruption time when a cluster is faulty. It protects key user programs to continuously provide external services, minimizing the impact of hardware, software, and human faults on services and ensuring service continuity.

- Hardware HA: Disk RAID, switch stacking, NIC bond, and uninterruptible power supply (UPS)
- Software HA: HA mechanism used for instances in the GaussDB(DWS) cluster, such as CNs, GTMs, and DNs)

Transaction Management

- Transaction blocks are supported. You can run **start transaction** to make the startup of a transaction block explicit.
- Single-statement transactions are supported. If you do not explicitly start a transaction, a single statement is processed as a transaction.
- Distributed transaction management and global transaction information management are supported. This includes gxid, snapshot, timestamp management, distributed transaction status management, and gxid overflow processing.
- Distributed transactions have ACID properties.
- Deadlocks are prevented in the distributed system. A transaction will be unlocked immediately after a deadlock (if any).

2.2 High Query Performance

The following GaussDB(DWS) features help achieve high query performance.

Fully Parallel Query

GaussDB(DWS) is an MPP system with the shared-nothing architecture. It consists of multiple independent logical nodes that do not share system resources, such as the CPU, memory, and storage units. In such a system architecture, service data is separately stored on numerous nodes. Data analysis tasks are executed in parallel on the nodes where data is stored. The massively parallel data processing significantly improves response speed.

In addition, GaussDB(DWS) improves data query performance by executing operators in parallel, executing commands in registers in parallel, and using LLVM to dynamically compile the logical conditions of redundancy prune.

Hybrid Row-Column Storage

GaussDB(DWS) supports both the row and column storage models. You can choose a row- or column-store table as needed.

The hybrid row-column storage engine achieves higher data compression ratio (column storage), index performance (column storage), and point update and point query (row storage) performance.

Data Compression in Column Storage

You can compress old, inactive data to free up space, reducing procurement and O&M costs.

In GaussDB(DWS), data can be compressed using the Delta Value Encoding, Dictionary, RLE, LZ4, and ZLIB algorithms. The system automatically selects a compression algorithm based on data characteristics. The average compression ratio is 7:1. Compressed data can be directly accessed and is transparent to services, greatly reducing the preparation time before accessing historical data.

2.3 Related Concepts

Database

A database manages data objects and is isolated from other databases. While creating an object, you can specify a tablespace for it. If you do not specify it, the object will be saved to the **PG_DEFAULT** space by default. Objects managed by a database can be distributed to multiple tablespaces.

Instance

In GaussDB(DWS), instances are a group of database processes running in the memory. An instance can manage one or more databases that form a cluster. A cluster is an area in the storage disk. This area is initialized during installation and

composed of a directory. The directory, called data directory, stores all data and is created by **initdb**. Theoretically, one server can start multiple instances on different ports, but GaussDB(DWS) manages only one instance at a time. The start and stop of an instance rely on the specific data directory. For compatibility purposes, the concept of instance name may be introduced.

Tablespaces

In GaussDB(DWS), 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(DWS) schemas logically separate databases. All database objects are created under certain schemas. In GaussDB(DWS), 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(DWS) 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(DWS), the difference between roles and users is that a role does not have the LOGIN permission by default. In GaussDB(DWS), 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 Management

In GaussDB(DWS), transactions are managed by multi-version concurrency control (MVCC) and two-phase locking (2PL). It enables smooth data reads and writes. In GaussDB(DWS), MVCC saves historical version data together with the current tuple version. GaussDB(DWS) uses the VACUUM process instead of rollback segments to routinely delete historical version data. Unless in performance optimization, you do not need to pay attention to the VACUUM process. Transactions are automatically submitted in GaussDB(DWS).

3 Defining Database Objects

3.1 Creating and Managing Databases

A database is a collection of objects such as tables, indexes, views, stored procedures, and operators. GaussDB (DWS) supports the creation of multiple databases. However, a client program can connect to and access only one database at a time, and cross-database query is not supported.

Template and Default Databases

- GaussDB (DWS) provides two template databases **template0** and **template1** and a default database gaussdb.
- By default, each newly created database is based on a template database. The GaussDB(DWS) database uses **template1** as the template by default. The encoding format is SQL_ASCII, and user-defined character encoding is not allowed. If you need to specify the character encoding when creating a database, use **template0** to create the database.
- Do not use a client or any other tools to connect to or to perform operations on both the two template databases.

NOTE

You can run the **show server_encoding** command to view the current database encoding.

Creating a Database.

Run the **CREATE DATABASE** statement to create a database.

```
CREATE DATABASE mydatabase;
```

NOTE

- When you create a database, if the length of the database name exceeds 63 bytes, the server truncates the database name and retains the first 63 bytes. Therefore, you are advised to set the length of the database name to a value less than or equal to 63 bytes. Do not use multi-byte characters as object names. If an object whose name is truncated mistakenly cannot be deleted, delete the object using the name before the truncation, or manually delete it from the corresponding system catalog on each node.
- Database names must comply with the naming convention of SQL identifiers. The current user 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 different schemas in the same database.
- A maximum of 128 databases can be created in GaussDB(DWS).
- You must have the permission to create a database or the permission that the system administrator owns.

Viewing Databases

To view databases, perform the following steps:

- Run the **\l** meta-command to view the database list of the database system.
  ```
  \l
  ```
- Querying the database list using the **pg_database** system catalog
  ```
  SELECT datname FROM pg_database;
  ```

Modifying a Database

You can use the **ALTER DATABASE** statement modify database configuration such as the database owner, name, and default settings.

- Run the following command to set the default search path for the database:
  ALTER DATABASE *mydatabase* **SET** *search_path* **TO** *pa_catalog,public*;
- Rename the database.
  ALTER DATABASE *mydatabase* **RENAME TO** *newdatabase*;

Deleting a Database

You can run **DROP DATABASE** statement to delete a database. This statement deletes the system catalog of the database and the database directory on the disk. Only the database owner or system administrator can delete a database. A database being accessed by users cannot be deleted, You need to connect to another database before deleting this database.

Run the **DROP DATABASE** statement to delete a database:


```
DROP DATABASE newdatabase;
```

3.2 Creating and Managing Schemas

A schema is the logical organization of objects and data in a database. Schema management allows multiple users to use the same database without interfering with each other. Third-party applications can be added to corresponding schemas to avoid conflicts.

The same database object name can be used in different schemas in a 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 in a database.

If a user is created, a schema named after the user will also be created in the current database.

The Default Schema Public

Each database has a schema named **Public**. If you do not create any schema, the object will be created in the schema named public. All database roles (users) have the CREATE and USAGE permissions in the public schema. When creating a schema, you need to grant the access permission to users.

Creating a Schema

- Run the **CREATE SCHEMA** command to create a schema.
  ```
  CREATE SCHEMA myschema;
  ```
  To create or access an object in the schema, the object name in the command should be composed of the schema name and the object name, which are separated by a dot (.), for example, **myschema.table**.
- Users can create a schema owned by others. For example, run the following command to create a schema named **myschema** and set the owner of the schema to user **jack**:
  ```
  CREATE SCHEMA myschema AUTHORIZATION jack;
  ```
  If **authorization username** is not specified, the schema owner is the user who runs the command.

Modifying a Schema

- Run the **ALTER SCHEMA** command to change the schema name. Only the schema owner can change the schema name.
  ```
  ALTER SCHEMA schema_name RENAME TO new_name;
  ```
- Run the **ALTER SCHEMA** command to change the schema owner.
  ```
  ALTER SCHEMA schema_name OWNER TO new_owner;
  ```

Setting the Schema Search Path

The GUC parameter **search_path** specifies the schema search sequence. The parameter value is a series of schema names separated by commas (,). If no schema is specified during object creation, the object will be added to the first schema displayed in the search path. If there are objects with the same name in 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.

- Run the **SHOW** command to view the current search path.
```
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.
- Run the **SET** command to modify the default schema of the current session. For example, if the search path is set to "**myschema**, **public**", **myschema** is searched first.
```
SET SEARCH_PATH TO myschema, public;
```
You can also run the **ALTER ROLE** command to set search_path for a role (user). For example:
```
ALTER ROLE jack SET search_path TO myschema, public;
```

Using 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 (.).

- Create a table **mytable** in **myschema**. Create a table in **schema_name.table_name** format.
```
CREATE TABLE myschema.mytable(id int, name varchar(20));
```
- Query all data in the table **mytable** in **myschema**.
```
SELECT * FROM myschema.mytable;
 id | name
----+------
(0 rows)
```

Viewing a Schema

- Use the **current_schema()** function to view the current schema.
```
SELECT current_schema();
 current_schema
----------------
 myschema
(1 row)
```
- 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.
```
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**.
```
SELECT * FROM PG_NAMESPACE;
```
- Use the **PGXC_TOTAL_SCHEMA_INFO** view to query the space usage of schemas in the cluster.
```
SELECT * FROM PGXC_TOTAL_SCHEMA_INFO;
```
- 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.


```
SELECT distinct(tablename),schemaname FROM PG_TABLES where schemaname = 'pg_catalog';
```

Schema Permission Control

By default, a user can only access database objects in its own schema. To access objects in other schemas, the user must have the **usage** permission of the corresponding schema.

By granting the **CREATE** permission for a schema to a user, the user can create objects in this schema.

- Grant the **usage** permission of **myschema** to user **jack**.
  GRANT USAGE ON schema *myschema* **TO** *jack*;
- Run the following command to revoke the **USAGE** permission for **myschema** from **jack**:
  REVOKE USAGE ON schema *myschema* **FROM** *jack*;

Drop Schema

- Run the **DROP SCHEMA** command to delete an empty schema (no database objects in the schema).
  DROP SCHEMA IF EXISTS *myschema*;
- By default, a schema must be empty before being deleted. To delete a schema and all its objects (such as tables, data, and functions), use the **CASCADE** keyword.
  DROP SCHEMA *myschema* **CASCADE**;

System Schema

- Each database has a **pg_catalog** schema, which contains system catalogs and all built-in 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.
- The **information_schema** consists of a collection of views that contain object information in a database. These views obtain system information from the system catalogs in a standardized way.

3.3 Creating and Managing Tables

Creating a Table

You can run the **CREATE TABLE** command to create a table. When creating a table, you can define the following information:

- Columns and **data type** of the table.
- Table or column constraints that restrict a column or the data contained in a table. For details, see **Definition of Table Constraints**.
- Distribution policy of a table, which determines how the GaussDB (DWS) database divides data between segments. For details, see **Definition of Table Distribution**.

- Table storage format. For details, see **Selecting a Table Storage Mode**.
- Partition table information. For details, see **Defining Table Partitions** .

Example: Use **CREATE TABLE** to create a table **web_returns_p1**, use **wr_item_sk** as the distribution key, and sets the range distribution function through **wr_returned_date_sk**.

```
CREATE TABLE web_returns_p1
(
    wr_returned_date_sk       integer,
    wr_returned_time_sk       integer,
    wr_item_sk                integer NOT NULL,
    wr_refunded_customer_sk   integer
)
WITH (orientation = column)
DISTRIBUTE BY HASH (wr_item_sk)
PARTITION BY RANGE(wr_returned_date_sk)
(
    PARTITION p2019 START(20191231) END(20221231) EVERY(10000),
    PARTITION p0 END(maxvalue)
);
```

Definition of Table Constraints

You can define constraints on columns and tables to restrict data in a table. However, there are the following restrictions:

- The primary key constraint and unique constraint in the table must contain a distribution column.
- Column-store tables support the **PARTIAL CLUSTER KEY** and table-level primary key and unique constraints, but do not support table-level foreign key constraints.
- Only the **NULL**, **NOT NULL**, and **DEFAULT** constant values can be used as column-store table column constraints.

Table 3-1 Table constraints

Constraint	Description	Example
Check constraint	A CHECK constraint allows you to specify that values in a specific column must satisfy a Boolean (true) expression.	Create the **products** table. The **price** column must be positive. `CREATE TABLE products ( product_no integer, name text, price numeric CHECK (price > 0) );`
NOT NULL constraint	A NOT NULL constraint specifies that a column cannot have null values. A non-null constraint is always written as a column constraint.	Create the **products** table. The values of **product_no** and **name** cannot be null. `CREATE TABLE products ( product_no integer NOT NULL, name text NOT NULL, price numeric );`

Constraint	Description	Example

UNIQUE constraint	A UNIQUE constraint specifies that the values in a column or a group of columns are all unique. If **DISTRIBUTE BY REPLICATION** is not specified, the column table that contains only unique values must contain distribution columns.	Create the **products** table. The values of **product_no** must be unique.
		`CREATE TABLE products`
		`(`
		`  product_no integer UNIQUE,`
		`  name text,`
		`  price numeric`
		`)DISTRIBUTE BY HASH(product_no);`

Primary key constraint	A primary key constraint is the combination of a UNIQUE constraint and a NOT NULL constraint. If **DISTRIBUTE BY REPLICATION** is not specified, the column set with a primary key constraint must contain distributed columns. If a table has a primary key, the column (or group of columns) of the primary key is selected as the distribution keys of the table by default.	Create the **products** table. The primary key constraint is **product_no**.
		`CREATE TABLE products`
		`(`
		`  product_no integer PRIMARY KEY,`
		`  name text,`
		`  price numeric`
		`)DISTRIBUTE BY HASH(product_no);`

Partial cluster key	Partial cluster key can minimize or maximize sparse indexes to quickly filter base tables. Partial cluster key can specify multiple columns, but you are advised to specify no more than two columns.	Create the **products** table with PCK set to **product_no**:
		`CREATE TABLE products`
		`(`
		`  product_no integer,`
		`  name text,`
		`  price numeric,`
		`  PARTIAL CLUSTER KEY(product_no)`
		`) WITH (ORIENTATION = COLUMN);`

Definition of Table Distribution

GaussDB(DWS) supports the following distribution modes: replication, hash, and roundrobin.

NOTE

The roundrobin distribution mode is supported only by cluster version 8.1.2 or later.

Policy	Description	Scenario	Advantages/Disadvantages
Replication	Full data in a table is stored on each DN in the cluster.	Small tables and dimension tables	• The advantage of replication is that each DN has full data of the table. During the join operation, data does not need to be redistributed, reducing network overheads and reducing plan segments (each plan segment starts a corresponding thread). • The disadvantage of replication is that each DN retains the complete data of the table, resulting in data redundancy. Generally, replication is only used for small dimension tables.
Hash	Table data is distributed on all DNs in the cluster.	Fact tables containing a large amount of data	• The I/O resources of each node can be used during data read/write, greatly improving the read/write speed of a table. • Generally, a large table (containing over 1 million records) is defined as a hash table.
Polling (Round-robin)	Each row in the table is sent to each DN in turn. Data can be evenly distributed on each DN.	Fact tables that contain a large amount of data and cannot find a proper distribution column in hash mode	• Round-robin can avoid data skew, improving the space utilization of the cluster. • Round-robin does not support local DN optimization like a hash table does, and the query performance of Round-robin is usually lower than that of a hash table. • If a proper distribution column can be found for a large table, use the hash distribution mode with better performance. Otherwise, define the table as a round-robin table.

Selecting a Distribution Key

If the hash distribution mode is used, a distribution key must be specified for the user table. When a record is inserted, the system hashes it based on the distribution key and then stores it on the corresponding DN.

Select a hash distribution key based on the following principles:

1. **The values 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 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 in some queries on the **dwcjk** table, you are not advised to use **zqdh** as the distribution key.
3. **With the above principles met, you can select join conditions as distribution keys**, so that join tasks can be pushed down to DNs for execution, reducing the amount of data transferred between the DNs.

   For a hash table, an inappropriate 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 statements 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.**
4. You are not advised to add a column as a distribution key, especially add a new column and use the SEQUENCE value to fill the column. (Sequences may cause performance bottlenecks and unnecessary maintenance costs.)

View the data in the table.

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


Deleting Data in a Table

You can delete outdated data from a table 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 column, 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.

- For example, to delete all the rows whose **c_customer_sk** column is **3869** from table **customer_t1**, run the following statement:
  ```
  DELETE FROM customer_t1 WHERE c_customer_sk = 3869;
  ```
- To delete all rows from the table, run either of the following statements:
  ```
  DELETE FROM customer_t1;
  TRUNCATE TABLE customer_t1;
  ```

  NOTE

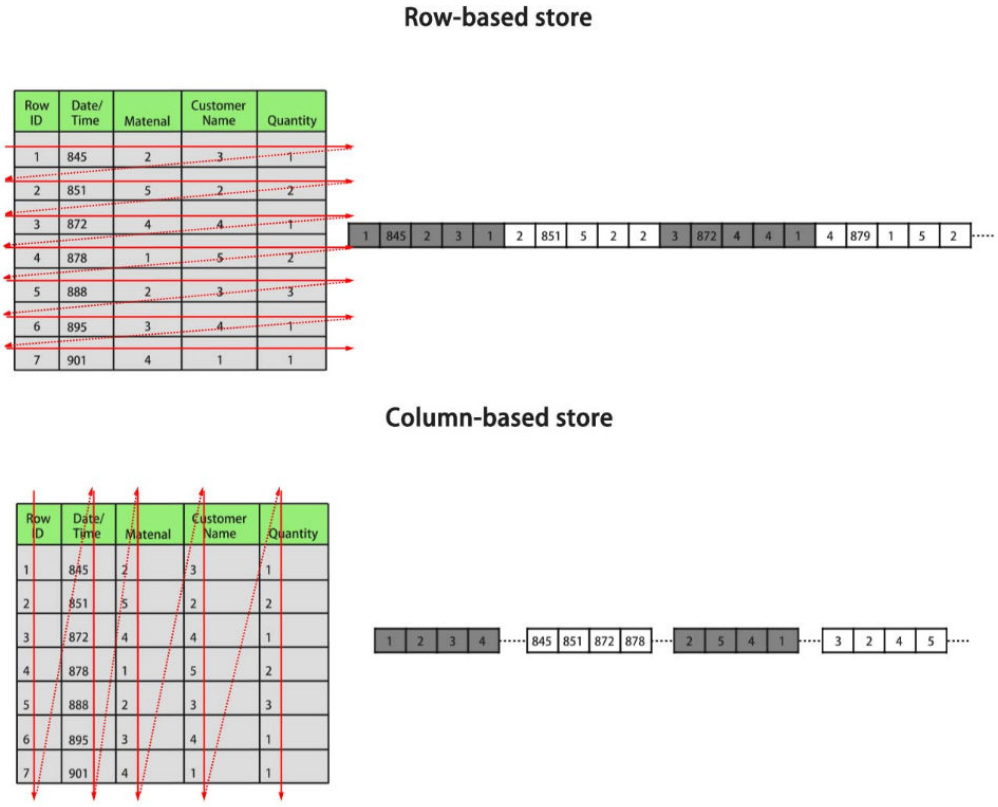
  If you need to delete an entire table, you are advised to use the **TRUNCATE** statement rather than **DELETE**. Using **TRUNCATE** to delete a large volume of data is much faster than using **DELETE**.
- Delete the created table.
  ```
  DROP TABLE customer_t1;
  ```

3.4 Selecting a Table Storage Mode

GaussDB(DWS) supports hybrid row and column storage. When creating a table, you can set the table storage mode to row storage or column storage.

Row storage stores tables to disk partitions by row, and column storage stores tables to disk partitions by column. By default, a table is created in row storage mode. For details about differences between row storage and column storage, see **Figure 3-1**.

Figure 3-1 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.

The row/column storage of a table is specified by the **orientation** attribute in the table definition. The value **row** indicates a row-store table and **column** indicates a column-store table. The default value is **row**. Each storage mode applies to specific scenarios. Select an appropriate mode when creating a table.

Table 3-2 Table storage modes and scenarios

Storage Mode	Benefit	Drawback	Application Scenarios
Row storage	Data is stored by row. When you query a row of data, you can quickly locate the target row.	All data in the queried row is read while only a few columns are needed.	1. The number of columns in the table is small, and most fields in the table are queried. 2. Point queries (simple index–based query that returns only a few records) are performed. 3. Add, Delete, Modify, and Query operations on entire rows are frequently performed.
Column storage	1. Only necessary columns in a query are read. 2. The homogeneity of data within a column facilitates efficient compression.	It is not suitable for INSERT or UPDATE operations on a small amount of data.	1. Query a few columns in a table that contains a large number of columns. 2. Statistical analysis queries (requiring a large number of association and grouping operations) 3. Ad hoc queries (using uncertain query conditions and unable to utilize indexes to scan row-store tables)

Creating a Row-store Table

For example, to create a row-store table named **customer_t1**, run the following command:

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

Creating a column-store table.

For example, to create a column-store table named **customer_t2**, run the following command:

```
CREATE TABLE customer_t2
(
  state_ID    CHAR(2),
```



```
  state_NAME VARCHAR2(40),
  area_ID    NUMBER
)
WITH (ORIENTATION = COLUMN);
```

Table Compression

Table compression can be enabled when a table is created. Table compression enables data in the table to be stored in compressed format to reduce memory usage.

In scenarios where I/O is large (much data is read and written) and CPU is sufficient (little data is computed), select a high compression ratio. In scenarios where I/O is small and CPU is insufficient, select a low compression ratio. Based on this principle, you are advised to select different compression ratios and test and compare the results to select the optimal compression ratio as required. Specify a compressions ratio using the **COMPRESSION** parameter. The supported values are as follows:

- The valid value of column-store tables is **YES**, **NO**, **LOW**, **MIDDLE**, or **HIGH**, and the default value is **LOW**.
- The valid values of row-store tables are **YES** and **NO**, and the default is **NO**. (The row-store table compression function is not put into commercial use. To use this function, contact technical support.)

The service scenarios applicable to each compression level are described in the following table.

Compression Level	Application Scenario
LOW	The system CPU usage is high and the disk storage space is sufficient.
MIDDLE	The system CPU usage is moderate and the disk storage space is insufficient.
HIGH	The system CPU usage is low and the disk storage space is insufficient.

For example, to create a compressed column-store table named **customer_t3**, run the following command:

```
CREATE TABLE customer_t3
(
  state_ID   CHAR(2),
  state_NAME VARCHAR2(40),
  area_ID    NUMBER
)
WITH (ORIENTATION = COLUMN,COMPRESSION=middle);
```

3.5 Defining Table Partitions

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

partition cable, and a physical piece is called a partition. Data is stored on these smaller physical pieces, namely, partitions, instead of the larger logical partitioned table. During conditional query, the system scans only the partitions that meet the conditions rather than scanning the entire table improving query performance.

Advantages of partitioned tables:

- Improved query performance. You can search in specific partitions, improving the search efficiency.
- Enhanced availability. If a partition is faulty, data in other partitions is still available.
- Improved maintainability. For expired historical data that needs to be periodically deleted, you can quickly delete it by dropping or truncate partitions.

Supported Table Partition Types

- Range partitioning: partitions are created based on a numeric range, for example, by date or price range.
- List partitioning: partitions are created based on a list of values, such as sales scope or product attribute. Only clusters of 8.1.3 and later versions support this function.

Choosing to Partition a Table

You can choose to partition a table when the table has the following characteristics:

- There are obvious ranges among the fields of the table.

  A table is partitioned based on obvious rangeable fields. Generally, columns such as date, area, and value are used for partitioning. The time column is most commonly used.
- Queries to the table have obvious range characteristics.

  If the queried data fall into specific ranges, its better tables are partitioned so that through partition pruning, only the queried partition needs to be scanned, improving data scanning efficiency and reducing the I/O overhead of data scanning.
- The table contains a large amount of data.

  Scanning small tables does not take much time, therefore the performance benefits of partitioning are not significant. Therefore, you are advised to partition only large tables. In column-store table, each column is an independent file storage unit, and the minimum storage unit CU can store 60,000 rows of data. Therefore, for column-store partitioned tables, it is recommended that the data volume in each partition be greater than or equal to the number of DNs multiplied by 60,000.

Creating a Range Partitioned Table

Example: Create a table **web_returns_p1** partitioned by the range **wr_returned_date_sk**.

```
CREATE TABLE web_returns_p1
(
```



```
    wr_returned_date_sk       integer,
    wr_returned_time_sk       integer,
    wr_item_sk                integer NOT NULL,
    wr_refunded_customer_sk   integer
)
WITH (orientation = column)
DISTRIBUTE BY HASH (wr_item_sk)
PARTITION BY RANGE (wr_returned_date_sk)
(
    PARTITION p2016 VALUES LESS THAN(20161231),
    PARTITION p2017 VALUES LESS THAN(20171231),
    PARTITION p2018 VALUES LESS THAN(20181231),
    PARTITION p2019 VALUES LESS THAN(20191231),
    PARTITION pxxxx VALUES LESS THAN(maxvalue)
);
```

Create partitions in batches, with fixed partition ranges. The following example can be used:

```
CREATE TABLE web_returns_p2
(
    wr_returned_date_sk       integer,
    wr_returned_time_sk       integer,
    wr_item_sk                integer NOT NULL,
    wr_refunded_customer_sk   integer
)
WITH (orientation = column)
DISTRIBUTE BY HASH (wr_item_sk)
PARTITION BY RANGE(wr_returned_date_sk)
(
    PARTITION p2016 START(20161231) END(20191231) EVERY(10000),
    PARTITION p0 END(maxvalue)
);
```

Creating a List Partitioned Table

A list partitioned table can use any column that allows value comparison as the partition key column. When creating a list partitioned table, you must declare the value partition for each partition.

Example: Create a list partitioned table **sales_info**.

```
CREATE TABLE sales_info
(
sale_time  timestamptz,
period     int,
city       text,
price      numeric(10,2),
remark     varchar2(100)
)
DISTRIBUTE BY HASH(sale_time)
PARTITION BY LIST (period, city)
(
PARTITION province1_202201 VALUES (('202201', 'city1'), ('202201', 'city2')),
PARTITION province2_202201 VALUES (('202201', 'city3'), ('202201', 'city4'), ('202201', 'city5')),
PARTITION rest VALUES (DEFAULT)
);
```

Partitioning an Existing Table

A table can be partitioned only when it is created. If you want to partition a table, you must create a partitioned table, load the data in the original table to the partitioned table, delete the original table, and rename the partitioned table as the name of the original table. You must also re-grant permissions on the table to users. For example:


```
CREATE TABLE web_returns_p2
(
    wr_returned_date_sk       integer,
    wr_returned_time_sk       integer,
    wr_item_sk                integer NOT NULL,
    wr_refunded_customer_sk   integer
)
WITH (orientation = column)
DISTRIBUTE BY HASH (wr_item_sk)
PARTITION BY RANGE(wr_returned_date_sk)
(
    PARTITION p2016 START(20161231) END(20191231) EVERY(10000),
    PARTITION p0 END(maxvalue)
);
INSERT INTO web_returns_p2 SELECT * FROM web_returns_p1;
DROP TABLE web_returns_p1;
ALTER TABLE web_returns_p2 RENAME TO web_returns_p1;
GRANT ALL PRIVILEGES ON web_returns_p1 TO dbadmin;
GRANT SELECT ON web_returns_p1 TO jack;
```

Adding a Partition

Run the **ALTER TABLE** statement to add a partition to a partitioned table. For example, to add partition **P2020** to the **web_returns_p1** table, run the following command:

```
ALTER TABLE web_returns_p1 ADD PARTITION P2020 VALUES LESS THAN (20201231);
```

Splitting a Partition

The syntax for splitting a partition varies between a range partitioned table and a list partitioned table.

- Run the **ALTER TABLE** statement to split a partition in a range partitioned table. For example, the partition **pxxxx** of the table **web_returns_p1** is split into two partitions **p2020** and **p20xx** at the splitting point **20201231**.
  ```
  ALTER TABLE web_returns_p1 SPLIT PARTITION pxxxx AT(20201231) INTO (PARTITION p2020,PARTITION p20xx);
  ```
- Run the **ALTER TABLE** statement to split a partition in a list partitioned table. For example, split the partition **province2_202201** of table **sales_inf** into two partitions **province3_202201** and **province4_202201**.
  ```
  ALTER TABLE sales_info SPLIT PARTITION province2_202201 VALUES(('202201', 'city5')) INTO (PARTITION province3_202201,PARTITION province4_202201);
  ```

Merging Partitions

Run the **ALTER TABLE** statement to merge two partitions in a partitioned table. For example, merge partitions **p2016** and **p2017** of table **web_returns_p1** into one partition **p20162017**.

```
ALTER TABLE web_returns_p1 MERGE PARTITIONS p2016,p2017 INTO PARTITION p20162017;
```

Deleting a Partition

Run the **ALTER TABLE** statement to delete a partition from a partitioned table. For example, run the following command to delete partition **P2020** from the **web_returns_p1** table:

```
ALTER TABLE web_returns_p1 DROP PARTITION P2020;
```


Querying a Partition

- Query partition **p2019**.
  ```
  SELECT * FROM web_returns_p1 PARTITION (p2019);
  SELECT * FROM web_returns_p1 PARTITION FOR (20201231);
  ```
- View partitioned tables using the system catalog **dba_tab_partitions**.
  ```
  SELECT * FROM dba_tab_partitions where table_name='web_returns_p1';
  ```

Deleting a Partitioned Table

Run the **DROP TABLE** statement to delete a partitioned table.

```
DROP TABLE web_returns_p1;
```

3.6 Creating and Managing Indexes

Indexes accelerate the data access speed but also add the processing time of the insert, update, and delete operations. Therefore, before creating an index, consider whether it is necessary and determine the columns where indexes will 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 sorted.

Index type

- **btree**: The B-tree index uses a structure that is similar to the B+ tree structure to store data key values, facilitating index search. **btree** supports comparison queries with ranges 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-based tables support the following index types: **btree** (default), **gin**, and **gist**. Column-based tables support the following index types: **Psort** (default), **btree**, and **gin**.

NOTE

Create a B-tree index for point queries.

Index Selection Principles

Indexes are created based on columns in database tables. When creating indexes, you need to determine the columns, which can be:

- Columns that are frequently searched: The search efficiency can be improved.
- The uniqueness of the columns and the data sequence structures is ensured.
- Columns that usually function as foreign keys and are used for connections. Then the connection efficiency is improved.
- Columns that are usually searched for by a specified scope. These indexes have already been arranged in a sequence, and the specified scope is contiguous.

- Columns that need to be arranged in a sequence. These indexes have already been arranged in a sequence, so the sequence query time is accelerated.
- Columns that usually use the WHERE clause. Then the condition decision efficiency is increased.
- Fields that are frequently used after keywords, such as **ORDER BY**, **GROUP BY**, and **DISTINCT**.

  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. Therefore, data operations increase. Therefore, delete unnecessary indexes periodically.

Creating an Index

GaussDB(DWS) supports four methods for creating indexes. For details, see **Table 3-3**.

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. Therefore, data operations increase. Therefore, delete unnecessary indexes periodically.

Table 3-3 Indexing Method

Indexing Method	Description
Unique index	Refers to an index that constrains the uniqueness of an index attribute or an attribute group. If a table declares unique constraints or primary keys, GaussDB(DWS) automatically creates unique indexes (or composite indexes) for columns that form the primary keys or unique constraints. Currently, only B-tree can create a unique index in GaussDB(DWS).
Composite index	Refers to an index that can be defined for multiple attributes of a table. Currently, composite indexes can be created only for B-tree in GaussDB(DWS) and a maximum of 32 columns can share a composite index.
Partial index	Refers to an index that can be created for subsets of a table. This indexing method contains only tuples that meet condition expressions.
Expression index	Refers to an index that is built on a function or an 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.

- Run the following command to create an ordinary table:
  ```
  CREATE TABLE tpcds.customer_address_bak AS TABLE tpcds.customer_address;
  ```
- Create a common index.

  You need to query the following information in the **tpcds.customer_address_bak** table:
  ```
  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 delete operation performance in the database.

  Run the following command to create an index:
  ```
  CREATE INDEX index_wr_returned_date_sk ON tpcds.customer_address_bak (ca_address_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 command:
  ```
  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 multiple-column index on **ca_address_sk** and **ca_street_number** columns:
  ```
  CREATE INDEX more_column_index ON
  tpcds.customer_address_bak(ca_address_sk ,ca_street_number );
  ```
- Create a partition index.

  If you only want to find records whose **ca_address_sk** is **5050**, you can create a partial index to facilitate your query.
  ```
  CREATE INDEX part_index ON tpcds.customer_address_bak(ca_address_sk) WHERE ca_address_sk = 5050;
  ```
- Create an expression index.

  Assume you need to frequently query records with **ca_street_number** smaller than **1000**, run the following command:
  ```
  SELECT * FROM tpcds.customer_address_bak WHERE trunc(ca_street_number) < 1000;
  ```

  The following expression index can be created for this query task:
  ```
  CREATE INDEX para_index ON tpcds.customer_address_bak (trunc(ca_street_number));
  ```

Querying an Index

- Run the following command to query all indexes defined by the system and users:
  ```
  SELECT RELNAME FROM PG_CLASS WHERE RELKIND='i';
  ```
- Run the following command to query information about a specified index:
  ```
  \di+ index_wr_returned_date_sk
  ```


Recreating an Index

- Recreate the index **index_wr_returned_date_sk**.
  ```
  REINDEX INDEX index_wr_returned_date_sk;
  ```
- Recreate all indexes of a table.
  ```
  REINDEX TABLE tpcds.customer_address_bak;
  ```

Deleting an Index

You can use the **DROP INDEX** statement to delete indexes.

```
DROP INDEX index_wr_returned_date_sk;
```

3.7 Creating and Using Sequences

A sequence is a database object that generates unique integers according to a certain rule and is usually used to generate primary key values.

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.
- Use **CREATE SEQUENCE** to create a new sequenc. Use the **nextval('***sequence_name***')** function to increment the sequence and return a new value. Specify the default value of the column as the sequence value returned by the **nextval(**'sequence_name'**)** function. In this way, this column can be used as a unique identifier.

Creating a Sequence.

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

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

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.
   ```
   CREATE SEQUENCE seq1 cache 100;
   ```
2. Set the initial value of the **nextval**('*sequence_name*') function to the default value of a column.
   ```
   CREATE TABLE T2
   (
     id   int not null default nextval('seq1'),
     name text
   );
   ```


> **NOTE**
>
> Methods 1 and 2 are similar except that method 2 specifies cache for the sequence. A sequence using cache has holes (non-consecutive values, for example, 1, 4, 5) and cannot keep the order of the values. After a sequence is deleted, its sub-sequences will be deleted automatically. A sequence shared by multiple columns is not forbidden in a database, but you are not advised to do that.
>
> Currently, the preceding two methods cannot be used for existing tables.

Modifying a Sequence

The **ALTER SEQUENCE** statement changes the attributes of an existing sequence, including the owner, owning column, and maximum value.

- Associate the sequence with a column.

  The sequence will be deleted when you delete the column or the table where the column resides.

  ```
  ALTER SEQUENCE seq1 OWNED BY T2.id;
  ```

- Modify the maximum value of **serial** to **300**.

  ```
  ALTER SEQUENCE seq1 MAXVALUE 300;
  ```

Deleting a Sequence

Run the **DROP SEQUENCE** command to delete a sequence. For example, to delete the sequence named **seq1**, run the following command:

```
DROP SEQUENCE seq1;
```

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. As GTM is a globally unique node, generating default sequence numbers can cause performance issues. For operations that need frequent sequence number generation, such as bulkload data import, this is not recommended. For example, the **INSERT FROM SELECT** statement has poor performance in the following scenario:

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

To improve the performance, run the following statements (assume that data of 10,000 rows will be imported from *T1* to *newT1*):

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


NOTE

Rollback is not supported by sequence functions, including **nextval()** and **setval()**. The value of the setval function immediately takes effects on nextval in the current session in any cases and takes effects 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.

If BulkLoad is used, set sufficient cache for *newSeq1* and do not set **Maxvalue** or **Minvalue**. To improve the performance, database may push down the invocation of **nextval**('*sequence_name*') to DNs. Currently, the concurrent connection requests that can be processed by the GTM 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 concurrent connection of BulkLoad to save the GTM connection resources. If the target table is a replication table (**DISTRIBUTE BY REPLICATION**), pushdown cannot be performed. If the data volume is large, this will be a disaster for the database. In addition, the database space may be exhausted. After the import is complete, do **VACUUM FULL**. Therefore, you are not advised to use sequences when BulkLoad is used.

After a sequence is created, a 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**.

3.8 Creating and Managing Views

Views allow users to save queries. Views are not physically stored on disks. Queries to a view run as subqueries. A database only stores the definition of a view and does not store its data. The data is still stored in the original 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.

Creating a view

Run the **CREATE VIEW** command to create a view.

```
CREATE OR REPLACE VIEW MyView AS SELECT * FROM tpcds.customer WHERE c_customer_sk < 150;
```

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.

View Details

- View the *MyView* view. Real-time data will be returned.

  ```
  SELECT * FROM myview;
  ```

- Run the following command to query the views in the current user:

  ```
  SELECT * FROM user_views;
  ```

- Run the following command to query all views:

  ```
  SELECT * FROM dba_views;
  ```


- View details about a specified view.

  Run the following command to view details about the dba_users view:

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

Rebuilding a View

Run the **ALTER VIEW** command to rebuild a view without entering query statements.

```
ALTER VIEW myview REBUILD;
```

Deleting a View

Run the **DROP VIEW** command to delete a view.

```
DROP VIEW myview;
```

DROP VIEW ... The **CASCADE** command can be used to delete objects that depend on the view. For example, view A depends on view B. If view B is deleted, view A will also be deleted. Without the CASCADE option, the **DROP VIEW** command will fail.

3.9 Creating and Managing Scheduled Tasks

GaussDB(DWS) allows users to create scheduled tasks, which are automatically executed at specified time points, reducing O&M workload.

Database complies with the Oracle scheduled task function using the DBMS.JOB interface, which can be used to create scheduled tasks, execute tasks automatically, delete a task, and modify task attributes(including task ID, enable/disable a task, the task triggering time/interval and task contents).

NOTE

- The hybrid data warehouse (standalone) does not support scheduled tasks.
- The execution statements of scheduled tasks are not recorded in the **Real-time Top SQL** logs. The statements can be recorded only in versions later than 8.2.1.
- By default, GaussDB(DWS) uses the UTC time. The execution time of the scheduled task needs to be converted to the time zone of the user.

Periodic Task Management

Step 1 Creates a test table.

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

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

```
CREATE TABLE
```

Step 2 Create the customized storage procedure.

```
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 task.

- Create a task with unspecified **job_id** and execute the **PRC_JOB_1** storage procedure every two minutes.

```
call dbms_job.submit('call public.prc_job_1(); ', sysdate, 'interval ''1 minute'''', :a);
job
-----
1
(1 row)
```

- Create task with specified job_id.

```
call dbms_job.isubmit(2,'call public.prc_job_1(); ', sysdate, 'interval ''1 minute''');
isubmit
---------


(1 row)
```

Step 4 View the created task information about the current user in the **USER_JOBS** view.

Only the system administrator can access this system view. For details about the fields, see **Table 15-293**.

```
postgresselect job,dbname,start_date,last_date,this_date,next_date,broken,status,interval,failures,what from
user_jobs;
 job |  dbname  |         start_date         |         last_date          |         this_date          |      next_date      |
broken | status |      interval       | failures |           what

-----+----------+----------------------------+----------------------------+----------------------------
+---------------------+--------+--------+---------------------+----------+----------------
-----------
   1 | db_demo | 2022-03-25 07:58:01.829436 | 2022-03-25 07:58:03.174817 | 2022-03-25 07:58:01.829436 |
2022-03-25 07:59:01 | n      | s      | interval '1 minute' |        0 | call public.prc
_job_1();
   2 | db_demo | 2022-03-25 07:58:15.893383 | 2022-03-25 07:58:16.608959 | 2022-03-25 07:58:15.893383 |
2022-03-25 07:59:15 | n      | s      | interval '1 minute' |        0 | call public.prc
_job_1();
(2 rows)
```

Step 5 Stop a task.

```
call dbms_job.broken(1,true);
broken
--------


(1 row)
```

Step 6 Start a task.

```
call dbms_job.broken(1,false);
broken
--------


(1 row)
```

Step 7 Modify attributes of a task.

- Modify the **Next_date** parameter information about a task. For example, change the value of **Next_date** of Job1 to 1 hour.


```
call dbms_job.next_date(1, sysdate+1.0/24);
next_date
-----------

(1 row)
```

- Modify the **Interval** parameter information of a task. For example, change the value of **Interval** of Job1 to 1 hour.

```
call dbms_job.interval(1,'sysdate + 1.0/24');
interval
----------

(1 row)
```

- Modify the **What** parameter information of a **JOB**. For example, change **What** of **Job1** to **insert into public.test values(333, sysdate+5)**.

```
call dbms_job.what(1,'insert into public.test values(333, sysdate+5);');
what
------

(1 row)
```

- Modify **Next_date**, **Interval**, and **What** parameter information of **JOB**.

```
call dbms_job.change(1, 'call public.prc_job_1();', sysdate, 'interval ''1 minute''');
change
--------

(1 row)
```

Step 8 Delete a job.

```
call dbms_job.remove(1);
remove
--------

(1 row)
```

Step 9 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 view, respectively.
- If the current user is a DBA user, system administrator, or the user who created the job (**log_user** in **pg_job**), the user has the permissions to delete or modify parameter settings of the job using the remove, change, next_data, what, or interval interface. Otherwise, the system displays a message indicating that the current user has no permission to perform operations on the 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 remove, change, next_data, what, or interval interface.
- When deleting the database that created a job, (that is, **dbname** in **pg_job**), the system associatively deletes the job records of the database.
- When deleting the user who created a job, (that is, **log_user** in **pg_job**), the system associatively deletes the job records of the user.

----End

3.10 Viewing a System Catalog

In addition to the created tables, a database contains many system catalogs These system catalogs contain cluster installation information and information about

various queries and processes in GaussDB(DWS). You can collect information about the database by querying the system catalog.

Querying Database Tables

For example, 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)
```

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 | spillspacelim
it
---------+----------+-------------+----------+-----------+---------+----------+----------+----------+-------------
+--------+------------+-----------+-----------+----------------+--------------
---
 Ruby    |       10 | t          | t        | t         | t       | ******** |          |          | default_pool |      0 |
|          |          |            |
 dbadmin |    16393 | f          | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |          |            |
 lily    |    16691 | f          | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |          |            |
 jack    |    70694 | f          | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |          |            |
(4 rows)
```

GaussDB(DWS) uses Ruby to perform routine management and maintenance. You can add **WHERE usesysid > 10** to the **SELECT** statement to filter queries so that only specified user names are displayed.

```
SELECT * FROM pg_user WHERE usesysid > 10;
 usename | usesysid | usecreatedb | usesuper | usecatupd | userepl |  passwd  | valbegin | valuntil |
respool    | parent | spacelimit | useconfig | nodegroup | tempspacelimit | spillspacelim
it
---------+----------+-------------+----------+-----------+---------+----------+----------+----------+-------------
+--------+------------+-----------+-----------+----------------+--------------
---
 dbadmin |    16393 | f          | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |          |            |
 lily    |    16691 | f          | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |          |            |
 jack    |    70694 | f          | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |          |            |
(3 rows)
```


Viewing and Stopping the Running Query Statements

You can view the running query statements in the **PG_STAT_ACTIVITY** view. Do as follows:

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, query statuses, and PIDs of the running query statements:

```
SELECT datname, usename, state,pid FROM pg_stat_activity;
```

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 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.

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

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
```

NOTE

If the **PG_TERMINATE_BACKEND** function is used to terminate the backend threads of the current session, the gsql client will be reconnected automatically rather than be logged out. The message "The connection to the server was lost." is returned. Attempting reset: Succeeded."

```
FATAL: terminating connection due to administrator command
FATAL: terminating connection due to administrator command
The connection to the server was lost. Attempting reset: Succeeded.
```

----End

4 Development and Design Proposal

4.1 Development and Design Proposal

This chapter describes the design specifications for database modeling and application development. Modeling compliant with these specifications fits the distributed processing architecture of GaussDB(DWS) 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.

4.2 Database Object Naming Conventions

The name of a database object must contain 1 to 63 characters, 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

You can run **SELECT * FROM pg_get_keywords()** to query GaussDB(DWS) keywords or view the keywords in section "Keywords" in *SQL Syntax Reference*.

- [Proposal] Do not use strings enclosed in double quotation marks to define database object names. In GaussDB(DWS), double quotation marks are used to specify that the enclosed database object names are case sensitive. 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.
  - A database object name consists of letters, digits, and underscores (_); and cannot start with a digit. You are advised to use multiple words separated with hyphens (-).
  - 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 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 data set.
  - 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*.

4.3 Database Object Design

4.3.1 Database and Schema Design

In GaussDB(DWS), 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 Suggestions

- Create databases as required. Do not use the default **gaussdb** database of a cluster.

- Create a maximum of three user-defined databases in a cluster.
- To make your database encoding compatible with most characters, you are advised to use the UTF-8 encoding when creating a database.
- Exercise caution when you set **ENCODING** and **DBCOMPATIBILITY** configuration items during database creation. In GaussDB(DWS), **DBCOMPATIBILITY** can be set to **TD**, **Oracle**, or **MySQL** to be compatible with Teradata, Oracle, or MySQL syntax, respectively. Syntax behavior may vary with the three modes. For details, see **Syntax Compatibility Differences Among Oracle, Teradata, and MySQL**.
- 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 Suggestions

- To let a user access an object in a schema, grant the **usage** permission and the permissions for the object to the user, unless the user has the **sysadmin** permission or is the schema owner.
- To let a user create an object in the schema, grant the **CREATE** permission for the schema to the user.
- 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.

4.3.2 Table Design

GaussDB(DWS) uses a distributed architecture. Data is distributed on DNs. Comply with the following principles to properly design a table:

- [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 column 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 Mode

[Proposal] Selecting a storage mode is the first step in defining a table. The storage mode mainly depends on the user's service type. For details, see **Table 4-1**.

Table 4-1 Table storage modes and scenarios

Storage Mode	Application Scenarios
Row storage	• Point queries (simple index-based queries that only return a few records) • Scenarios requiring frequent addition, deletion, and modification
Column storage	• Statistical analysis queries (requiring a large number of association and grouping operations) • 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 4-2 Table distribution modes and scenarios

Distribution Mode	Description	Application Scenarios
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 a cluster.	Dimension tables and fact tables containing a small amount of data
Round-robin	Each row of the table is sent to each DN in turn. Therefore, data is evenly distributed on each DN.	Fact tables that contain a large amount of data and cannot find a proper distribution column in hash mode

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:

```
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)
);
```

Selecting a Distribution Key

Selecting a distribution key is important for a hash 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. After you select a distribution policy for a hash table, check for 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 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.

4.3.3 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(DWS).

Table 4-3 Common string types

Parameter	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

Parameter	Description	Max. Storage Capacity
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
TEXT	Variable-length string. Its maximum length is 8203 bytes less than 1 GB.	8203 bytes less than 1 GB

4.3.4 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, because doing so will generate unexpected results 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 Key

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(DWS). 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 least distinct values.

Unique Constraint

- [Notice] Both row-store and column-store tables support unique constraints.
- [Proposal] The constraint name should indicate that it is a unique constraint, for example, **UNI***Included columns*.

Primary Key Constraint

- [Notice] Both row-store and column-store tables support the primary key constraint.
- [Proposal] The constraint name should indicate that it is a primary key constraint, for example, **PK***Included columns*.

Check Constraint

- [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*.

4.3.5 View and Joined Table Design

View Design

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

Joined Table Design

- [Proposal] Minimize joined columns across tables.
- [Proposal] Joined columns should use the same data type.
- [Proposal] The names of associated fields should show the associations. For example, they can use the same name.

4.4 JDBC Configuration

Currently, third-party tools are connected to GaussDB(DWS) trough JDBC. This section describes the precautions for configuring the tools.

Connection Parameters

- [Notice] When a third-party tool connects to GaussDB(DWS) through JDBC, JDBC sends a connection request to GaussDB(DWS). 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", "2" },
{ "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 connecting to the database through JDBC, ensure that the following two time zones are the same:
  - Time zone of the host where the JDBC client is located
  - Time zone of the host where the GaussDB(DWS) server is located

fetchsize

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

autocommit

[Proposal] It is recommended that you enable the **autocommit** switch in the code for connecting to GaussDB(DWS) 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

[Proposal] 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.

[Proposal] After an application completes its tasks, disconnect its connection to GaussDB(DWS) to release occupied resources. You are advised to set the session timeout interval in the task.

[Proposal] 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, before you return the connection to the connection pool, run **SET SESSION AUTHORIZATION DEFAULT;RESET ALL;** to clear the connection status.
- If a temporary table is used, delete it before you return the connection to the connection pool.

CopyManager

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

For details about how to use CopyManager, see **CopyManager**.

4.5 SQL Compilation

DDL

- [Proposal] In GaussDB(DWS), 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(DWS) cannot ensure the security of unlogged tables in abnormal scenarios.
- [Proposal] Suggestions on the storage mode of temporary and unlogged tables are the same as those on base tables. Create temporary tables in the same storage mode 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. 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] Perform type coercion to convert data types. 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] In Oracle compatibility mode, null strings will be automatically converted to NULL during data import. If a null string needs to be reserved, you need to create a database that is compatible with Teradata.

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

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 *****. 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] Do not use 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 with 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.
- [Notice] When constants are used to filter data, the system searches for functions used for calculating these two data types based on the data types of the constants and matched columns. If no function is found, the system converts the data type implicitly. Then, the system searches for a function used for calculating the converted data type.

  ```
  SELECT * FROM test WHERE timestamp_col = 20000101;
  ```

  In the preceding example, if **timestamp_col** is the timestamp type, the system first searches for the function that supports the "equal" operation of the timestamp and int types (constant numbers are considered as the int type). If no such function is found, the **timestamp_col** data and constant numbers are implicitly converted into the text type for calculation.
- [Proposal] Do not use scalar subquery statements. A scalar subquery appears in the output list of a **SELECT** statement. In the following example, the part enclosed in parentheses 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 sorted. 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, when the column name is placed on one side of a comparison operator, 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 sorting operations. Sorting 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(DWS) is sorted by ASC & NULL LAST.
- [Proposal] When the **ORDER BY** clause is used for sorting, specify sorting 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. Example:

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

- [Proposal] If an **in(val1, val2, va...)** expression contains a large number of columns, you are advised to replace it with the **in (values (va1), (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 T1,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 T1.C1 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 it and commit transaction once the query is finished.

4.6 User-defined External Function Usage (pgSQL/Java)

- [Notice] Java UDFs can perform some Java logic calculation. Do not encapsulate services in Java UDFs.
- [Notice] Do not connect to a database in any way (for example, by using JDBC) in Java functions.
- [Notice] Only the data types listed in the following table can be used. User-defined types and complex data types (Java Array and derived classes) are not supported.
- [Notice] User-defined aggregation functions (UDAFs) and user-defined table-generating functions (UDTFs) are not supported.

Table 4-4 PL/Java mapping for default data types

GaussDB(DWS)	Java
BOOLEAN	boolean
"char"	byte
bytea	byte[]
SMALLINT	short
INTEGER	int
BIGINT	long
FLOAT4	float
FLOAT8	double
CHAR	java.lang.String
VARCHAR	java.lang.String
TEXT	java.lang.String
name	java.lang.String
DATE	java.sql.Timestamp

GaussDB(DWS)	Java
TIME	java.sql.Time (stored value treated as local time)
TIMETZ	java.sql.Time
TIMESTAMP	java.sql.Timestamp
TIMESTAMPTZ	java.sql.Timestamp

4.7 PL/pgSQL Usage

General Principles

1. Development shall strictly comply with design documents.
2. Program modules shall be highly cohesive and loosely coupled.
3. Proper, comprehensive troubleshooting measures shall be developed.
4. Code shall be reasonable and clear.
5. Program names shall comply with a unified naming rule.
6. Fully consider the program efficiency, including the program execution efficiency and database query and storage efficiency. Use efficient and effective processing methods.
7. Program comments shall be detailed, correct, and standard.
8. The commit or rollback operation shall be performed at the end of a stored procedure, unless otherwise required by applications.
9. Programs shall support 24/7 processing. In the case of an interruption, the applications shall provide secure, easy-to-use resuming features.
10. Application output shall be standard and simple. The output shall show the progress, error description, and execution results for application maintenance personnel, and provide clear and intuitive reports and documents for business personnel.

Programming Principles

1. Use bound variables in SQL statements in the PL/pgSQL.
2. **RETURNING** is recommended for SQL statements in PL/pgSQL.
3. Principles for using stored procedures:
   a. Do not use more than 50 output parameters of the Varchar or Varchar2 type in a stored procedure.
   b. Do not use the LONG type for input or output parameters.
   c. Use the CLOB type for output strings that exceed 10 MB.
4. Variable declaration principles:
   a. Use **%TYPE** to declare a variable that has the same meaning as that of a column or variable in an application table.

   b. Use **%ROWTYPE** to declare a record that has the same meaning as that of a row in an application table.
   c. Each line of a variable declaration shall contain only one statement.
   d. Do not declare variables of the LONG type.
5. Principles for using cursors:
   a. Explicit cursors shall be closed after being used.
   b. A cursor variable shall be closed after being used. If the cursor variable needs to transfer data to an invoked application, the cursor shall be closed in the application. If the cursor variable is used only in a stored procedure, the cursor shall be closed explicitly.
   c. Before using **DBMS_SQL.CLOSE_CURSOR** to close a cursor, use **DBMS_SQL.IS_OPEN** to check whether the cursor is open.
6. Principles for collections:
   a. You are advised to use the **FOR ALL** statement instead of the **FOR** loop statement to reference elements in a collection.
7. Principles for using dynamic statements:
   a. Dynamic SQL shall not be used in the transaction programs of online systems.
   b. Dynamic SQL statements can be used to implement DDL statements and system control commands in PL/pgSQL.
   c. Variable binding is recommended.
8. Principles for assembling SQL statements:
   a. You are advised to use bound variables to assemble SQL statements.
   b. If the conditions for assembling SQL statements contain external input sources, the characters in the input conditions shall be checked to prevent attacks.
   c. In a PL/pgSQL script, the length of a single line of code cannot exceed 2499 characters.
9. Principles for using triggers:
   a. Triggers can be used to implement availability design in scenarios where differential data logs are irrelevant to service processing.
   b. Do not use triggers to implement service processing functions.

Exception Handling Principles

Any error that occurs in a PL/pgSQL function aborts the execution of the function and related transactions. You can use a **BEGIN** block with an **EXCEPTION** clause to catch and fix errors.

1. In a PL/pgSQL block, if an SQL statement cannot return a definite result, you are advised to handle exceptions (if any) in **EXCEPTION**. Otherwise, unhandled errors may be transferred to the external block and cause program logic errors.
2. You can directly use the exceptions that have been defined in the system. DWS does not support custom exceptions.
3. 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.

Writing Standard

1. Variable naming rules:
   a. The input parameter format of a procedure or function is **IN**_*Parameter_name*. The parameter name shall be in uppercase.
   b. The output parameter format of a procedure or function is **OUT**_*Parameter_name*. The parameter name shall be in uppercase.
   c. The input and output parameter format of a procedure or function is **IO**_*Parameter_name*. The parameter name shall be in uppercase.
   d. Variables used in procedures and functions shall be composed of **v**_*Variable_name*. The variable name shall be in lower case.
   e. In query concatenation, the concatenation variable name of the **WHERE** statement shall be **v_where**, and the concatenation variable name of the **SELECT** statement shall be **v_select**.
   f. The record type (TYPE) name shall consist of **T** and a variable name. The name shall be in uppercase.
   g. A cursor name shall consist of **CUR** and a variable name. The name shall be in uppercase.
   h. The name of a reference cursor (REF CURSOR) shall consist of **REF** and a variable name. The name shall be in uppercase.
2. Rules for defining variable types:
   a. Use **%TYPE** to declare the type of a variable that has the same meaning as that of a column in an application table.
   b. Use **%ROWTYPE** to declare the type of a record that has the same meaning as that of a row in an application table.
3. Rules for writing comments:
   a. Comments shall be meaningful and shall not just repeat the code content.
   b. Comments shall be concise and easy to understand.
   c. Comments shall be provided at the beginning of each stored procedure or function. The comments shall contain a brief function description, author, compilation date, program version number, and program change history. The format of the comments at the beginning of stored procedures shall be the same.
   d. Comments shall be provided next to the input and output parameters to describe the meaning of variables.
   e. Comments shall be provided at the beginning of each block or large branch to briefly describe the function of the block. If an algorithm is used, comments shall be provided to describe the purpose and result of the algorithm.
4. Variable declaration format:

   Each line shall contain only one statement. To assign initial values, write them in the same line.
5. Letter case:

   Use uppercase letters except for variable names.
6. Indentation:

In the statements used for creating a stored procedure, the keywords **CREATE**, **AS/IS**, **BEGIN**, and **END** at the same level shall have the same indent.

7. Statement rules:
   a. For statements that define variables, Each line shall contain only one statement.
   b. The keywords **IF**, **ELSE IF**, **ELSE**, and **END** at the same level shall have the same indent.
   c. The keywords **CASE** and **END** shall have the same indent. The keywords **WHEN** and **ELSE** shall be indented.
   d. The keywords **LOOP** and **END LOOP** at the same level shall have the same indent. Nested statements or statements at lower levels shall have more indent.

5 Database Security Management

5.1 Managing Users and Their Permissions

5.1.1 Database Users

Without separation of permissions, GaussDB(DWS) supports two types of database accounts: administrator and common user. For details about user types and permissions under separation of permissions, see **Separation of Permissions**.

- The administrator can manage all common users and databases.
- Common users can connect to and access the database, and perform specific database operations and execute SQL statements after being authorized.

Users are authenticated when they log in to the GaussDB(DWS) database. 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 to these databases.

Database User Types

Table 5-1 Database user types

User Type	Description	Allowed Operations	How to Create

Administrator **dbadmin**	An administrator, also called a system administrator, is an account with the **SYSADMIN** attribute.	If separation of permissions is not enabled, this account has the highest permission in the system and can perform all operations. The system administrator has the same permissions as the object owner.	• User **dbadmin** created during cluster creation on the GaussDB(DWS) management console is a system administrator.
			• Use the **CREATE USER** or **ALTER USER** syntax to create an administrator.
			`CREATE USER sysadmin WITH SYSADMIN password '{Password}';`
			`ALTER USER u1 SYSADMIN;`

Common user	Common user	• Use a tool to connect to the database. • Have the attributes of specific database system operations, such as **CREATEDB**, **CREATEROLE**, and **SYSADMIN**. • Access database objects. • Run SQL statements.	Run the **CREATE USER** syntax to create a common user. `CREATE USER u1 PASSWORD '{Password}';`
	Private user	A user created with the **INDEPENDENT** attribute in non-separation-of-permissions mode. Database administrators can manage (**DROP**, **ALTER**, and **TRUNCATE**) objects of private users but cannot access (**INSERT**, **DELETE**, **SELECT**, **UPDATE**, **COPY**, **GRANT**, **REVOKE**, and **ALTER OWNER**) the objects before being authorized.	Use the **CREATE USER** syntax to create a private user. `CREATE USER user_independent WITH INDEPENDENT IDENTIFIED BY '{Password}';`

5.1.2 User Management

You can use **CREATE USER** and **ALTER USER** to create and manage database users.

- In the non-**separation-of-permission** mode, a GaussDB(DWS) user account can be created and deleted only by a system administrator or a security administrator with the **CREATEROLE** attribute.
- In separation-of-permission mode, a user account can be created only by a security administrator.

Creating a User

The **CREATE USER** statement is used to create a GaussDB (DWS) user. After creating a user, you can use the user to connect to the database.

- Create common user **u1** and assign the **CREATEDB** attribute to the user.
  ```
  CREATE USER u1 WITH CREATEDB PASSWORD '{Password}';
  ```
- To create the system administrator **mydbadmin**, you need to specify the **SYSADMIN** parameter.
  ```
  CREATE USER mydbadmin sysadmin PASSWORD '{Password}';
  ```
- View the created user in the **PG_USER** view.
  ```
  SELECT * FROM pg_user;
  ```
- To view user attributes, query the system catalog **PG_AUTHID**.
  ```
  SELECT * FROM pg_authid;
  ```

Altering User Attributes

The **ALTER USER** statement is used to alter user attributes, such as changing user passwords or permissions.

Example:

- Rename user **u1** to **u2**.
  ```
  ALTER USER u1 RENAME TO u2;
  ```
- Grant the **CREATEROLE** permission to user **u1**:
  ```
  ALTER USER u1 CREATEROLE;
  ```
- For details about how to change the user password, see **Setting and Changing a Password**.

Locking a User

The **ACCOUNT LOCK** | **ACCOUNT UNLOCK** parameter in the statement is used to lock or unlock a user. A locked user cannot log in to the system. If an account is stolen or illegally accessed, the administrator can manually lock the account. After the account is secured, the administrator can manually unlock the account.

Example:

- To lock user **u1**, run the following command:
  ```
  ALTER USER u1 ACCOUNT LOCK;
  ```
- To unlock user **u1**, run the following command:
  ```
  ALTER USER u1 ACCOUNT UNLOCK;
  ```


Deleting a User

The **DROP USER** statement is used to delete one or more GaussDB(DWS) users. An administrator can delete an account that is no longer used. Deleted users cannot be restored.

- If multiple users are deleted at the same time, separate them with commas (,).
- After a user is deleted successfully, all the permissions of the user are also deleted.
- When an account to be deleted is in the active state, it is deleted after the session is disconnected.
- When **CASCADE** is specified in the **DROP USER** statement, objects such as tables that depend on the user will be deleted. That is, the objects whose owner is the user are deleted, and the authorizations of other objects to the user are also deleted.

Example:

- -- Delete user **u1**.
  ```
  DROP USER u1;
  ```
- Delete account **u2** in a cascading manner.
  ```
  DROP USER u2 CASCADE;
  ```

5.1.3 User-defined Password Policy

When creating or modifying a user, you need to specify a password. GaussDB(DWS) has default password complexity requirements. You can also define database account password policies.

Default GaussDB(DWS) Password Policy

By default, GaussDB(DWS) verifies the password complexity (that is, the GUC parameter **password_policy** is set to **1** by default). The default password policy requires that the password:

- Contain 8 to 32 characters.
- Contain at least three types of the following characters: uppercase letters, lowercase letters, digits, and special characters.
- Cannot be the same as the user name or the user name in reverse order, case insensitive.
- Cannot be the current password or the current password in reverse order.

User-defined Password Policy

The password policy includes the password complexity requirements, password validity period, password reuse settings, password encryption mode, and password retry and lock policies. Different policy items are controlled by the corresponding GUC parameters. For details, see **Security and Authentication (postgresql.conf)**.

Table 5-2 User-defined password policies and corresponding GUC parameters

Password Policy	Parameter	Description	Value Range	Default Value in GaussDB(DWS)
Password complexity check	password_policy	Specifies whether to check the password complexity when a GaussDB(DWS) account is created or modified.	Integer, **0** or **1** • **0** indicates that no password complexity policy is used. Setting this parameter to **0** leads to security risks. You are advised not to set this parameter to **0**. • **1** indicates that the default password complexity policy is used.	1
Password complexity requirement	password_min_length	Specifies the minimum password length.	An integer ranging from 6 to 999	8
	password_max_length	Specifies the maximum password length.	An integer ranging from 6 to 999	32
	password_min_uppercase	Minimum number of uppercase letters (A-Z)	An integer ranging from 0 to 999 • **0** means no requirements. • **1**-**999** indicates the minimum number of uppercase letters in the password.	0
	password_min_lowercase	Minimum number of lowercase letters (a-z)	An integer ranging from 0 to 999 • **0** means no requirements. • **1**-**999** indicates the minimum number of lower letters in the password.	0

Password Policy	Parameter	Description	Value Range	Default Value in GaussDB(DWS)
	password_min_digital	Minimum number of digits (0-9)	An integer ranging from 0 to 999 • **0** means no requirements. • **1**-**999** indicates the minimum number of digits in the password.	0
	password_min_special	Minimum number of special characters (**password_min_special**)	An integer ranging from 0 to 999 • **0** means no requirements. • **1**-**999** indicates the minimum number of special characters in the password.	0
Password validity	password_effect_time	Password validity period When the number of days in advance a user is notified that the password is about to expire reaches the value of **password_notify_time**, the system prompts the user to change the password when the user logs in to the database.	The value is a floating point number ranging from 0 to 999. The unit is day. • **0** indicates the validity period is disabled. • A floating point number from 1 to 999 indicates the validity period of the password. When the password is about to expire or has expired, the system prompts the user to change the password.	90

Password Policy	Parameter	Description	Value Range	Default Value in GaussDB(DWS)
	password_notify_time	Specifies for how many days you are reminded of the password expiry.	The value is an integer ranging from 0 to 999. The unit is day. ● **0** indicates the reminder is disabled. ● A value ranging from 1 to 999 indicates the number of days prior to password expiration that a user will receive a notification.	7
Password reuse settings	password_reuse_time	Specifies the number of days after which the password cannot be reused.	A Floating point number ranging from 0 to 3650. The unit is day. ● **0** indicates that the password reuse days are not checked. ● A positive number indicates that the new password cannot be chosen from passwords in history that are newer than the specified number of days.	60
	password_reuse_max	Specifies the number of the most recent passwords that the new password cannot be chosen from.	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 chosen from the specified number of the most recent passwords.	0

Password Policy	Parameter	Description	Value Range	Default Value in GaussDB(DWS)
Encryption mode	password_encryption_type	Specifies the password storage encryption mode.	0, 1, 2 ● **0** indicates that passwords are encrypted in MD5 mode. The password is encrypted using MD5. This mode is not recommended for users. ● **1** indicates that passwords are encrypted with SHA-256, which is compatible with the MD5 user authentication method of the PostgreSQL client. The password is stored in ciphertext encrypted by MD5 and SHA256. ● **2** indicates that passwords are encrypted using SHA-256. The password is encrypted using SHA256.	1

Password Policy	Parameter	Description	Value Range	Default Value in GaussDB(DWS)
Retry and lock	password_lock_time	Specifies the duration for a locked account to be automatically unlocked.	A Floating point number ranging from 0 to 365. The unit is day. ● **0** indicates that the account is not automatically locked if the password verification fails. ● A positive number indicates the duration after which a locked account is automatically unlocked. **NOTE** The integral part of the value of the **password_lock_time** parameter indicates the number of days and its decimal part can be converted into hours, minutes, and seconds.	1
	failed_login_attempts	If the number of incorrect password attempts reaches the value of failed_login_attempts, the account is locked and will be automatically unlocked in X (which indicates the value of password_lock_time) seconds.	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 value of **failed_login_attempts**.	10

Table 5-3 Special characters

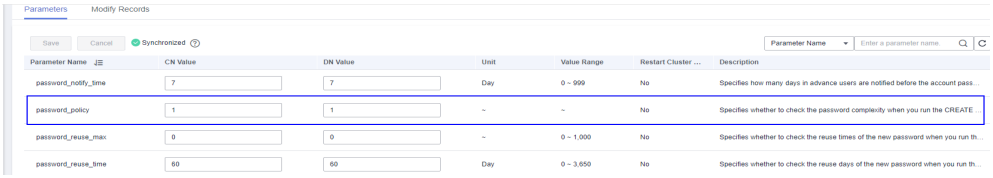
No.	Character	No.	Character	No.	Character	No.	Character
1	~	9	*	17	|	25	<
2	!	10	(	18	[	26	.
3	@	11	)	19	{	27	>
4	#	12	-	20	}	28	/
5	$	13	_	21	]	29	?
6	%	14	=	22	;	-	-
7	^	15	+	23	:	-	-
8	&	16	\	24	,	-	-

Example of User-defined Password Policies

Example 1: Configure the password complexity parameter password_policy.

1. Log in to the GaussDB(DWS) management console.
2. In the navigation pane on the left, choose **Clusters**.
3. In the cluster list, find the target cluster and click the cluster name. The **Cluster Information** page is displayed.
4. Click the **Parameters** tab, change the value of **password_policy**, and click **Save**. The **password_policy** parameter takes effect immediately after being modified. You do not need to restart the cluster.

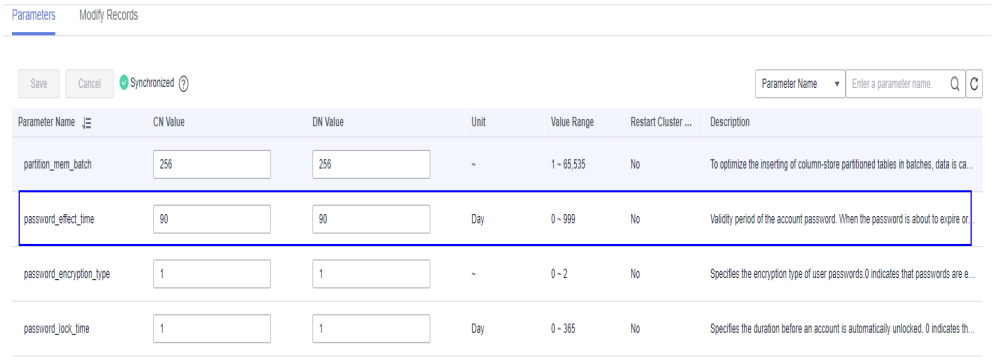
Figure 5-1 password_policy



Example 2: Configure password_effect_time for password validity period.

1. Log in to the GaussDB(DWS) management console.
2. In the navigation pane on the left, choose **Clusters**.
3. In the cluster list, find the target cluster and click the cluster name. The **Cluster Information** page is displayed.
4. Click the **Parameters** tab, change the value of **password_effect_time**, and click **Save**. The modification of **password_effect_time** takes effect immediately. You do not need to restart the cluster.

Figure 5-2 password_effect_time



Setting and Changing a Password

- Both 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 the user **user1**, connect to the database as the administrator and run the following command:

  ```
  ALTER USER user1 IDENTIFIED BY 'newpassword' REPLACE 'oldpassword';
  ```

  NOTE

  The password must meet input requirements, or the execution will fail.

- An administrator can change its own password and other accounts' passwords. With the permission for changing other accounts' passwords, the administrator can resolve a login failure when a user forgets its password.

  To change the password of the user **joe**, run the following command:

  ```
  ALTER USER joe IDENTIFIED BY 'password';
  ```

  NOTE

  - System administrators are not allowed to change passwords for each other.
  - When a system administrator changes the password of a common user, the original password is not required.
  - However, when a system administrator changes its own password, the original password is required.

- 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.

  To set the password of the user **joe**, run the following command:

  ```
  SET ROLE joe PASSWORD 'password';
  ```

  If the following information is displayed, the role setting has been modified:

  ```
  SET ROLE
  ```


5.1.4 Permissions Management

Permission Overview

Permissions are used to control whether a user is allowed to access a database object (including schemas, tables, functions, and sequences) to perform operations such as adding, deleting, modifying, querying, and creating a database object.

Permission management in GaussDB(DWS) falls into three categories:

- System permissions

  System permissions are also called user attributes, including **SYSADMIN**, **CREATEDB**, **CREATEROLE**, **AUDITADMIN**, and **LOGIN**.

  They can be specified only by the **CREATE ROLE** or **ALTER ROLE** syntax. The **SYSADMIN** permission 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**.

- Object permissions

  Permissions on a database object (table, view, column, database, function, schema, or tablespace) can be granted to a role or user. The **GRANT** command can be used to grant permissions to a user or role. These permissions granted are added to the existing ones.

- Permissions

  Grant a role's or user's permissions to one or more roles or users. 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 member can in turn grant permissions in the role to others, and revoke permissions in the role as well. If a role or user granted with certain permissions is changed or revoked, the permissions inherited from the role or user also change.

  A database administrator can grant permissions to and revoke them from any role or user. Roles having **CREATEROLE** permission can grant or revoke membership in any role that is not an administrator.

Hierarchical Permission Management

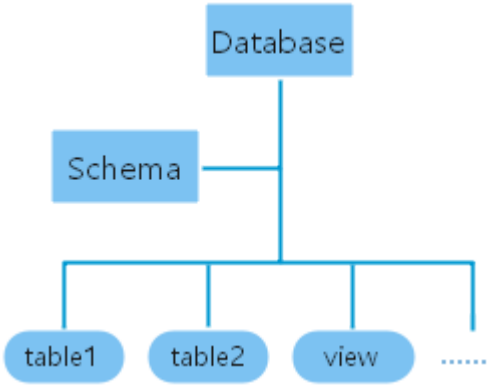
GaussDB(DWS) implements a hierarchical permission management on databases, schemas, and data objects.

- Databases cannot communicate with each other and share very few resources. Their connections and permissions can be isolated. The database cluster has one or more named 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.
- Schemas share more resources than databases do. User permissions on schemas and subordinate objects can be flexibly configured using the **GRANT** and **REVOKE** syntax. Each database has one or more schemas. Each schema contains various types of objects, such as tables, views, and functions. To

access an object contained in a specified schema, a user must have the **USAGE** permission on the schema.

- After an object is created, by default, only the object owner or system administrator can query, modify, and delete the object. To access a specific database object, for example, **table1**, other users must be granted the **CONNECT** permission of database, the **USAGE** permission of schema, and the **SELECT** permission of **table1**. To access an object at the bottom layer, a user must be granted the permission on the object at the upper layer. To create or delete a schema, you must have the **CREATE** permission on its database.

Figure 5-3 Hierarchical Permission Management



Roles

The permission management model of GaussDB(DWS) is a typical implementation of the role-based permission control (RBAC). It manages users, roles, and permissions through this model.

A role is a set of permissions.

- The concept of "user" is equivalent to that of "role". The only difference is that "user" has the **login** permission while "role" has the **nologin** permission.
- Roles are assigned with different permissions based on their responsibilities in the database system. A role is a set of database permissions and represents the behavior constraints of a database user or a group of data users.
- Roles and users can be converted. You can use **ALTER** to assign the **login** permission to a role.
- 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 permission changes take effect for all the members of the role.
- In non-separation-of-duty scenarios, a role can be created, modified, and deleted only by a system administrator or a user with the **CREATEROLE** attribute. In separation-of-duty scenarios, a role can be created, modified, and deleted only by a user with the **CREATEROLE** attribute.

To view all roles, query the system catalog **PG_ROLES**.


```
SELECT * FROM PG_ROLES;
```

For details about how to create, modify, and delete a role, see **CREARE ROLE**/**ALTER ROLE**/**DROP ROLE** in *SQL Syntax Reference*.

Preset Roles

GaussDB(DWS) provides a group of preset roles. Their names start with **gs_role_**. These roles allow access to operations that require high permissions. You can grant these roles to other users or roles in the database for them to access or use specific information and functions. Exercise caution and ensure security when using preset roles.

The following table describes the permissions of preset roles.

Table 5-4 Permissions of preset roles

Role	Permission
gs_role_signal_backend	Invokes functions such as **pg_cancel_backend**, **pg_terminate_backend**, **pg_terminate_query**, **pg_cancel_query**, **pgxc_terminate_query**, and **pgxc_cancel_query** to cancel or terminate sessions, excluding those of the initial users.
gs_role_read_all_stats	Reads the system status view and uses various extension-related statistics, including information that is usually visible only to system administrators. For example: Resource management views: • pgxc_wlm_operator_history • pgxc_wlm_operator_info • pgxc_wlm_operator_statistics • pgxc_wlm_session_info • pgxc_wlm_session_statistics • pgxc_wlm_workload_records • pgxc_workload_sql_count • pgxc_workload_sql_elapse_time • pgxc_workload_transaction Status information views: • pgxc_stat_activity • pgxc_get_table_skewness • table_distribution • pgxc_total_memory_detail • pgxc_os_run_info • pg_nodes_memory • pgxc_instance_time • pgxc_redo_stat

Role	Permission
gs_role_analyze_any	A user with the system-level **ANALYZE** permission can skip the schema permission check and perform **ANALYZE** on all tables.
gs_role_vacuum_any	A user with the system-level **VACUUM** permission can skip the schema permission check and perform **ANALYZE** on all tables.

Restrictions on using preset roles:

- **gs_role_** is the name field dedicated to preset 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 preset roles.
- By default, a preset role does not have the **LOGIN** permission, so there is no preset login password for the role.
- The gsql meta-commands **\du** and **\dg** do not display information about preset roles. However, if **PATTERN** is specified, information about preset roles will be displayed.
- If the separation of permissions is disabled, the system administrator and users with the **ADMIN OPTION** permission of preset roles are allowed to perform GRANT and REVOKE operations on preset roles. If the separation of permissions is enabled, the security administrator (with the **CREATEROLE** attribute) and users with the **ADMIN OPTION** permission of preset roles are allowed to perform GRANT and REVOKE operations on preset roles. Example:

```
GRANT gs_role_signal_backend TO user1;
REVOKE gs_role_signal_backend FROM user1;
```

Granting or Revoking Permissions

A user who creates an object is the owner of this object. By default, **Separation of Permissions** 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 **GRANT** by default. To enable a user to use an object, the object owner or administrator can run the **GRANT** or **REVOKE** command to grant permissions to or revoke permissions from the user or role.

- Run the **GRANT** statement to grant permissions.

  For example, grant the permission of schema **myschema** to role **u1**, and grant the **SELECT** permission of table **myschema.t1** to role **u1**.

  ```
  GRANT USAGE ON SCHEMA myschema TO u1;
  GRANT SELECT ON TABLE myschema.t1 to u1;
  ```

- Run the **REVOKE** command to revoke a permission that has been granted.

  For example, revoke all permissions of user **u1** on the **myschema.t1** table.

  ```
  REVOKE ALL PRIVILEGES ON myschema.t1 FROM u1;
  ```


5.1.5 Separation of Permissions

By default, the system administrator with the **SYSADMIN** attribute has the highest permission in the system. To avoid risks caused by centralized permissions, you can enable the separation of permissions to delegate system administrator permissions to security administrators and audit administrators.

- After the separation of permissions is enabled, a system administrator does not have the **CREATEROLE** attribute (security administrator) and **AUDITADMIN** attribute (audit administrator). That is, you do not have the permissions for creating roles and users and the permissions for viewing and maintaining database audit logs. For details about the **CREATEROLE** and **AUDITADMIN** attributes, see CREATE ROLE.
- After the separation of permissions is enabled, system administrators have the permissions only for the objects owned by them.

For details about how to configure separation of permissions, see **Configuring Separation of Permissions**.

For details about permission changes before and after enabling the separation of permissions, see **Table 5-5** and **Table 5-6**.

Table 5-5 Default user permissions

Object	System Administrator	Security Administrator	Audit Administrator	Common User
Tablespace	Can create, modify, delete, access, and allocate tablespaces.	Cannot create, modify, delete, or allocate tablespaces, with authorization required for accessing tablespaces.		
Table	Has permissions for all tables.	Has permissions for its own tables, but does not have permissions for other users' tables.		
Index	Can create indexes on all tables.	Can create indexes on their own tables.		
Schema	Has permissions for all schemas.	Has all permissions for its own schemas, but does not have permissions for other users' schemas.		
Function	Has permissions for all functions.	Has permissions for its own functions, has the call permission for other users' functions in the **public** schema, but does not have permissions for other users' functions in other schemas.		
Customized view	Has permissions for all views.	Has permissions for its own views, but does not have permissions for other users' views.		

Object	System Administrator	Security Administrator	Audit Administrator	Common User
System catalog and system view	Has permissions for querying all system catalogs and views.	Has permissions for querying only some system catalogs and views. For details, see **System Catalogs and System Views**.		

Table 5-6 Changes in permissions after the separation of permissions

Object	System Administrator	Security Administrator	Audit Administrator	Common User
Tablespace	No change	No change		
Table	Permissions reduced Has all permissions for its own tables, but does not have permissions for other users' tables in their schemas.	No change		
Index	Permissions reduced Can create indexes on its own tables.	No change		
Schema	Permissions reduced Has all permissions for its own schemas, but does not have permissions for other users' schemas.	No change		
Function	Permissions reduced Has all permissions for its own functions, but does not have permissions for other users' functions in their schemas.	No change		
Customized view	Permissions reduced Has all permissions for its own views and other users' views in the **public** schema, but does not have permissions for other users' views in their schemas.	No change		

Object	System Administrator	Security Administrator	Audit Administrator	Common User
System catalog and system view	No change	No change	No change	Has no permission for viewing any system catalogs or views.

5.2 Sensitive Data Management

5.2.1 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.
CREATE ROLE alice PASSWORD 'password';
CREATE ROLE bob PASSWORD 'password';
CREATE ROLE peter PASSWORD 'password';

-- Create the public.all_data table that contains user information.
CREATE TABLE public.all_data(id int, role varchar(100), data varchar(100));

-- Insert data into the data table.
INSERT INTO all_data VALUES(1, 'alice', 'alice data');
INSERT INTO all_data VALUES(2, 'bob', 'bob data');
INSERT INTO all_data VALUES(3, 'peter', 'peter data');

-- Grant the read permission for the all_data table to users alice, bob, and peter.
GRANT SELECT ON all_data TO alice, bob, peter;
```



```
-- Enable row-level access control.
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.
CREATE ROW LEVEL SECURITY POLICY all_data_rls ON all_data USING(role = CURRENT_USER);

-- View table details.
 \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 all_data.
SET ROLE alice PASSWORD 'password';
SELECT * FROM all_data;
 id | role  |    data
----+-------+------------
  1 | alice | alice data
(1 row)

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)

-- Switch to user peter and run SELECT * FROM .all_data.
SET ROLE peter PASSWORD 'password';
SELECT * FROM all_data;
 id | role  |    data
----+-------+------------
  3 | peter | peter data
(1 row)

 EXPLAIN(COSTS OFF) SELECT * FROM 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)
```

5.2.2 Data Redaction

GaussDB(DWS) provides the column-level dynamic data masking (DDM) function. For sensitive data (such as the ID card number, mobile number, and bank card number), the DDM function is used to redact the original data to protect data security and user privacy.

- Creating a data masking policy for a table

GaussDB(DWS) uses the **CREATE REDACTION POLICY** syntax to create a data masking policy on a table (Do not perform masking), **MASK_FULL** (Mask data into a fixed value), and **MASK_PARTIAL** (Perform partial masking based on the character type, numeric type, or time type.) to specify the application scope of the masking policy.

- Modifying the data masking policy of a table

  The **ALTER REDACTION POLICY** syntax is used to modify the expression for enabling a masking policy, rename a masking policy, and add, modify, or delete masked columns.

- Deleting the masking policy of a table

  The **DROP REDACTION POLICY** syntax is used to delete the masking function information of a masking policy on all columns of a table.

- Viewing the masking policy and masked columns

  Masking policy information is stored in the system catalog **PG_REDACTION_POLICY**, and masked column information is stored in the system catalog **PG_REDACTION_COLUMN**. You can view information about the masking policy and masked columns in the system views **REDACTION_POLICIES** and **REDACTION_COLUMNS**.

NOTE

- Generally, you can run the SELECT statement to view the data masking result. If a statement has the following features, sensitive data may be deliberately obtained. In this case, an error will be reported during statement execution.
  - The GROUP BY clause references the Target Entry containing masked columns as the target column.
  - DISTINCT works on the output masked columns.
  - The statement contains CTE.
  - Operations on sets are involved.
  - The target columns of a subquery are not masked columns of the base table, but the expressions or function calls for masked columns of the base table.
- You can use COPY TO or GDS to export the masked data. Due to the irreversibility of the data masking, secondary masking of the data is meaningless.
- Do not set target columns of UPDATE, MERGE INTO, and DELETE statements to masked columns.
- The UPSERT statement allows you to insert update data through EXCLUDED. If data in the base table is updated by referencing masked columns, the data may be modified by mistake. As a result, an error will be reported during the execution.
- In the 8.2.1 cluster version, multiple masking policies can be created for the same table to implement diversified sensitive data classification. The principles for selecting and applying masking policies are as follows:
  - Select the policy with the largest **policy_order** among multiple candidate policies that meet the requirements of the current session. A larger **policy_order** indicates a later creation.
  - During data masking, the DML statement inherits only the policy with the largest **policy_order**.

Examples

The following uses the employee table **emp**, table owner **alice**, and roles **matu** and **july** as an example to illustrate the data masking process. The **emp** table contains private data such as the employee name, mobile number, email address, bank card number, and salary.

Step 1 After connecting to the database as the administrator, create roles **alice**, **matu**, and **july**.

```
CREATE ROLE alice PASSWORD 'password';
CREATE ROLE matu PASSWORD 'password';
CREATE ROLE july PASSWORD 'password';
```

Step 2 Grant schema permissions on the current database to **alice**, **matu**, and **july**.

```
GRANT ALL PRIVILEGES on schema public to alice,matu,july;
```

Step 3 Switch to role **alice**, create the **emp** table, and insert three pieces of employee information.

```
SET ROLE alice PASSWORD 'password';

CREATE TABLE emp(id int, name varchar(20), phone_no varchar(11), card_no number, card_string
varchar(19), email text, salary numeric(100, 4), birthday date);

INSERT INTO emp VALUES(1, 'anny', '13420002340', 1234123412341234, '1234-1234-1234-1234',
'smithWu@163.com', 10000.00, '1999-10-02');
INSERT INTO emp VALUES(2, 'bob', '18299023211', 3456345634563456, '3456-3456-3456-3456',
'66allen_mm@qq.com', 9999.99, '1989-12-12');
INSERT INTO emp VALUES(3, 'cici', '15512231233', NULL, NULL, 'jonesishere@sina.com', NULL,
'1992-11-06');
```

Step 4 **alice** grants the read permission on the **emp** table to **matu** and **july**.

```
GRANT SELECT ON emp TO matu, july;
```

Step 5 Create the masking policy **mask_emp**: Only user **alice** can view all employee information. User **matu** and **july** cannot view employee bank card numbers and salary data. The **card_no** column is of the numeric type and all of its data is masked into 0 by the **MASK_FULL** function. The **card_string** column is of the character type and part of its data is masked by the **MASK_PARTIAL** function based on the specified input and output formats. The **salary** column is of the numeric type and the **MASK_PARTIAL** function is used to mask all digits before the penultimate digit using the number 9.

```
CREATE REDACTION POLICY mask_emp ON emp WHEN (current_user IN ('matu', 'july'))
 ADD COLUMN card_no WITH mask_full(card_no),
 ADD COLUMN card_string WITH mask_partial(card_string, 'VVVVFVVVVFVVVVFVVVV','VVVV-VVVV-VVVV-
VVVV','#',1,12),
 ADD COLUMN salary WITH mask_partial(salary, '9', 1, length(salary) - 2);
```

Step 6 Switch to **matu** and **july** and view the employee table **emp**.

```
SET ROLE matu PASSWORD 'password';
SELECT * FROM emp;
 id | name |  phone_no   | card_no |     card_string     |        email         |   salary   |      birthday
----+------+-------------+---------+---------------------+----------------------+------------+---------------------
  1 | anny | 13420002340 |       0 | ####-####-####-1234 | smithWu@163.com      | 99999.9990 |
1999-10-02 00:00:00
  2 | bob  | 18299023211 |       0 | ####-####-####-3456 | 66allen_mm@qq.com    |  9999.9990 |
1989-12-12 00:00:00
  3 | cici | 15512231233 |         |                     | jonesishere@sina.com |            | 1992-11-06 00:00:00
(3 rows)

SET ROLE july PASSWORD 'password';
SELECT * FROM emp;
 id | name |  phone_no   | card_no |     card_string     |        email         |   salary   |      birthday
----+------+-------------+---------+---------------------+----------------------+------------+---------------------
  1 | anny | 13420002340 |       0 | ####-####-####-1234 | smithWu@163.com      | 99999.9990 |
1999-10-02 00:00:00
  2 | bob  | 18299023211 |       0 | ####-####-####-3456 | 66allen_mm@qq.com    |  9999.9990 |
1989-12-12 00:00:00
  3 | cici | 15512231233 |         |                     | jonesishere@sina.com |            | 1992-11-06 00:00:00
(3 rows)
```


Step 7 If you want **matu** to have the permission to view all employee information, but do not want **july** to have. In this case, you only need to modify the effective scope of the policy.

```
SET ROLE alice PASSWORD 'password';
ALTER REDACTION POLICY mask_emp ON emp WHEN(current_user = 'july');
```

Step 8 Switch to users **matu** and **july** and view the **emp** table again, respectively.

```
SET ROLE matu PASSWORD 'password';
SELECT * FROM emp;
 id | name |  phone_no   |     card_no      |     card_string     |       email        |  salary   |      birthday
----+------+-------------+------------------+---------------------+----------------------+------------
+---------------------
  1 | anny | 13420002340 | 1234123412341234 | 1234-1234-1234-1234 | smithWu@163.com      |
10000.0000 | 1999-10-02 00:00:00
  2 | bob  | 18299023211 | 3456345634563456 | 3456-3456-3456-3456 | 66allen_mm@qq.com    |
9999.9900 | 1989-12-12 00:00:00
  3 | cici | 15512231233 |                  |                     | jonesishere@sina.com |            | 1992-11-06 00:00:00
(3 rows)

SET ROLE july PASSWORD 'password';
SELECT * FROM emp;
 id | name |  phone_no   | card_no |     card_string     |       email        |  salary   |      birthday
----+------+-------------+---------+---------------------+----------------------+------------+---------------------
  1 | anny | 13420002340 |       0 | ####-####-####-1234 | smithWu@163.com      | 99999.9990 |
1999-10-02 00:00:00
  2 | bob  | 18299023211 |       0 | ####-####-####-3456 | 66allen_mm@qq.com    |  9999.9990 |
1989-12-12 00:00:00
  3 | cici | 15512231233 |         |                     | jonesishere@sina.com |            | 1992-11-06 00:00:00
(3 rows)
```

Step 9 The information in the **phone_no**, **email**, and **birthday** columns is private data. Update masking policy **mask_emp** and add three masked columns.

```
SET ROLE alice PASSWORD 'password';
ALTER REDACTION POLICY mask_emp ON emp ADD COLUMN phone_no WITH mask_partial(phone_no, '*',
4);
ALTER REDACTION POLICY mask_emp ON emp ADD COLUMN email WITH mask_partial(email, '*', 1,
position('@' in email));
ALTER REDACTION POLICY mask_emp ON emp ADD COLUMN birthday WITH mask_full(birthday);
```

Step 10 Switch to **july** and view data in the **emp** table.

```
SET ROLE july PASSWORD 'password';
SELECT * FROM emp;
 id | name |  phone_no   | card_no |     card_string     |       email        |  salary   |      birthday
----+------+-------------+---------+---------------------+----------------------+------------+---------------------
  1 | anny | 134******** |       0 | ####-####-####-1234 | ********163.com      | 99999.9990 | 1970-01-01
00:00:00
  2 | bob  | 182******** |       0 | ####-####-####-3456 | ***********qq.com    |  9999.9990 | 1970-01-01
00:00:00
  3 | cici | 155******** |         |                     | ************sina.com |            | 1970-01-01 00:00:00
(3 rows)
```

Step 11 Query **redaction_policies** and **redaction_columns** to view details about the current redaction policy **mask_emp**.

```
SELECT * FROM redaction_policies;
 object_schema | object_owner | object_name | policy_name |            expression             | enable |
policy_description | inherited
---------------+--------------+-------------+-------------+-----------------------------------+--------
+--------------------+-----------
 public        | alice        | emp         | mask_emp    | ("current_user"() = 'july'::name) | t      |                    |
f
(1 row)

SELECT object_name, column_name, function_info FROM redaction_columns;
 object_name | column_name |                                  function_info
-------------+-------------
+-------------------------------------------------------------------------------------------------------
```

```
 emp         | card_no     | mask_full(card_no)
 emp         | card_string | mask_partial(card_string, 'VVVVFVVVVFVVVVFVVVV'::text, 'VVVV-VVVV-VVVV-
VVVV'::text, '#'::text, 1, 12)
 emp         | email       | mask_partial(email, '*'::text, 1, "position"(email, '@'::text))
 emp         | salary      | mask_partial(salary, '9'::text, 1, (length((salary)::text) - 2))
 emp         | birthday    | mask_full(birthday)
 emp         | phone_no    | mask_partial(phone_no, '*'::text, 4)
(6 rows)
```

Step 12 Add the **salary_info** column. To replace the salary information in text format with *.*, you can create a user-defined masking function. In this step, you can use the PL/pgSQL to define the masking function **mask_regexp_salary**. To create a masking column, you simply need to customize the function name and parameter list. For details, see **User-Defined Functions**.

```
SET ROLE alice PASSWORD 'password';

ALTER TABLE emp ADD COLUMN salary_info TEXT;
UPDATE emp SET salary_info = salary::text;

CREATE FUNCTION mask_regexp_salary(salary_info text) RETURNS text AS
$$
 SELECT regexp_replace($1, '[0-9]+','*','g');
$$
 LANGUAGE SQL
STRICT SHIPPABLE;

ALTER REDACTION POLICY mask_emp ON emp ADD COLUMN salary_info WITH
mask_regexp_salary(salary_info);

SET ROLE july PASSWORD 'password';
SELECT id, name, salary_info FROM emp;
 id | name | salary_info
----+------+-------------
  1 | anny | *.*
  2 | bob  | *.*
  3 | cici |
(3 rows)
```

Step 13 If there is no need to set a redaction policy for the **emp** table, delete redaction policy **mask_emp**.

```
SET ROLE alice PASSWORD 'password';
DROP REDACTION POLICY mask_emp ON emp;
```

----End

5.2.3 Using Functions for Encryption and Decryption

GaussDB(DWS) supports encryption and decryption of strings using the following functions:

- gs_encrypt(encryptstr, keystr, cryptotype, cryptomode, hashmethod)

  Description: Encrypts an **encryptstr** string using the **keystr** key based on the encryption algorithm specified by **cryptotype** and **cryptomode** and the HMAC algorithm specified by **hashmethod**, and returns the encrypted string. **cryptotype** can be **aes128**, **aes192**, **aes256**, or **sm4**. **cryptomode** is **cbc**. **hashmethod** can be **sha256**, **sha384**, **sha512**, or **sm3**. 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. The **keystr** length is related to the encryption algorithm and contains 1 to **KeyLen** bytes. If **cryptotype** is **aes128** or **sm4**, **KeyLen** is **16**; if **cryptotype** is **aes192**, **KeyLen** is **24**; if **cryptotype** is **aes256**, **KeyLen** is **32**.

Return type: text

Length of the return value: at least 4 x [(maclen + 56)/3] bytes and no more than 4 x [(Len + maclen + 56)/3] bytes, where **Len** indicates the string length (in bytes) before the encryption and **maclen** indicates the length of the HMAC value. If **hashmethod** is **sha256** or **sm3**, **maclen** is **32**; if **hashmethod** is **sha384**, **maclen** is **48**; if **hashmethod** is **sha512**, **maclen** is **64**. That is, if **hashmethod** is **sha256** or **sm3**, the returned string contains 120 to 4 x [(Len + 88)/3] bytes; if **hashmethod** is **sha384**, the returned string contains 140 to 4 x [(Len + 104)/3] bytes; if **hashmethod** is **sha512**, the returned string contains 160 to 4 x [(Len + 120)/3] bytes.

Example:

```
SELECT gs_encrypt('GaussDB(DWS)', '1234', 'aes128', 'cbc',  'sha256');
                                                gs_encrypt
-----------------------------------------------------------------------------------------------------------------------------
---
 AAAAAAAAAACcFjDcCSbop7D87sOa2nxTFrkE9RJQGK34ypgrOPsFJIqggI8tl
+eMDcQYT3po98wPCC7VBfhv7mdBy7IVnzdrp0rdMrD6/zTl8w0v9/s2OA==
(1 row)
```

NOTE

- A decryption password is required during the execution of this function. For security purposes, the gsql tool does not record this function in the execution history. That is, the execution history of this function cannot be found in **gsql** by paging up and down.
- Do not use the **ge_encrypt** and **gs_encrypt_aes128** functions for the same data table.

- gs_decrypt(decryptstr, keystr, cryptotype, cryptomode, hashmethod)

  Description: Decrypts a **decryptstr** string using the **keystr** key based on the encryption algorithm specified by **cryptotype** and **cryptomode** and the HMAC algorithm specified by **hashmethod**, and returns the decrypted string. The **keystr** used for decryption must be consistent with that used for encryption. **keystr** cannot be empty.

  Return type: text

  Example:

  ```
  SELECT gs_decrypt('AAAAAAAAAACcFjDcCSbop7D87sOa2nxTFrkE9RJQGK34ypgrOPsFJIqggI8tl
  +eMDcQYT3po98wPCC7VBfhv7mdBy7IVnzdrp0rdMrD6/zTl8w0v9/s2OA==', '1234', 'aes128', 'cbc',
  'sha256');
    gs_decrypt
  --------------
   GaussDB(DWS)
  (1 row)
  ```

  NOTE

  - A decryption password is required during the execution of this function. For security purposes, the gsql tool does not record this function in the execution history. That is, the execution history of this function cannot be found in **gsql** by paging up and down.
  - This function works with the **gs_encrypt** function, and the two functions must use the same encryption algorithm and HMAC algorithm.

- gs_encrypt_aes128(encryptstr,keystr)

  Description: Encrypts **encryptstr** strings using **keystr** as the key and returns encrypted strings. The length of **keystr** ranges from 1 to 16 bytes. 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:

```
SELECT gs_encrypt_aes128('DWS','1234');
                                gs_encrypt_aes128
------------------------------------------------------------------------------------------------
 ZrCp794vO5I9qJ+jHFf/sQqRyMBy0lKIDGP5S8RJXzgmpXoa/
e4EgmK82P5y5xe1bOXbJeoNxyHagK9OhPVVeJDbn/M=
(1 row)
```

NOTE

- A decryption password is required during the execution of this function. For security purposes, the gsql tool does not record this function in the execution history. That is, the execution history of this function cannot be found in **gsql** by paging up and down.
- Do not use the **ge_encrypt** and **gs_encrypt_aes128** functions for the same data table.

- gs_decrypt_aes128(decryptstr,keystr)

  Description: Decrypts a **decryptstr** string using the **keystr** key and returns the decrypted string. The **keystr** used for decryption must be consistent with that used for encryption. **keystr** cannot be empty.

  Return type: text

  Example:

  ```
  SELECT gs_decrypt_aes128('ZrCp794vO5I9qJ+jHFf/sQqRyMBy0lKIDGP5S8RJXzgmpXoa/
  e4EgmK82P5y5xe1bOXbJeoNxyHagK9OhPVVeJDbn/M=','1234');
   gs_decrypt_aes128
  -------------------
   DWS
  (1 row)
  ```

  NOTE

  - A decryption password is required during the execution of this function. For security purposes, the gsql tool does not record this function in the execution history. That is, the execution history of this function cannot be found in **gsql** by paging up and down.
  - This function works with the **gs_encrypt_aes128** function.

- gs_hash(hashstr, hashmethod)

  Description: Obtains the digest string of a **hashstr** string based on the algorithm specified by **hashmethod**. **hashmethod** can be **sha256**, **sha384**, **sha512**, or **sm3**.

  Return type: text

  Length of the return value: 64 bytes if **hashmethod** is **sha256** or **sm3**; 96 bytes if **hashmethod** is **sha384**; 128 bytes if **hashmethod** is **sha512**

  Example:

  ```
  SELECT gs_hash('GaussDB(DWS)', 'sha256');
                                      gs_hash
  ----------------------------------------------------------------------------------------------------

  e59069daa6541ae20af7c747662702c731b26b8abd7a788f4d15611aa0db608efdbb5587ba90789a983f8
  ```



```
5dd51766609
(1 row)
```

- md5(string)

  Description: Encrypts a string in MD5 mode and returns a value in hexadecimal form.

  NOTE

  MD5 is insecure and is not recommended.

  Return type: text

  Example:

```
SELECT md5('ABC');
              md5
----------------------------------
 902fbdd2b1df0c4f70b4a5d23525e932
(1 row)
```

5.2.4 Use pgcrypto to Encrypt Data

GaussDB(DWS) 8.2.0 and later provides a built-in cryptographic module pgcrypto. The pgcrypto module allows database users to store certain columns of data after encryption, enhancing sensitive data security. Users without the encryption key cannot read the encrypted data stored in GaussDB(DWS).

The pgcrypto function runs inside database servers, which means that all data and passwords are transmitted in plaintext between pgcrypto and client applications. For security purposes, you are advised to use the SSL connection between the client and the GaussDB(DWS) server.

The functions in the pgcrypto module are as follows.

General Hash Functions

- digest()

  The digest() function can generate binary hash values by using a specified algorithm. The syntax is as follows:

```
digest(data text, type text) returns bytea
digest(data bytea, type text) returns bytea
```

  data indicates the original data, and **type** indicates the encryption algorithm (**md5**, **sha1**, **sha224**, **sha256**, **sha384**, **sha512**, or **sm3**). The return value of the function is a binary string.

  Example:

  Use the digest() function to encrypt the GaussDB(DWS) string using SHA256 for storage.

```
select digest('GaussDB(DWS)', 'sha256');
                              digest
--------------------------------------------------------------------
 \xcc2d1b97c6adfba44bbce7386516f63f16fc6e6a10bd938861d3aba501ac8aab
(1 row)
```

- hmac()

  The hmac() function can calculate the MAC value for data with a key by using a specified algorithm. The syntax is as follows:

```
hmac(data text, key text, type text) returns bytea
hmac(data bytea, key bytea, type text) returns bytea
```

data indicates the original data, **key** indicates the encryption key, and **type** indicates the encryption algorithm (**md5**, **sha1**, **sha224**, **sha256**, **sha384**, **sha512**, or **sm3**). The return value of the function is a binary string.

Example:

Use **key123** and the SHA256 algorithm to calculate the MAC value for the string **GaussDB(DWS)**.

```
select hmac('GaussDB(DWS)', 'key123', 'sha256');
hmac
------------------------------------------------------------------------
\x14e1d9e110e9b11ab8379dc02b49533d50a6f4deafe6d6cd451d06c106c97d83
(1 row)
```

If both the original data and its encryption result are modified, the digest() function cannot identify the changes. The hmac() function can identify the changes as long as the key is not disclosed.

If the key is longer than the hash block, it will be hashed first, and the hash result will be used as the key.

Cryptographic Hash Functions

The crypt() and gen_salt() functions are used for password hashing. crypt() executes hashes to encrypt data, and gen_salt() generates salted hashes.

The algorithms in crypt() differ from the common MD5 and SHA1 hash algorithms in the following aspects:

- The algorithms used in crypt() are slow. This is the only way to make it difficult for brute-force attackers to crack passwords, which only contain a small amount of data.
- A random value (called salt) is used for encryption, so that users will get different ciphertexts even if they use the same passwords. This can protect passwords for cracking algorithms.
- The encryption results include algorithm types. Passwords can be encrypted using different algorithms for different users.
- Some of the algorithms are self-adaptive. They can slow down computing if it is too fast, and do not cause incompatibility issues with existing passwords.

The following table lists the algorithms supported by the crypt() function.

Table 5-7 Algorithms supported by crypt()

Algorithm	Maximum Password Length	Adaptability	Salt Bits	Standard Output Length	Description
bf	72	√	128	60	Blowfish-based 2a variation
md5	unlimited	×	48	34	MD5-based algorithm
xdes	8	√	24	20	Extended DES

Algorithm	Maximum Password Length	Adaptability	Salt Bits	Standard Output Length	Description
des	8	×	12	13	Native UNIX algorithm

- crypt()

  The syntax of crypt() is as follows:

  ```
  crypt(password text, salt text) returns text
  ```

  This function returns a hash value of the password string in crypt(3) format. The salt parameter is generated by the gen_salt() function.

  For the same password, the crypt() function returns a different result each time, because the gen_salt() function generates a different salt each time. During password verification, the previously generated hash result can be used as the salt.

  For example, to set a new password, run the following command:

  ```
  UPDATE ... SET pswhash = crypt('new password', gen_salt('bf',10));
  ```

  The hash values of the entered password and the stored password are compared.

  ```
  SELECT (pswhash = crypt('entered password', pswhash)) AS pswmatch FROM ... ;
  ```

  If the entered password is correct, **true** is returned.

  Example:

  ```
  create table userpwd(userid int8, pwd text);
  CREATE TABLE

  insert into userpwd values (1, crypt('this is a pwd', gen_salt('bf',10)));
  INSERT 0 1

  select crypt('this is a pwd', pwd)=pwd as result from userpwd where userid =1;
   result
  --------
   t
  (1 row)

  select crypt('this is a wrong pwd', pwd)=pwd as result from userpwd where userid =1;
   result
  --------
   f
  (1 row)
  ```

- gen_salt()

  The gen_salt() function is used to generate random parameters for **crypt**. The syntax is as follows:

  ```
  gen_salt(type text [, iter_count integer ]) returns text
  ```

  This function generates a random salt string each time. The string determines the algorithm used by the crypt() function. The **type** parameter specifies a hash algorithm (**des**, **xdes**, **md5**, or **bf**) for generating a string. For the xdes and bf algorithms, **iter_count** indicates the number of iterations. A large value indicates a long encryption or cracking time.

  ```
  SELECT gen_salt('des'), gen_salt('xdes'), gen_salt('md5'), gen_salt('bf');
   gen_salt | gen_salt  |  gen_salt   |          gen_salt
  ```



```
----------+------------+-------------+------------------------------
 qh       | _J9..uEUi | $1$SNgqyKAi | $2a$06$B/Etc3J8zYBV49LrDU97MO
(1 row)
```

The salt generated by an algorithm has a fixed format. For example, in **$2a$06$** in the bf algorithm result, **2a** indicates the 2a variation of Blowfish, and **06** indicates the number of iterations.

If **iter_count** is ignored, the default number of iterations will be used. The valid **iter_count** values depend on the algorithm used, as shown in the table below. For the xdes algorithm, the number of iterations must be an odd number.

Table 5-8 Iteration counts of crypt()

Algorithm	Default Value	Min.	Max.
xdes	725	1	16777215
bf	6	4	31

PGP Encryption Functions

The PGP encryption function of GaussDB(DWS) complies with the OpenPGP (RFC 4880) standard, which includes requirements for symmetric key (private key) encryption and asymmetric key (public key) encryption.

An encrypted PGP message consists of the following parts:

- Session key (encrypted symmetric key or public key) of the message
- Data encrypted using the session key

For symmetric key (password) encryption:

1. The key is encrypted using the String2Key (S2K) algorithm, which is like a slowed down crypt() algorithm with a random salt. A full-length binary key will be generated.
2. If a separate session key is required, a random key will be generated. If it is not required, the S2K key will be used as the session key.
3. If the S2K key is directly used for a session, this key will be put in the session key packet. Otherwise, the S2K key will be used to encrypt the session key, and the encryption result will be put in the session key packet.

For public key encryption:

1. A random session key is generated.
2. This random key is encrypted using the public key and then put in the session key packet.

In either case, the data encryption process is as follows:

1. (Optional) Compress data, convert data to UTF-8, or convert newline characters.
2. A block consisting of random bytes is added before the data, serving as a random initial value (IV).

3. A random prefix and the SHA1 hash value suffix are added to the data.
4. The entire content is encrypted using the session key and then placed in the data packet.

Supported PGP encryption functions

- pgp_sym_encrypt()

  Description: Encrypts a symmetric key.

  Syntax:
  ```
  pgp_sym_encrypt(data text, psw text [, options text ]) returns bytea
  pgp_sym_encrypt_bytea(data bytea, psw text [, options text ]) returns bytea
  ```

  data indicates the data to be encrypted, **psw** indicates the PGP symmetric key, and **options** is used to set options. For details, see **Table 5-9**.

- pgp_sym_decrypt()

  Description: Decrypts a message encrypted using a PGP symmetric key.

  Syntax:
  ```
  pgp_sym_decrypt(msg bytea, psw text [, options text ]) returns text
  pgp_sym_decrypt_bytea(msg bytea, psw text [, options text ]) returns bytea
  ```

  msg indicates the data to be decrypted, **psw** indicates the PGP symmetric key, and **options** is used to set options. For details, see **Table 5-9**. To avoid generating invalid characters, you are not allowed to use the pgp_sym_decrypt function to decrypt bytea data. You can use the pgp_sym_decrypt_bytea function instead.

- pgp_pub_encrypt()

  Description: Encrypts a public key.

  Syntax:
  ```
  pgp_pub_encrypt(data text, key bytea [, options text ]) returns bytea
  pgp_pub_encrypt_bytea(data bytea, key bytea [, options text ]) returns bytea
  ```

  data indicates the data to be encrypted. **key** indicates the PGP public key. If a private key is used as input, an error will be returned. **options** is used to set options. For details, see **Table 5-9**.

- pgp_pub_decrypt()

  Description: Decrypts a message encrypted using a PGP public key.

  Syntax:
  ```
  pgp_pub_decrypt(msg bytea, key bytea [, psw text [, options text ]]) returns text
  pgp_pub_decrypt_bytea(msg bytea, key bytea [, psw text [, options text ]]) returns bytea
  ```

  You can decrypt a message encrypted using a public key. The **key** must be the private key corresponding to the public key used for encryption. If the private key is password protected, specify the password in **psw**. If you have not specified any password but want to specify this option now, provide an empty password.

  To avoid generating invalid characters, you are not allowed to use the pgp_pub_decrypt function to decrypt bytea data. You can use pgp_pub_decrypt_bytea function instead.

  The **key** must be the private key corresponding to the public key used for encryption. If the private key is password protected, specify the password in **psw**. If you have not specified any password but want to specify this option now, provide an empty password. The options **parameter** is used to set options. For details, see **Table 5-9**.

- pgp_key_id()

  Description: Extracts the key ID of the PGP public or private key. If an encrypted message is used as the input, the ID of the key used to encrypt the message will be returned.

  Syntax:

  ```
  pgp_key_id(bytea) returns text
  ```

  This function can return two special key IDs:

  – **SYMKEY**, indicating that a message is encrypted using a symmetric key.

  – **ANYKEY**, indicating that a message is encrypted using the public key, but the key ID has been deleted. To decrypt the message in this case, you need to try all the keys until you find the correct private key. pgcrypto does not produce such encrypted messages.

  NOTE

  Different keys may have the same ID. This situation rarely occurs. In this case, the client application needs to try different keys for decryption, in the same way it deals with **ANYKEY**.

- armor()

  Description: Converts binary data into PGP ASCII-armor format by the CRC calculation and formatting of a Base64 string.

  Syntax:

  ```
  armor(data bytea [ , keys text[], values text[] ]) returns text
  ```

- dearmor()

  Description: Performs the reverse conversion.

  Syntax:

  ```
  dearmor(data text) returns bytea
  ```

  Converts the encrypted data bytea to the PGP ASCII-armor format, or the other way around.

  data indicates the data to be converted. If multiple pairs of keys and values are specified, an armor header will be generated for each key-value pair and added to the output. The two arrays are both one-dimensional arrays with the same length, and cannot contain non-ASCII characters.

- pgp_armor_headers()

  Description: Returns the armor header in the data.

  ```
  pgp_armor_headers(data text, key out text, value out text) returns setof record
  ```

  The return result is a data row set consisting of key and value columns. Any non-ASCII characters contained in the set are regarded as UTF-8 characters.

  Using GnuPG to generate PGP keys

  To generate a key, run the following command:

  ```
  gpg --gen-key
  ```

  DSA and Elgamal keys are recommended.

  To use an RSA key, you must create a DSA or RSA key as the master key used only for signature, and then specify **gpg --edit-key** to add an RSA encryption subkey.

  To list keys, run the following command:

  ```
  gpg --list-secret-keys
  ```

  To export a public key in ASCII-protected format, run the following command:


```
gpg -a --export KEYID > public.key
```

To export a private key in ASCII-protected format, run the following command:

```
gpg -a --export-secret-keys KEYID > secret.key
```

Before using these keys as the input to the PGP function, run dearmor() on them. Alternatively, if you can process binary data, remove **-a** from the command.

NOTICE

The PGP encryption function has the following restrictions:

- Signatures are not supported. This function does not check whether the encryption subkey belongs to the master key.
- The encryption key cannot be used as the master key. This constraint does not impose much impact, because it is rarely violated.
- Only one subkey is allowed. This may be a problem, because multiple subkeys are often required. General GPG and PGP keys cannot be used as pgcrypto encryption keys. Their usage is totally different.

PGP function parameters

The option names in the pgcrypto function are similar to those in the GnuPG function. Option values are set using equal signs (=), and the options are separated by commas (,). Example:

```
pgp_sym_encrypt(data, psw, 'compress-algo=1, cipher-algo=aes256')
```

Options other than **convert-crlf** can be used only for encryption functions. The decryption function obtains parameters from PGP data.

The most common options are **compress-algo** and **unicode-mode**. You can retain the default values for other options.

Table 5-9 pgcrypto encryption options

Option	Description	Default Value	Value	Function
cipher-algo	Cryptographic algorithm	aes128	bf, aes128, aes192, aes256, 3des, cast5	pgp_sym_encrypt, pgp_pub_encrypt
compress-algo	Compression algorithm	0	• **0**: not compressed • **1**: ZIP compression • **2**: ZLIB compression (ZIP + Metadata + CRC)	pgp_sym_encrypt, pgp_pub_encrypt

Option	Description	Default Value	Value	Function
compress-level	Compression level. A high level indicates the compression will be slow, but the data size after compression will be small. **0** disables compression.	6	0, 1-9	pgp_sym_encrypt, pgp_pub_encrypt
convert-crlf	Indicates whether to convert **\n** to **\r\n** during encryption, and whether to convert **\r\n** to **\n** during decryption. RFC4880 requires that **\r\n** must be used as the newline character in text data storage.	0	0, 1	pgp_sym_encrypt, pgp_pub_encrypt, pgp_sym_decrypt, pgp_pub_decrypt
disable-mdc	SHA-1 is not used to protect data. It is used only for compatibility with old PGP products.	0	0, 1	pgp_sym_encrypt, pgp_pub_encrypt
sess-key	A separate session key is used. Public key encryption always uses a separate session key. This option is used for symmetric key encryption, which directly uses the S2K key by default.	0	0, 1	pgp_sym_encrypt

Option	Description	Default Value	Value	Function
s2k-mode	S2K algorithm	3	• **0**: Salt is not used. This setting is not recommended. • **1**: Salt is used, but the number of iterations is fixed. • **3**: Salt is used, and the number of iterations can be changed.	pgp_sym_encrypt
s2k-count	Number of iterations of the S2K algorithm	A random value between 65,536 and 253,952.	1024 ≤ Value ≤ 65,011,712	**pgp_sym_encrypt** and **s2k-mode=3**
s2k-digest-algo	Digest algorithm used during S2K calculation	sha1	md5, sha1	pgp_sym_encrypt
s2k-cipher-algo	Password used to encrypt a separate session key	cipher-algo algorithm	bf, aes, aes128, aes192, aes256	pgp_sym_encrypt

Option	Description	Default Value	Value	Function
unicode-mode	Whether to convert text data between database internal encoding and UTF-8. If the database already uses UTF-8 encoding, no conversion will be performed, but the message will be marked as UTF-8. If this parameter is not specified, the message will not be marked.	0	0, 1	pgp_sym_encrypt, pgp_pub_encrypt

Raw Encryption Functions

Raw encryption functions only run a cipher over data. They don't have any advanced features of PGP encryption. Therefore they have the following problems:

- They use user key directly as cipher key.
- No integrity check is performed to check whether the encrypted data was modified.
- You need to associate all encryption parameters yourself, including IV.
- Text data cannot be processed.

With the introduction of PGP encryption, these raw encryption functions are not recommended.

```
encrypt(data bytea, key bytea, type text) returns bytea
decrypt(data bytea, key bytea, type text) returns bytea
encrypt_iv(data bytea, key bytea, iv bytea, type text) returns bytea
decrypt_iv(data bytea, key bytea, iv bytea, type text) returns bytea
```

data indicates the data to be encrypted, and **type** indicates the encryption/decryption method. The syntax of the **type** parameter is as follows:

```
algorithm [ - mode ] [ /pad: padding ]
```

The options of **algorithm** are as follows:

- **bf**: Blowfish algorithm. Synonyms: **BF**, **BF-CBC**; **BLOWFISH**, **BF-CBC**; **BLOWFISH-CBC**, **BF-CBC**; **BLOWFISH-ECB**, **BF-ECB**; **BLOWFISH-CFB**, **BF-CFB**
- **aes**: AES algorithm (Rijndael-128, -192, or -256). **Synonyms**: **AES**, **AES-CBC**, **RIJNDAEL**, **AES-CBC**, **RIJNDAEL**, **AES-CBC**, **RIJNDAEL-CBC**, **AES-CBC**, **RIJNDAEL-ECB**, **AES-ECB**

- DES algorithm. Synonyms: **DES**, **DES-CBC**; **3DES**, **DES3-CBC**, **3DES-ECB**, **DES3-ECB**; **3DES-CBC**, **DES3-CBC**
- **sm4**: SM4 algorithm. Synonym: **SM4-CBC**
- CAST5 algorithm. Synonym: **CAST5-CBC**

The options of **mode** are as follows:

- **cbc**: The next block depends on the previous block. (This is the default value.)
- **ecb**: Each block is encrypted separately. (This value is used only for tests.)

The options of **padding** are as follows:

- **pkcs**: The data can be of any length. (This is the default value.)
- **none**: The data must be a multiple of cipher block size.

For example, the encryption results of the following functions are the same:

```
encrypt(data, 'fooz', 'bf')
encrypt(data, 'fooz', 'bf-cbc/pad:pkcs')
```

For the **encrypt_iv** and **decrypt_iv** functions, the **iv** parameter indicates the initial value for the CBC mode. This parameter is ignored for ECB. It is truncated or padded with zeroes if not exactly block size. It defaults to all zeroes in the functions without this parameter.

Random Data Functions

- The gen_random_bytes() function is used to generate cryptographically strong random bytes.

  ```
  gen_random_bytes(count integer) returns bytea
  ```

  count indicates the number of returned bytes. The value range is 1 to 1024.

  Example:

  ```
  SELECT gen_random_bytes(16);
          gen_random_bytes
  ----------------------------------
   \x1f1eddc11153afdde0f9e1229f8f4caf
  (1 row)
  ```

- The gen_random_uuid() function is used to return a random UUID of version 4.

  ```
  SELECT gen_random_uuid();
  gen_random_uuid
  --------------------------------------
  2bd664a2-b760-4859-8af6-8d09ccc5b830
  ```


6 Syntax Compatibility Differences Among Oracle, Teradata, and MySQL

GaussDB(DWS) is compatible with Oracle, Teradata and MySQL syntax, of which the syntax behavior is different.

Table 6-1 Compatibility differences

Compatibility Item	Oracle	Teradata	MySQL
Empty string	Only **null** is available.	An empty string is distinguished from **null**.	An empty string is distinguished from **null**.
Conversion of an empty string to a number	null	0	0
Automatic truncation of overlong characters	Not supported	Supported (set GUC parameter **td_compatible_truncation** to **ON**)	Not supported
null concatenation	Returns a non-null object after combining a non-null object with **null**. For example, **'abc'||null** returns **'abc'**.	The **strict_text_concat_td** option is added to the GUC parameter **behavior_compat_options** to be compatible with the Teradata behavior. After the null type is concatenated, **null** is returned. For example, **'abc'|| null** returns **null**.	Compatible with MySQL behavior. After the null type is concatenated, **null** is returned. For example, **'abc'|| null** returns **null**.

Compatibility Item	Oracle	Teradata	MySQL
Concatenation of the char(n) type	Removes spaces and placeholders on the right when the char(n) type is concatenated. For example, **cast('a' as char(3))||'b'** returns **'ab'**.	After the **bpchar_text_without_rtrim** option is added to the GUC parameter **behavior_compat_options**, when the char(n) type is concatenated, spaces are reserved and supplemented to the specified length *n*. Currently, ignoring spaces at the end of a string for comparison is not supported. If the concatenated string contains spaces at the end, the comparison is space-sensitive. For example, **cast('a' as char(3))||'b'** returns **'a b'**.	Removes spaces and placeholders on the right.
concat(str1,str2)	Returns the concatenation of all non-null strings.	Returns the concatenation of all non-null strings.	If an input parameter is **null**, **null** is returned.
left and right processing of negative values	Returns all characters except the first and last |n| characters.	Returns all characters except the first and last |n| characters.	Returns an empty string.

Compatibility Item	Oracle	Teradata	MySQL
lpad(string text, length int [, fill text]) rpad(string text, length int [, fill text])	Fills up the string to the specified **length** by appending the **fill** characters (a space by default). If the string is already longer than **length** then it is truncated (on the right). If **fill** is an empty string or **length** is a negative number, **null** is returned.	If **fill** is an empty string and the string length is less than the specified **length**, the original string is returned. If **length** is a negative number, an empty string is returned.	If **fill** is an empty string and the string length is less than the specified **length**, an empty string is returned. If **length** is a negative number, **null** is returned.
substr(str, s[, n])	If **s** is set to 0, the first n characters are returned.	If **s** is set to 0, the first n characters are returned.	If **s** is set to 0, an empty string is returned.
substring(str, s[, n]) substring(str [from s] [for n])	If **s** is set to 0, the first n - 1 characters are returned. If **s** is < 0, the first s + n - 1 characters are returned. If **n** is < 0, an error is reported.	If **s** is set to 0, the first n - 1 characters are returned. If **s** is < 0, the first s + n - 1 characters are returned. If **n** is < 0, an error is reported.	If **s** is set to 0, an empty string is returned. If **s** is < 0, n characters starting from the last |s| character are truncated. If **n** is < 0, an empty string is returned.
trim, ltrim, rtrim, btrim(string[, characters])	Removes the longest string that contains only the characters (a space by default) in the *characters* from a specified position of the *string*.	Removes the longest string that contains only the characters (a space by default) in the *characters* from a specified position of the *string*.	Removes the string that is equivalent to characters (a space by default) from a specified position of the *string*.
log(x)	Returns the logarithm with 10 as the base.	Returns the logarithm with 10 as the base.	Returns the natural logarithm.

Compatibility Item	Oracle	Teradata	MySQL
mod(x, 0)	Returns x if the divisor is 0.	Returns x if the divisor is 0.	Reports an error if the divisor is 0.
date data type	Converts the date data type to the timestamp data type which stores year, month, day, hour, minute, and second values.	Stores year and month values.	Stores year and month values.
to_char(date)	The maximum value of the input parameter can only be the maximum value of the timestamp type. The maximum value of the date type is not supported. The return value is of the timestamp type.	The maximum value of the input parameter can only be the maximum value of the timestamp type. The maximum value of the date type is not supported. The return value is of the date type in YYYY/MM/DD format. (The GUC parameter **convert_empty_str_to_null_td** is enabled.)	Only the timestamp type and the date type support the maximum input value. The return value is of the date type.
to_date, to_timestamp, and to_number processing of empty strings	Returns **null**.	Returns **null**. (The **convert_empty_str_to_null_td** parameter is enabled.)	**to_date** and **to_timestamp** returns **null**. If the parameter passed to **to_number** is an empty string, **0** is returned.
Return value types of last_day and next_day	Returns values of the timestamp type.	Returns values of the timestamp type.	Returns values of the date type.

Compatibility Item	Oracle	Teradata	MySQL
Return value type of add_months	Returns values of the timestamp type.	Returns values of the timestamp type.	If the input parameter is of the date type, the return value is of the date type. If the input parameter is of the timestamp type, the return value is of the timestamp type. If the input parameter is of the timestamptz type, the return value is of the timestamptz type.
CURRENT_TIME CURRENT_TIME(p)	Obtains the time of the current transaction. The return value is of the timetz type.	Obtains the time of the current transaction. The return value is of the timetz type.	Obtains the execution time of the current statement. The return value is of the time type.
CURRENT_TIMESTAMP CURRENT_TIMESTAMP(p)	Obtains the execution time of the current statement. The return value is of the timestamptz type.	Obtains the execution time of the current statement. The return value is of the timestamptz type.	Obtains the execution time of the current statement. The return value is of the timestamp type.
CURDATE	Not supported	Not supported	Obtains the execution date of the current statement. The return value is of the date type.
CURTIME(p)	Not supported	Not supported	Obtains the execution time of the current statement. The return value is of the time type.

Compatibility Item	Oracle	Teradata	MySQL
LOCALTIME LOCALTIME(p)	Obtains the time of the current transaction. The return value is of the time type.	Obtains the time of the current transaction. The return value is of the time type.	Obtains the execution time of the current statement. The return value is of the timestamp type.
LOCALTIMESTAMP LOCALTIMESTAMP(p)	Obtains the time of the current transaction. The return value is of the timestamp type.	Obtains the time of the current transaction. The return value is of the timestamp type.	Obtains the execution time of the current statement. The return value is of the timestamp type.
SYSDATE SYSDATE(p)	Obtains the execution time of the current statement. The return value is of the timestamp(0) type.	Obtains the execution time of the current statement. The return value is of the timestamp(0) type.	Obtains the current system time. The return value is of the timestamp(0) type. This function cannot be pushed down. You are advised to use current_date instead.
now()	Obtains the time of the current transaction. The return value is of the timestamptz type.	Obtains the time of the current transaction. The return value is of the timestamptz type.	Obtains the statement execution time. The return value is of the timestamptz type.
Operator ^	Performs exponentiation.	Performs exponentiation.	Performs the exclusive OR operation.
Expressions GREATEST and LEAST	Returns the comparison results of all non-null input parameters.	Returns the comparison results of all non-null input parameters.	If an input parameter is **null**, **null** is returned.

Compatibility Item	Oracle	Teradata	MySQL
Different input parameter types of CASE, COALESCE, IF, and IFNULL expressions	Reports error.	Is compatible with behavior of Teradata and supports type conversion between digits and strings. For example, if input parameters for COALESCE are of INT and VARCHAR types, the parameters are resolved as VARCHAR type.	Is compatible with behavior of MySQL and supports type conversion between strings and other types. For example, if input parameters for COALESCE are of DATE, INT, and VARCHAR types, the parameters are resolved as VARCHAR type.
Backquote (`)	Not supported	Not supported	Distinguishes MySQL reserved words from common characters.

7 Guide: JDBC- or ODBC-Based Development

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

If you do not do so, the status of connections in the connection pool will remain, which affects subsequent operations using the connection pool.

7.2 Downloading Drivers

For details, see **Downloading the JDBC or ODBC Driver**.

7.3 JDBC-Based Development

Java Database Connectivity (JDBC) is a Java API for executing SQL statements, providing a unified access interface for different relational databases, based on which applications process data. GaussDB(DWS) supports JDBC 4.0 and requires JDK 1.6 or later for code compiling. It does not support JDBC-ODBC Bridge.

7.3.1 JDBC Package and Driver Class

JDBC Package

Obtain a JDBC package from the release package. The package name is **dws_8.x.x_jdbc_driver.zip**. For more information, see **Downloading Drivers**.

After the decompression, you will obtain the following JDBC packages in .jar format:

- **gsjdbc4.jar**: Driver package compatible with PostgreSQL. The class name and class structure in the driver are the same as those in the PostgreSQL driver. All the applications running on PostgreSQL can be smoothly transferred to the current system.
- **gsjdbc200.jar**: This driver package is used when both PostgreSQL and GaussDB(DWS) are accessed in a JVM process. The main class name is **com.huawei.gauss200.jdbc.Driver** and the prefix of the URL for database connection is **jdbc:gaussdb**. Other information of this driver package is the same as that of **gsjdbc4.jar**.

Driver Class

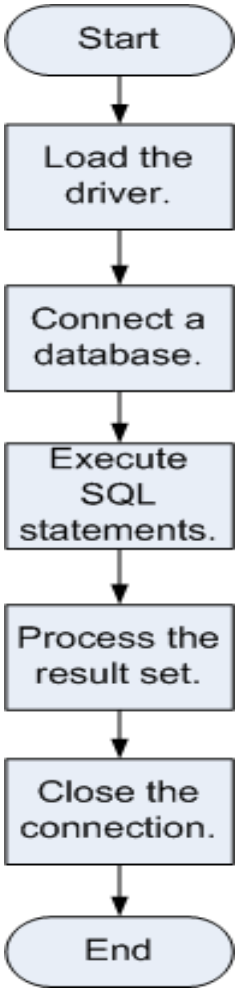
Before creating a database connection, you need to load the database driver class **org.postgresql.Driver** (decompressed from **gsjdbc4.jar**) or **com.huawei.gauss200.jdbc.Driver** (decompressed from **gsjdbc200.jar**).

NOTE

GaussDB(DWS) is compatible with PostgreSQL in the use of JDBC. If two JDBC drivers are used in the same process, class names may conflict.

7.3.2 Development Process

Figure 7-1 JDBC-based application development process



7.3.3 Loading a Driver

Load the database driver before creating a database connection.

You can load the driver in the following ways:

- Implicitly loading the driver before creating a connection in the code: **Class.forName ("org.postgresql.Driver")**
- Transferring a parameter during the JVM startup: **java -Djdbc.drivers=org.postgresql.Driver jdbctest**

  NOTE

  - **jdbctest** is the name of a test application.
  - If **gsjdbc200.jar** is used, change the driver class name to **"com.huawei.gauss200.jdbc.Driver"**.

7.3.4 Connecting to a Database

After a database is connected, you can run SQL statements the database to perform operations on data.

NOTE

If you use an open-source Java Database Connectivity (JDBC) driver, ensure that the database parameter **password_encryption_type** is set to **1**. If the value is not 1, the connection may fail. A typical error message is "none of the server's SASL authentication mechanisms are supported." To avoid such problems, perform the following operations:

1. Set **password_encryption_type** to **1**. For details, see **Modifying Database Parameters**.
2. Create a new database user for connection or reset the password of the existing database user.
   - If you use an administrator account, reset the password. For details, see **Password Reset**.
   - If you are a common user, use another client tool (such as Data Studio) to connect to the database and run the **ALTER USER** statement to change your password.
3. Connect to the database.

Here are the reasons why you need to perform these operations:

- MD5 algorithms may by vulnerable to collision attacks and cannot be used for password verification. Currently, GaussDB(DWS) uses the default security design. By default, MD5 password verification is disabled, but MD5 is required by the open-source libpq communication protocol of PostgreSQL. For connectivity purposes, you need to adjust the cryptographic algorithm parameter **password_encryption_type** and enable the MD5 algorithm.
- The database stores the hash digest of passwords instead of password text. During password verification, the system compares the hash digest with the password digest sent from the client (salt operations are involved). If you change your cryptographic algorithm policy, the database cannot generate a new MD5 hash digest for your existing password. For connectivity purposes, you must manually change your password or create a new user. The new password will be encrypted using the hash algorithm and stored for authentication in the next connection.

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);

Parameter

Table 7-1 Database connection parameters

Parameter	Description
url	**gsjdbc4.jar** database connection descriptor. The descriptor format can be: • jdbc:postgresql:database • jdbc:postgresql://host/database • jdbc:postgresql://host:port/database • jdbc:postgresql://host:port[,host:port][...]/database **NOTE** If **gsjdbc200.jar** is used, replace **jdbc:postgresql** with **jdbc:gaussdb**. • **database**: indicates the name of the database to be connected. • **host** indicates the name or IP address of the database server. If an ELB is bound to the cluster, set **host** to the IP address of the ELB. If the host is on a different network segment from the GaussDB(DWS) it connects to, set the IP address of the server specified by **host** to the value of **mppdb.coo.cooListenIp2** (IP address accessed by applications) set on FusionInsight Manager. For security purposes, the 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**. If you do not do so, the error message "FATAL: Forbid remote connection with trust method!" may be displayed. It is recommended that the service system be deployed outside the cluster. If it is deployed inside, the database performance may be affected. • **port**: indicates the port number of a database server. By default, the database on port **8000** of the local host is connected. • Multiple IP addresses and ports can be configured. JDBC balances load by random access and failover, and will automatically ignore unreachable IP addresses. IP addresses are separated using commas. Example: **jdbc:postgresql://10.10.0.13:8000,10.10.0.14:8000/database** • If JDBC is used to connect to a cluster, only JDBC connection parameters can be configured in a cluster address. Variables cannot be added.

Parameter	Description
info	Database connection properties. Common properties include: • **user**: string type. It indicates the database user establishing a connection. • **password**: string type. It indicates the password of a database user. • **ssl**: Boolean type. It indicates whether the Secure Socket Layer (SSL) is used. • **loggerLevel**: string type. It indicates the amount of information that the driver logs and prints to the LogStream or LogWriter specified in the DriverManager. Currently, **OFF**, **DEBUG**, and **TRACE** are supported. **DEBUG** indicates that only logs of the **DEBUG** or higher level are printed, generating a few log information. **TRACE** indicates that logs of the **DEBUG** and **TRACE** levels are printed, generating detailed log information. The default value is **OFF**, indicating that no information will be logged. • **prepareThreshold**: integer type. It indicates the number of **PreparedStatement** executions required before SQL statements are switched over to servers as prepared statements. The default value is **5**. • **batchMode**: boolean type. It indicates whether to connect the database in batch mode. • **fetchsize**: integer type. It indicates the default fetchsize for statements in the created connection. • **ApplicationName**: string type. It indicates an application name. The default value is **PostgreSQL JDBC Driver**. • **allowReadOnly**: boolean type. It indicates whether to enable the read-only mode for connection. The default value is **false**. If the value is not changed to **true**, the execution of **connection.setReadOnly** does not take effect. • **blobMode**: string type. It is used to set the setBinaryStream method to assign values to different data types. The value **on** indicates that values are assigned to the BLOB data type and **off** indicates that values are assigned to the bytea data type. The default value is **on**. • **connectionExtraInfo**: boolean type. It indicates whether the JDBC driver reports the driver deployment path and process owner to the database. **NOTE** The value can be **true** or **false**. The default value is **true**. If **connectionExtraInfo** is set to **true**, the JDBC 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 **PG_STAT_ACTIVITY** or **PGXC_STAT_ACTIVITY**.
user	Indicates a database user.

Parameter	Description
password	Indicates the password of a database user.

Examples

```
//gsjdbc4.jar is used as an example. To use gsjdbc200.jar, replace the driver class name org.postgresql with com.huawei.gauss200.jdbc and replace the URL prefix jdbc:postgresql with jdbc:gaussdb.
//The following code encapsulates database connection operations into an interface. The database can then be connected using an authorized username and password.

public static Connection GetConnection(String username, String passwd) {
    //Set the driver class.
    String driver = "org.postgresql.Driver";
    //Database connection descriptor.
    String sourceURL = "jdbc:postgresql://10.10.0.13:8000/postgres?currentSchema=test";
    Connection conn = null;

    try {
        //Load the driver.
        Class.forName(driver);
    } catch (ClassNotFoundException e ){
        e.printStackTrace();
        return null;
    }

    try {
         //Establish a connection.
        conn = DriverManager.getConnection(sourceURL, username, passwd);
        System.out.println("Connection succeed!");
    } catch (SQLException e) {
        e.printStackTrace();
        return null;
    }

    return conn;
}
```

7.3.5 Executing SQL Statements

Executing an Ordinary SQL Statement

The application performs data (parameter statements do not need to be transferred) in the database by running SQL statements, and you need to perform the following steps:

Step 1 Create a statement object by triggering the createStatement method in Connection.

```
Statement stmt = con.createStatement();
```

Step 2 Execute the SQL statement by triggering the executeUpdate method in Statement.

```
int rc = stmt.executeUpdate("CREATE TABLE customer_t1(c_customer_sk INTEGER, c_customer_name VARCHAR(32));");
```


> **NOTE**
>
> If an execution request (not in a transaction block) received in the database contains multiple statements, the request is packed into a transaction. **VACUUM** is not supported in a transaction block. If one of the statements fails, the entire request will be rolled back.

Step 3 Close the statement object.

```
stmt.close();
```

----End

Executing a Prepared SQL Statement

Pre-compiled statements were once complied and optimized and can have additional parameters for different usage. For the statements have been pre-compiled, the execution efficiency is greatly improved. If you want to execute a statement for several times, use a precompiled statement. Perform the following procedure:

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 triggering the setShort method in PreparedStatement.

```
pstmt.setShort(1, (short)2);
```

Step 3 Execute the precompiled SQL statement by triggering the executeUpdate method in PreparedStatement.

```
int rowcount = pstmt.executeUpdate();
```

Step 4 Close the precompiled statement object by calling the close method in PreparedStatement.

```
pstmt.close();
```

----End

Calling a Stored Procedure

Perform the following steps to call existing stored procedures through the JDBC interface in GaussDB(DWS):

Step 1 Create a call statement object by calling the prepareCall method in Connection.

```
CallableStatement cstmt = myConn.prepareCall("{? = CALL TESTPROC(?,?,?)}");
```

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 with an output parameter by calling the registerOutParameter method in CallableStatement.

```
cstmt.registerOutParameter(4, Types.INTEGER);  //Register an OUT parameter as an integer.
```

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.
```

For example:

```
//The following stored procedure has been created with the OUT parameter:
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. Close these actions 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 a 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(DWS) JDBC driver does not support this method.
- GaussDB(DWS) does not support functions containing OUT parameters, or default values of stored procedures and function parameters.

----End

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 executed separately.

Batch Processing

When a prepared statement batch processes multiple pieces of similar data, the database creates only one execution plan. This improves the compilation and optimization efficiency. Perform the following procedure:

Step 1 Create a prepared statement object by calling the prepareStatement method in Connection.

```
PreparedStatement pstmt = con.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 Execute batch processing by calling the executeBatch method in PreparedStatement.


```
int[] rowcount = pstmt.executeBatch();
```

Step 4 Close the precompiled statement object by calling the close method in PreparedStatement.

```
pstmt.close();
```

NOTE

Do not terminate a batch processing action when it is ongoing; otherwise, the database performance will deteriorate. Therefore, disable the automatic submission function during batch processing, and manually submit every several lines. The statement for disabling automatic submission is **conn.setAutoCommit(false)**.

----End

7.3.6 Processing Data in a Result Set

Setting a Result Set Type

Different types of result sets are applicable to different application scenarios. Applications select proper types of result sets based on requirements. Before executing an SQL statement, you must create a statement object. Some methods of creating statement objects can set the type of a result set. **Table 7-2** 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);
```


Table 7-2 Result set types

Parameter	Description
resultSetType	Indicates the type of a result set. There are three types of result sets: • **ResultSet.TYPE_FORWARD_ONLY**: The ResultSet object can only be navigated forward. It is the default value. • **ResultSet.TYPE_SCROLL_SENSITIVE**: You can view the modified result by scrolling to the modified row. • **ResultSet.TYPE_SCROLL_INSENSITIVE**: The ResultSet object is insensitive to changes in the underlying data source. **NOTE** 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	Indicates the concurrency type of a result set. There are two types of concurrency. • **ResultSet.CONCUR_READ_ONLY**: The data in a result set cannot be updated except that an updated statement has been created in the result set data. • **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 7-3** lists these methods.

Table 7-3 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.

Method	Description
beforeFirst()	Places cursor before the first row.
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 cursor forward or backward a specified number of rows.

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. JDBC driver provides a method to obtain the cursor position in a result set. **Table 7-4** lists the method.

Table 7-4 Method for obtaining the 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 7-5** lists the common methods for obtaining data. If you want to know more about other methods, see JDK official documents.

Table 7-5 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 int.
int getInt(String columnLabel)	Retrieves the value of the column designated by a column label in the current row as an int.
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.

7.3.7 Closing the Connection

After you complete required data operations in the database, close the database connection.

Call the close method to close the connection, such as, **conn. close()**.

7.3.8 Example: Common Operations

Example 1

Before completing the following example, you need to create a stored procedure.

```
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;
/
```

This example illustrates how to develop applications based on the GaussDB(DWS) JDBC interface.

```
//DBtest.java
//gsjdbc4.jar is used as an example. To use gsjdbc200.jar, replace the driver class name org.postgresql
```


with **com.huawei.gauss200.jdbc** and replace the URL prefix **jdbc:postgresql** with **jdbc:gaussdb**.

```
// 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;

public class DBTest {

  //Establish a connection to the database.
  public static Connection GetConnection(String username, String passwd) {
    String driver = "org.postgresql.Driver";
    String sourceURL = "jdbc:postgresql://localhost:/gaussdb";
    Connection conn = null;
    try {
      //Load the database driver.
      Class.forName(driver).newInstance();
    } catch (Exception e) {
      e.printStackTrace();
      return null;
    }

    try {
      //Establish a connection to the database.
      conn = DriverManager.getConnection(sourceURL, username, passwd);
      System.out.println("Connection succeed!");
    } catch (Exception e) {
      e.printStackTrace();
      return null;
    }

    return conn;
  };

  //Run an ordinary SQL statement. Create a customer_t1 table.
  public static void CreateTable(Connection conn) {
    Statement stmt = null;
    try {
      stmt = conn.createStatement();

      //Run an ordinary 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 the preprocessing 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();
    }
    //Run batch processing.
    pst.executeBatch();
    pst.close();
  } catch (SQLException e) {
    if (pst != null) {
      try {
        pst.close();
      } catch (SQLException e1) {
      e1.printStackTrace();
      }
    }
    e.printStackTrace();
  }
}

 //Run the precompilation 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();
   }
 }


//Run a stored procedure.
 public static void ExecCallableSQL(Connection conn) {
   CallableStatement cstmt = null;
   try {

     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 as an integer.
     cstmt.execute();
     int out = cstmt.getInt(4);  //Obtain the out parameter value.
     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) {
   //Establish a connection to the database.
   Connection conn = GetConnection("tester", "password");

   //Create a table.
   CreateTable(conn);

   //Insert data in batches.
   BatchInsertData(conn);

  //Run the precompilation 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, you need to disable the autocommit function.

```
// Disable the autocommit function.
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.");
}
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.");
}
rs.close();

// Close the statement.
st.close();
```


7.3.9 Example: Retrying SQL Queries for Applications

If the primary DN is faulty and cannot be restored within 40s, its standby is automatically promoted to primary to ensure the normal running of the cluster. Jobs running during the failover will fail and those started after the failover will not be affected. To protect upper-layer services from being affected by the failover, refer to the following example to construct a SQL retry mechanism at the service layer.

```
//gsjdbc4.jar is used as an example. To use gsjdbc200.jar, replace the driver class name org.postgresql
with com.huawei.gauss200.jdbc and replace the URL prefix jdbc:postgresql with jdbc:gaussdb.
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 {
  //Establish a connection to the database.
   public static Connection GetConnection(String username, String passwd) {
     String driver = "org.postgresql.Driver";
     String sourceURL = "jdbc:postgresql://10.131.72.136:8000/gaussdb";
     Connection conn = null;
     try {
      //Load the database driver.
       Class.forName(driver).newInstance();
     } catch (Exception e) {
       e.printStackTrace();
       return null;
     }

     try {
      //Establish a connection to the database.
       conn = DriverManager.getConnection(sourceURL, username, passwd);
       System.out.println("Connection succeed!");
     } catch (Exception e) {
       e.printStackTrace();
       return null;
     }

     return conn;
}
```



```
//Run an ordinary SQL statement. Create a jdbc_test1 table.
 public static void CreateTable(Connection conn) {
   Statement stmt = null;
   try {
     stmt = conn.createStatement();

     // add ctrl+c handler
     Runtime.getRuntime().addShutdownHook(new ExitHandler(stmt));

    // Run an ordinary 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 the preprocessing 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 the precompilation 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;
     }

//Run a query statement and retry upon a failure. The number of retry times can be configured.
   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 {
      //Establish a connection to the database.
       Connection conn = GetConnection("testuser", "test@123");

      //Create a table.
       CreateTable(conn);

      //Insert data in batches.
       BatchInsertData(conn);

      //Run the precompilation statement to update data.
       ExecPreparedSQL(conn);

      //Disconnect from the database.
       try {
         conn.close();
       } catch (SQLException e) {
         e.printStackTrace();
       }
```



```
 }

}
```

7.3.10 Example: Importing and Exporting Data Through Local Files

When the JAVA language is used for secondary development based on GaussDB(DWS), 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(DWS) JDBC driver before running it.

```
//gsjdbc4.jar is used as an example. To use gsjdbc200.jar, replace the driver class name org.postgresql
with com.huawei.gauss200.jdbc and replace the URL prefix jdbc:postgresql with jdbc:gaussdb.
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/gaussdb"); //URL of the database
     String username = new String("jack");            //Username
     String password = new String("********");       // Password
     String tablename = new String("migration_table"); //Define table information.
     String tablename1 = new String("migration_table_1"); //Define 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 migration_table to the local file d:/data.txt.
     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", migration_table_1);
  } catch (SQLException e) {
 // TODO Auto-generated catch block
        e.printStackTrace();
} catch (IOException e) {
 // TODO Auto-generated catch block
```



```
 e.printStackTrace();
}

    //Export the data from the migration_table_1 table to the d:/data1.txt file.
    try {
    copyToFile(conn, "d:/data1.txt", migration_table_1);
 } 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();
          }
       }
    }
 }
}
```

7.3.11 Example: Migrating Data from MySQL to GaussDB(DWS)

The following example shows how to use CopyManager to migrate data from MySQL to GaussDB(DWS).

```
//gsjdbc4.jar is used as an example. To use gsjdbc200.jar, replace the driver class name org.postgresql with com.huawei.gauss200.jdbc and replace the URL prefix jdbc:postgresql with jdbc:gaussdb.
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/gaussdb"); //URL of the database
        String user = new String("jack");            //DWS username
String pass = new String("********");     //DWS password
        String tablename = new String("migration_table"); //Define table information.
        String delimiter = new String("|");              //Define a delimiter.
        String encoding = new String("UTF8");            //Define a character set.
        String driver = "org.postgresql.Driver";
        StringBuffer buffer = new StringBuffer();       //Define the 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
newline character to form 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 table information.
                String sql = "Copy " + tablename + " from STDIN DELIMITER " + "'" + delimiter + "'" + "
ENCODING " + "'" + encoding + "'";

                //Submit 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();
        }
    }

    //**********************************
    //Return the query result 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", "********");
            Statement stmt = conn.createStatement();
            rs = stmt.executeQuery("select * from migration_table");
        } catch (SQLException e) {
            e.printStackTrace();
        } catch (Exception e) {
            e.printStackTrace();
        }
        return rs;
    }
}
```

7.3.12 Example: Processing the RoaringBitmap Result Set on Application Then Importing It to GaussDB(DWS)

GaussDB(DWS) 8.1.3 and later versions support the RoaringBitmap function. When using the Java language to perform secondary development based on GaussDB(DWS), you can use the CopyManager interface to import a small amount of RoaringBitmap data to GaussDB(DWS).

NOTE

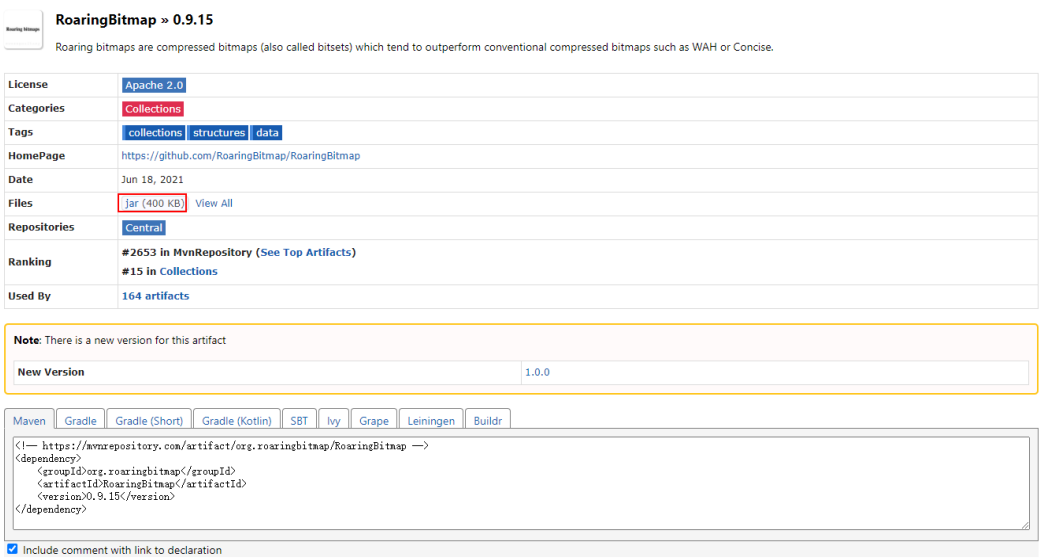
To import a large amount of RoaringBitmap data, computing power of the application side needs to be increased. Otherwise, the import performance will be affected.

Processing RoaringBitmap Data

Step 1 Visit **Maven** to download the open-source RoaringBitmap JAR package. Version 0.9.15 is recommended.

The dependency items of the POM file are configured as follows:

```
<dependencies>
 <dependency>
 <groupId>org.roaringbitmap</groupId>
 <artifactId>RoaringBitmap</artifactId>
 <version>0.9.15</version>
 </dependency>
 </dependencies>
```



Step 2 Invoke the JAR package to convert data to the RoaringBitmap type.

The general process is to declare a Roaring bitmap, call the add() method to convert data of the int type into the Roaringbitmap type, and then serialize the converted data. The sample code is as follows:

```
RoaringBitmap rr2 = new RoaringBitmap ();
for (int i = 1; i < 10000000;  i++)  {
     rr2.add(i);
}
ByteArrayOutputStream a = new ByteArrayOutputStream();
DataOutputStream b = new DataOutputStream(a);
rr2.serialize(b);
```

----End

Data Import

Invoke CopyManager to import data to the database. In this way, a small amount of RoaringBitmap data can be imported to the database without having to be stored locally.

```
//gsjdbc4.jar is used as an example. If gsjdbc200.jar is used, replace the driver class name org.postgresql with com.huawei.gauss200.jdbc and replace the URL prefix jdbc:postgresql with jdbc:gaussdb.

package rb_demo;

import org.postgresql.copy.CopyManager;
import org.postgresql.core.BaseConnection;
import org.roaringbitmap.RoaringBitmap;

import java.io.ByteArrayInputStream;
import java.io.ByteArrayOutputStream;
import java.io.DataOutputStream;
import java.io.IOException;
import java.io.InputStream;
import java.io.StringReader;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.PreparedStatement;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;

public class rb_demo {

   private static String hexStr =  "0123456789ABCDEF";

   public static String bytesToHex(byte[] bytes) {
      StringBuffer sb = new StringBuffer();
      for (int i = 0; i < bytes.length; i++) {
         String hex = Integer.toHexString(bytes[i] & 0xFF);
         if (hex.length() < 2) {
            sb.append(0);
         }
         sb.append(hex);
      }
      return sb.toString();
   }

   public static Connection GetConnection(String username, String passwd) {
      String driver = "org.postgresql.Driver";
String sourceURL = "jdbc:postgresql://10.185.180.161: 8000/gaussdb"; //Database URL
      Connection conn = null;
      try {
     //Load the database driver.
```



```
            Class.forName(driver).newInstance();
        } catch (Exception e) {
            e.printStackTrace();
            return null;
        }

        try {
    //Establish a connection to the database.
            conn = DriverManager.getConnection(sourceURL, username, passwd);
            System.out.println("Connection succeed!");
        } catch (Exception e) {
            e.printStackTrace();
            return null;
        }

        return conn;
    }

    public static void main(String[] args) throws IOException {

        RoaringBitmap rr2 = new RoaringBitmap();

        for (int i = 1; i < 10000000; i++) {
            rr2.add(i);
        }

        ByteArrayOutputStream a = new ByteArrayOutputStream();

        DataOutputStream b = new DataOutputStream(a);
        rr2.serialize(b);

Connection conn = GetConnection("test", "Gauss_234"); //User name and password.
        Statement pstmt = null;
        try {
            conn.setAutoCommit(true);
            pstmt = conn.createStatement();

            pstmt.execute("drop table if exists t_rb");
            pstmt.execute("create table t_rb(c1 int, c2 roaringbitmap) distribute by hash (c1);");

            StringReader sr = null;
            CopyManager cm = null;
            cm = new CopyManager((BaseConnection) conn);

            String delimiter = "|";
            StringBuffer tuples = new StringBuffer();
            tuples.append("1" + delimiter + "\\x" + bytesToHex(a.toByteArray()));


            StringBuffer sb = new StringBuffer();
            sb.append(tuples.toString());

            sr = new StringReader(tuples.toString());
            String sql = "copy t_rb from STDIN with (delimiter '|', NOESCAPING)";

long rows = cm.copyIn(sql, sr);//Execute the COPY command to save data to the database.

            pstmt.close();
        } catch (SQLException e) {
            if (pstmt != null) {
                try {
                    pstmt.close();
                } catch (SQLException e1) {
                    e1.printStackTrace();
                }
            }
            e.printStackTrace();
        }
```



```
    }
}
```

7.3.13 JDBC Interface Reference

JDBC interface is a set of API methods for users. This section describes some common interfaces. For other interfaces, see information in JDK1.6 (software package) and JDBC4.0.

7.3.13.1 java.sql.Connection

This section describes **java.sql.Connection**, the interface for connecting to a database.

Table 7-6 Support status for java.sql.Connection

Method Name	Return Type	Support JDBC 4
close()	void	Yes
commit()	void	Yes
createStatement()	Statement	Yes
getAutoCommit()	boolean	Yes
getClientInfo()	Properties	Yes
getClientInfo(String name)	String	Yes
getTransactionIsolation()	int	Yes
isClosed()	boolean	Yes
isReadOnly()	boolean	Yes
prepareStatement(String sql)	PreparedStatement	Yes
rollback()	void	Yes
setAutoCommit(boolean autoCommit)	void	Yes
setClientInfo(Properties properties)	void	Yes
setClientInfo(String name,String value)	void	Yes

NOTICE

The AutoCommit mode is used by default within the interface. If you disable it 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.

7.3.13.2 java.sql.CallableStatement

This section describes **java.sql.CallableStatement**, the stored procedure execution interface.

Table 7-7 Support status for java.sql.CallableStatement

Method Name	Return Type	Support JDBC 4
registerOutParameter(int parameterIndex, int type)	void	Yes
wasNull()	boolean	Yes
getString(int parameterIndex)	String	Yes
getBoolean(int parameterIndex)	boolean	Yes
getByte(int parameterIndex)	byte	Yes
getShort(int parameterIndex)	short	Yes
getInt(int parameterIndex)	int	Yes
getLong(int parameterIndex)	long	Yes
getFloat(int parameterIndex)	float	Yes
getDouble(int parameterIndex)	double	Yes
getBigDecimal(int parameterIndex)	BigDecimal	Yes
getBytes(int parameterIndex)	byte[]	Yes
getDate(int parameterIndex)	Date	Yes
getTime(int parameterIndex)	Time	Yes
getTimestamp(int parameterIndex)	Timestamp	Yes
getObject(int parameterIndex)	Object	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.

7.3.13.3 java.sql.DatabaseMetaData

This section describes **java.sql.DatabaseMetaData**, the interface for defining database objects.

Table 7-8 Support status for java.sql.DatabaseMetaData

Method Name	Return Type	Support JDBC 4
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
getDriverName()	String	Yes
getDriverVersion()	String	Yes
getDriverMajorVersion()	int	Yes
getDriverMinorVersion()	int	Yes

Method Name	Return Type	Support JDBC 4
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
supportsGroupBy()	boolean	Yes
supportsGroupByUnrelated()	boolean	Yes
supportsGroupByBeyondSelect()	boolean	Yes
supportsLikeEscapeClause()	boolean	Yes

Method Name	Return Type	Support JDBC 4
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
getJDBCMajorVersion()	int	Yes
getJDBCMinorVersion()	int	Yes

7.3.13.4 java.sql.Driver

This section describes **java.sql.Driver**, the database driver interface.

Table 7-9 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

7.3.13.5 java.sql.PreparedStatement

This section describes **java.sql.PreparedStatement**, the interface for preparing statements.

Table 7-10 Support status for java.sql.PreparedStatement

Method Name	Return Type	Support JDBC 4
clearParameters()	void	Yes
execute()	boolean	Yes
executeQuery()	ResultSet	Yes
excuteUpdate()	int	Yes
getMetaData()	ResultSetMetaData	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

Method Name	Return Type	Support JDBC 4
setFloat(int parameterIndex, float x)	void	Yes
setInt(int parameterIndex, int x)	void	Yes
setLong(int parameterIndex, long x)	void	Yes
setNString(int parameterIndex, String value)	void	Yes
setShort(int parameterIndex, short x)	void	Yes
setString(int parameterIndex, String x)	void	Yes
addBatch()	void	Yes
executeBatch()	int[]	Yes
clearBatch()	void	Yes

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 (add a batch again), set*() is not necessary.
- The following methods are inherited from java.sql.Statement: close, execute, executeQuery, executeUpdate, getConnection, getResultSet, getUpdateCount, isClosed, setMaxRows, and setFetchSize.

7.3.13.6 java.sql.ResultSet

This section describes **java.sql.ResultSet**, the interface for execution result sets.

Table 7-11 Support status for java.sql.ResultSet

Method Name	Return Type	Support JDBC 4
findColumn(String columnLabel)	int	Yes
getBigDecimal(int columnIndex)	BigDecimal	Yes

Method Name	Return Type	Support JDBC 4
getBigDecimal(String columnLabel)	BigDecimal	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
getDate(int columnIndex)	Date	Yes
getDate(String columnLabel)	Date	Yes
getDouble(int columnIndex)	double	Yes
getDouble(String columnLabel)	double	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
getShort(int columnIndex)	short	Yes
getShort(String columnLabel)	short	Yes
getString(int columnIndex)	String	Yes
getString(String columnLabel)	String	Yes

Method Name	Return Type	Support JDBC 4
getTime(int columnIndex)	Time	Yes
getTime(String columnLabel)	Time	Yes
getTimestamp(int columnIndex)	Timestamp	Yes
getTimestamp(String columnLabel)	Timestamp	Yes
isAfterLast()	boolean	Yes
isBeforeFirst()	boolean	Yes
isFirst()	boolean	Yes
next()	boolean	Yes

NOTE

- One Statement cannot have multiple open ResultSets.
- The cursor that is used for traversing the ResultSet cannot be open after committed.

7.3.13.7 java.sql.ResultSetMetaData

This section describes **java.sql.ResultSetMetaData**, which provides details about ResultSet object information.

Table 7-12 Support status for java.sql.ResultSetMetaData

Method Name	Return Type	Support JDBC 4
getColumnCount()	int	Yes
getColumnName(int column)	String	Yes
getColumnType(int column)	int	Yes
getColumnTypeName(int column)	String	Yes

7.3.13.8 java.sql.Statement

This section describes **java.sql.Statement**, the interface for executing SQL statements.

Table 7-13 Support status for java.sql.Statement

Method Name	Return Type	Support JDBC 4
close()	void	Yes
execute(String sql)	boolean	Yes
executeQuery(String sql)	ResultSet	Yes
executeUpdate(String sql)	int	Yes
getConnection()	Connection	Yes
getResultSet()	ResultSet	Yes
getQueryTimeout()	int	Yes
getUpdateCount()	int	Yes
isClosed()	boolean	Yes
setQueryTimeout(int seconds)	void	Yes
setFetchSize(int rows)	void	Yes
cancel()	void	Yes

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 transaction. If **setFetchSize** is set, set **setAutoCommit(false)** and commit transactions on the connection to flush service data to a database.

7.3.13.9 javax.sql.ConnectionPoolDataSource

This section describes **javax.sql.ConnectionPoolDataSource**, the interface for data source connection pools.

Table 7-14 Support status for javax.sql.ConnectionPoolDataSource

Method Name	Return Type	Support JDBC 4
getLoginTimeout()	int	Yes
getLogWriter()	PrintWriter	Yes
getPooledConnection()	PooledConnection	Yes

Method Name	Return Type	Support JDBC 4
getPooledConnection(String user,String password)	PooledConnection	Yes
setLoginTimeout(int seconds)	void	Yes
setLogWriter(PrintWriter out)	void	Yes

7.3.13.10 javax.sql.DataSource

This section describes **javax.sql.DataSource**, the interface for data sources.

Table 7-15 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

7.3.13.11 javax.sql.PooledConnection

This section describes **javax.sql.PooledConnection**, the connection interface created by a connection pool.

Table 7-16 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

Method Name	Return Type	Support JDBC 4
addStatementEventListener (StatementEventListener listener)	void	Yes
removeStatementEventListener (StatementEventListener listener)	void	Yes

7.3.13.12 javax.naming.Context

This section describes **javax.naming.Context**, the context interface for connection configuration.

Table 7-17 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

7.3.13.13 javax.naming.spi.InitialContextFactory

This section describes **javax.naming.spi.InitialContextFactory**, the initial context factory interface.

Table 7-18 Support status for javax.naming.spi.InitialContextFactory

Method Name	Return Type	Support JDBC 4
getInitialContext(Hashtable<?,?> environment)	Context	Yes

7.3.13.14 CopyManager

CopyManager is an API interface class provided by the JDBC driver in GaussDB(DWS). It is used to import data to GaussDB(DWS) in batches.

Inheritance Relationship of CopyManager

The CopyManager class is in the **org.postgresql.copy** package class and inherits the java.lang.Object class. The declaration of the class is as follows:

```
public class CopyManager
extends Object
```

Construction Method

public CopyManager(BaseConnection connection)

throws SQLException

Basic Methods

Table 7-19 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

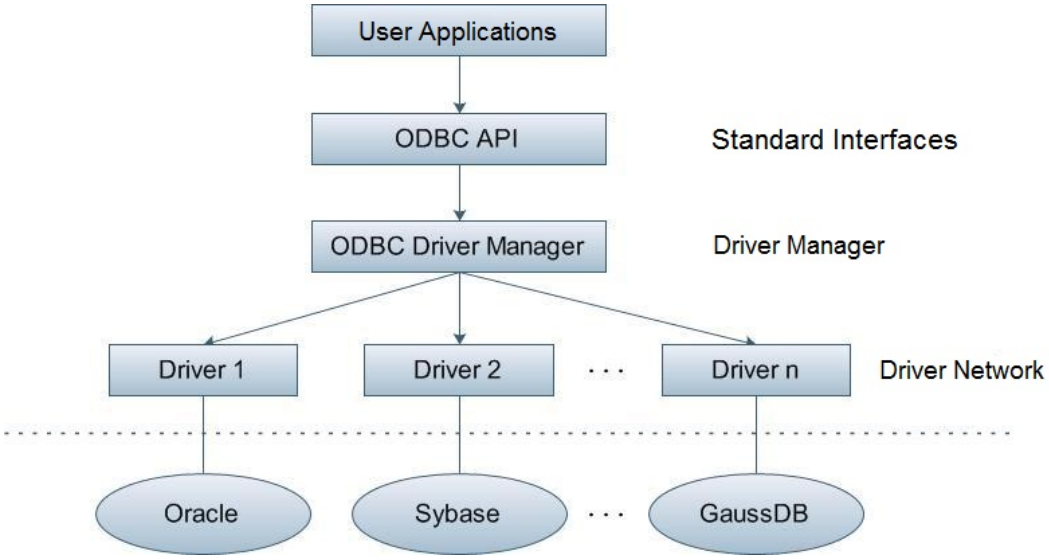
Return Value	Method	Description	throws
long	copyIn(String sql, Reader from)	Uses **COPY FROM STDIN** to quickly load data to tables in the database from Reader.	SQLException,IOException
long	copyIn(String sql, Reader from, int bufferSize)	Uses **COPY FROM STDIN** to quickly load data to tables in the database from Reader.	SQLException,IOException
CopyOut	copyOut(String sql)	-	SQLException
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

7.4 ODBC-Based Development

Open Database Connectivity (ODBC) is a Microsoft API for accessing databases based on the X/OPEN CLI. The ODBC API alleviates applications from directly operating in databases, and enhances the database portability, extensibility, and maintainability.

Figure 7-2 shows the system structure of ODBC.

Figure 7-2 ODBC system structure



GaussDB(DWS) supports ODBC 3.5 in the following environments.

Table 7-20 OSs Supported by ODBC

OS	Platform
SUSE Linux Enterprise Server 11 SP1/SP2/SP3/SP4 SUSE Linux Enterprise Server 12 and SP1/SP2/SP3/SP5	x86_64
Red Hat Enterprise Linux 6.4/6.5/6.6/6.7/6.8/6.9/7.0/7.1/7.2/7.3/7.4/7.5	x86_64
Red Hat Enterprise Linux 7.5	ARM64
CentOS 6.4/6.5/6.6/6.7/6.8/6.9/7.0/7.1/7.2/7.3/7.4	x86_64
CentOS 7.6	ARM64
EulerOS 2.0 SP2/SP3	x86_64
EulerOS 2.0 SP8	ARM64
NeoKylin 7.5/7.6	ARM64
Oracle Linux R7U4	x86_64
Windows 7	32-bit
Windows 7	64-bit
Windows Server 2008	32-bit
Windows Server 2008	64-bit

The operating systems listed above refer to the operating systems on which the ODBC program runs. They can be different from the operating systems where databases are deployed.

The ODBC Driver Manager running on UNIX or Linux can be unixODBC or iODBC. Select unixODBC-2.3.0 here as the component for connecting 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 GaussDB(DWS) data types, such as tinyint, smalldatetime, and nvarchar2.

7.4.1 ODBC Package and Its Dependent Libraries and Header Files

ODBC Package for the Linux OS

Obtain the **dws_8**.*x.x*_**odbc_driver_for**_*xxx_xxx*.**zip** package from the release package. In the Linux OS, header files (including **sql.h** and **sqlext.h**) and library (**libodbc.so**) are required in application development. These header files and libraries can be obtained from the unixODBC-2.3.0 installation package.

ODBC Package for the Windows OS

Obtain the **dws_8**.*x.x*_**odbc_driver_for_windows.zip** package from the release package. In the Windows OS, the required header files and library files are system-resident.

7.4.2 Configuring a Data Source in the Linux OS

The ODBC DRIVER (psqlodbcw.so) provided by GaussDB(DWS) can be used after it has been configured in the data source. To configure data sources, users 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 at: Currently, unixODBC-2.2.1 is not supported. unixODBC-2.3.0 is used as an example.

https://sourceforge.net/projects/unixodbc/files/unixODBC/2.3.0/unixODBC-2.3.0.tar.gz/download

Step 2 Prepare **unixODBC**.

1. Decompress the **unixODBC** code file.
   ```
   tar -xvf unixODBC-2.3.0.tar.gz
   ```
2. Compile the code file and install the driver.
   ```
   cd unixODBC-2.3.0
   ./configure --enable-gui=no
   ```



```
make
make install
```

NOTE

- After the unixODBC is compiled and installed, the ***.so.2** library file will be in the installation directory. To create the ***.so.1** library file, change **LIB_VERSION** in the configure file to **1:0:0**.
  ```
  LIB_VERSION="1:0:0"
  ```
- This driver dynamically loads the **libodbcinst.so.*** library files. If one of the library files is successfully loaded, the library file is loaded. The loading priority is **libodbcinst.so** > **libodbcinst.so.1** > **libodbcinst.so.1.0.0** > **libodbcinst.so.2** > **libodbcinst.so.2.0.0**.

  For example, a directory can be dynamically linked to **libodbcinst.so.1**, **libodbcinst.so.1.0.0**, and **libodbcinst.so.2**. The driver file loads **libodbcinst.so** first. If **libodbcinst.so** cannot be found in the current environment, the driver file searches for **libodbcinst.so.1**, which has a lower priority. After **libodbcinst.so.1** is loaded, the loading is complete.

Step 3 Replace the GaussDB(DWS) client driver.

Decompress **dws_8**.*x.x*_**odbc_driver_for**_*xxx_xxx*.**zip** to obtain the **psqlodbcw.la** and **psqlodbcw.so** files in the **/dws_8**.*x.x*_**odbc_driver_for**_*xxx_xxx*/**odbc/lib** directory.

Step 4 Configure the data source.

1. Configure the ODBC driver file.

   Add the following content to the end of 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 7-21**.

   Table 7-21 odbcinst.ini configuration parameters

Parameter	Description	Example
[DriverName]	Driver name, corresponding to Driver in DSN.	[DRIVER_N]
Driver64	Path of the dynamic driver library	Driver64=/xxx/odbc/lib/psqlodbcw.so
setup	Driver installation path, which is the same as the dynamic library path in Driver64.	setup=/xxx/odbc/lib/psqlodbcw.so

2. Configure the data source file.

   Add the following content to the end of the **/usr/local/etc/odbc.ini** file:

   ```
   [MPPODBC]
   Driver=GaussMPP
   Servername=10.10.0.13 (database server IP address)
   Database=gaussdb (database name)
   Username=dbadmin (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 7-22**.

Table 7-22 odbc.ini configuration parameters

Parameter	Description	Example
[DSN]	Data source name	[MPPODBC]
Driver	Driver name, corresponding to DriverName in **odbcinst.ini**	Driver=DRIVER_N
Servername	IP address of the server	Servername=10.145.130.26
Database	Name of the database to connect to	Database=gaussdb
Username	Name of the database user	Username=dbadmin
Password	Password of the database user	Password= **NOTE** After a user established a connection, the ODBC driver automatically clears their password stored in memory. 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. 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.
Port	Port ID of the server	Port=8000
Sslmode	Whether to enable the SSL	Sslmode=allow
UseServerSidePrepare	Whether to enable the extended query protocol for the database. The value can be **0** or **1**. The default value is **1**, indicating that the extended query protocol is enabled.	UseServerSidePrepare=1

Parameter	Description	Example
UseBatchProtocol	Whether to enable the batch query protocol. If it is enabled, the DML performance can be improved. The value can be **0** or **1**. The default value is **1**. If this parameter is set to **0**, the batch query protocol is disabled (mainly for communication with earlier database versions). If this parameter is set to **1** and the **support_batch_bind** parameter is set to **on**, the batch query protocol is enabled.	UseBatchProtocol=1
ConnectionExtraInfo	Whether to display the driver deployment path and process owner in the **connection_info** parameter mentioned in **connection_info**	ConnectionExtraInfo=1 **NOTE** The default value is **1**. If this parameter is set to **0**, the ODBC driver reports the name and version of the current driver to the database. If this parameter is set to **1**, the ODBC driver reports the name, deployment path, and process owner of the current driver to the database and records them in the **connection_info** parameter (see **connection_info**). You can query this parameter in **PG_STAT_ACTIVITY** and **PGXC_STAT_ACTIVITY**.

Parameter	Description	Example
ForExtensionConnector	ETL tool performance optimization parameter. It can be used to optimize the memory and reduce the memory usage by the peer CN, to avoid system instability caused by excessive CN memory usage. The value can be **0** or **1**. The default value is **0**, indicating that the optimization item is disabled. Do not set this parameter for other services outside the database system. Otherwise, the service correctness may be affected.	ForExtensionConnector=1
KeepDisallowPremature	Specifies whether the cursor in the SQL statement has the **with hold** attribute when the following conditions are met: **UseDeclareFetch** is set to **1**, and the application invokes **SQLNumResultCols**, **SQLDescribeCol**, or **SQLColAttribute** after invoking **SQLPrepare** to obtain the column information of the result set. The value can be **0** or **1**. **0** indicates that the with hold attribute is supported, and **1** indicates that the with hold attribute is not supported. The default value is **0**.	KeepDisallowPremature=1 **NOTE** When **UseServerSidePrepare** is set to **1**, the **KeepDisallowPremature** parameter does not take effect. To use this parameter, set **UseServerSidePrepare** to **0**. For example, set **UseDeclareFetch** to **1**. KeepDisallowPremature=1 UseServerSidePrepare=0

The valid values of **sslmode** are as follows.

Table 7-23 sslmode options

sslmode	Whether SSL Encryption Is Enabled	Description
disable	No	The SSL secure connection is not used.
allow	Probably	The SSL secure encrypted connection is used if required by the database server, but does not check the authenticity of the server.
prefer	Probably	The SSL secure encrypted connection is used as a preferred mode if supported by the database, but does not check the authenticity of the server.
require	Yes	The SSL secure connection must be used, but it only encrypts data and does not check the authenticity of the server.
verify-ca	Yes	The SSL secure connection must be used, and it checks whether the database has certificates issued by a trusted CA.
verify-full	Yes	The SSL secure connection must be used. In addition to the check scope specified by **verify-ca**, it checks whether the name of the host where the database resides is the same as that on the certificate. This mode is not supported.

Step 5 Enable the SSL mode.

To use SSL certificates for connection, decompress the certificate package contained in the GaussDB(DWS) installation package, and run **source sslcert_env.sh** in a shell environment to deploy certificates in the default location of the current session.

Or manually declare the following environment variables and ensure that the permission for the client.key* series files is set to 600.

```
export PGSSLCERT= "/YOUR/PATH/OF/client.crt" # Change the path to the absolute path of client.crt.
export PGSSLKEY= "/YOUR/PATH/OF/client.key" # Change the path to the absolute path of client.key.
```

In addition, change the value of **Sslmode** in the data source to **verify-ca**.

Step 6 Add the IP address segment of the host where the client is located to the security group rules of GaussDB(DWS) to ensure that the host can communicate with GaussDB(DWS).

Step 7 Configure environment variables.

```
vim ~/.bashrc
```

Add the following content to the end of the configuration file:

```
export LD_LIBRARY_PATH=/usr/local/lib/:$LD_LIBRARY_PATH
export ODBCSYSINI=/usr/local/etc
export ODBCINI=/usr/local/etc/odbc.ini
```


Step 8 Run the following commands to validate the settings:

```
source ~/.bashrc
```

----End

Testing Data Source Configuration

Run the **isql**-*v GaussODBC* command (*GaussODBC* 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.

Troubleshooting

- [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 the **ls** *file path in the error information* command to check whether the **psqlodbcw.so** file exists and you have execution permissions on it.

  – The dependent library of **psqlodbcw.so** does not exist or is not in system environment variables.

  Run the **ldd** *file path in the error information* command. If **libodbc.so.1** or other UnixODBC libraries are lacking, configure UnixODBC again following the procedure provided in this section, and add the **lib** directory under its installation directory to **LD_LIBRARY_PATH**. If other libraries are lacking, add the **lib** directory under 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 based on database server configurations in the procedure in this section.

  – Firewall and network gatekeeper settings are improper.

  Check firewall settings, ensuring 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 it to **allow** or a higher level. For more details, see **Table 7-23**.

- 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 CA 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.

- FATAL: Forbid remote connection with trust method!

  For security purposes, the 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 machine 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, the 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.
- In versions earlier than V100R002C80SPC300, the database stores only SHA-256 hashes and no MD5 hashes. Therefore, MD5 cannot be used for user password authentication.
- In V100R002C80SPC300 and later, 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. If your database is upgraded from a version earlier than V100R002C80SPC300, passwords in the old version will only have SHA-256 hashes and not support MD5 authentication.

To solve this problem, you can update the user password. Alternatively, create a user, assign the same permissions to the user, and use the new user to connect to the database.

- 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.

7.4.3 Configuring a Data Source in the Windows OS

Configure the ODBC data source using the ODBC data source manager preinstalled in the Windows OS.

Procedure

Step 1 Replace the GaussDB(DWS) client driver.

Decompress **GaussDB-8.2.1-Windows-Odbc.tar.gz** and install **psqlodbc.msi** (for 32-bit OS) or **psqlodbc_x64.msi** (for 64-bit OS).

Step 2 Open Driver Manager.

Use the Driver Manager suitable for your OS to configure the data source. (Assume the Windows system drive is drive C.)

- If you develop 32-bit programs in the 64-bit Windows OS, open the 32-bit Driver Manager at **C:\Windows\SysWOW64\odbcad32.exe** after you install the 32-bit driver.

  Do not open Driver Manager by choosing **Control Panel**, clicking **Administrative Tools**, and clicking **Data Sources (ODBC)**.

  NOTE

  WoW64 is the acronym for "Windows 32-bit on Windows 64-bit". **C:\Windows\SysWOW64** stores the 32-bit environment on a 64-bit system.

- If you develop 64-bit programs in the 64-bit Windows OS, open the 64-bit Driver Manager at **C:\Windows\System32\odbcad32.exe** after you install the 64-bit driver.

  Do not open **Driver Manager** by choosing **Control Panel**, clicking **Administrative Tools**, and clicking **Data Sources (ODBC)**.

NOTE

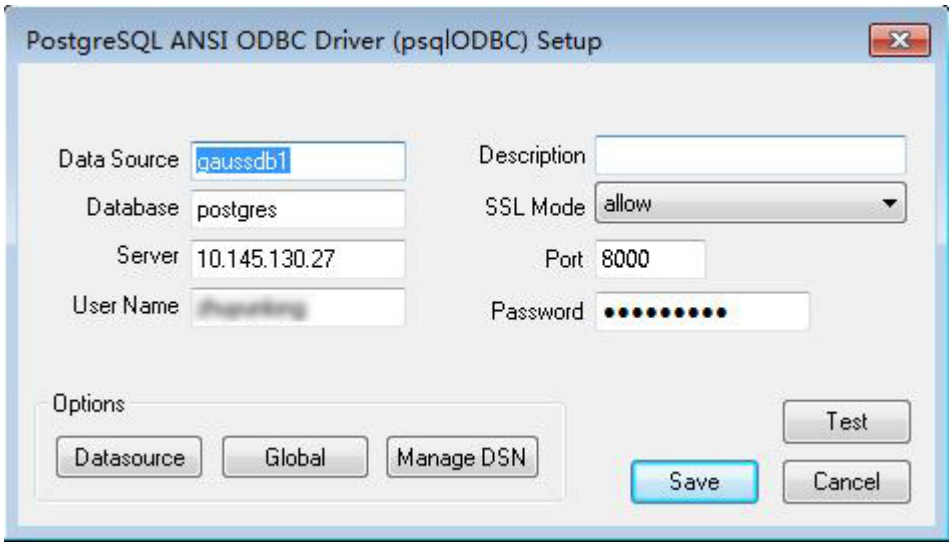
C:\Windows\System32 stores the environment consistent with the current OS. For technical details, see Windows technical documents.

- In a 32-bit Windows OS, open **C:\Windows\System32\odbcad32.exe**.

  In the Windows OS, click **Computer**, and choose **Control Panel**. Click **Administrative Tools** and click **Data Sources (ODBC)**.

Step 3 Configure the data source.

On the **User DSN** tab, click **Add**, and choose **PostgreSQL Unicode** for setup. (An identifier will be displayed for the 64-bit OS.)



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.

To use SSL certificates for connection, decompress the certificate package contained in the GaussDB(DWS) installation package, and double-click the **sslcert_env.bat** file to deploy certificates in the default location.

NOTICE

The **sslcert_env.bat** file ensures the purity of the certificate environment. When the **%APPDATA%\postgresql** directory exists, a message will be prompted asking you whether you want to remove related directories. If you want to remove related directories, back up files in the directory.

Alternatively, you can copy the **client.crt**, **client.key**, **client.key.cipher**, and **client.key.rand** files in the certificate file folder to the manually created **%APPDATA%\postgresql** directory. 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**.

Change the value of **SSL Mode** in step 2 to **verify-ca**.

Table 7-24 sslmode options

sslmode	Whether SSL Encryption Is Enabled	Description
disable	No	The SSL secure connection is not used.
allow	Probably	The SSL secure encrypted connection is used if required by the database server, but does not check the authenticity of the server.
prefer	Probably	The SSL secure encrypted connection is used as a preferred mode if supported by the database, but does not check the authenticity of the server.
require	Yes	The SSL secure connection must be used, but it only encrypts data and does not check the authenticity of the server.
verify-ca	Yes	The SSL secure connection must be used, and it checks whether the database has certificates issued by a trusted CA.
verify-full	Yes	The SSL secure connection must be used. In addition to the check scope specified by **verify-ca**, it checks whether the name of the host where the database resides is the same as that on the certificate. **NOTE** This mode cannot be used.

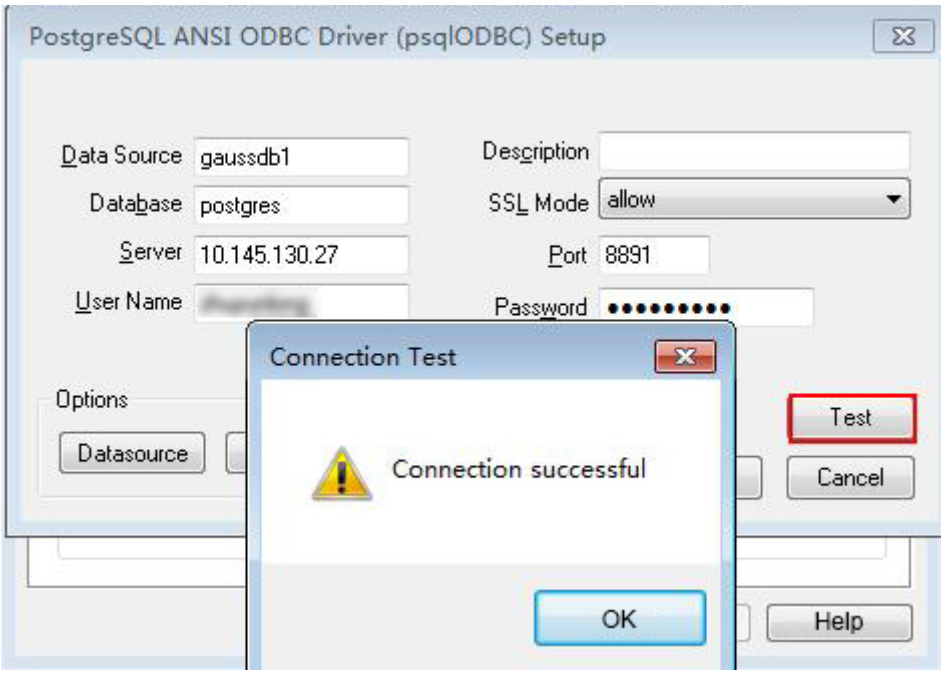
Step 5 Add the IP address segment of the host where the client is located to the security group rules of GaussDB(DWS) to ensure that the host can communicate with GaussDB(DWS).

----End

Testing Data Source Configuration

Click **Test**.

- If the following information is displayed, the configuration is correct and the connection succeeds.



- If error information is displayed, the configuration is incorrect. Check the configuration.

Troubleshooting

- Server common name "xxxx" does not match host name "xxxxx"

  This problem occurs because when **verify-full** is used for SSL encryption, the driver checks whether the host name in certificates is the same as the actual one. To solve this problem, use **verify-ca** to stop checking host names, or generate a set of CA certificates containing the actual host names.

- 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 based on database server configurations in the procedure in this section.

  – Firewall and network gatekeeper settings are improper.

    Check firewall settings, ensuring that the database communication port is trusted.

    Check to ensure network gatekeeper settings are proper (if any).

- In the specified DSN, the system structures of the drive do not match those of the application.

  Possible cause: The bit versions of the drive and program are different.

  C:\Windows\SysWOW64\odbcad32.exe is a 32-bit ODBC Drive Manager.

  C:\Windows\System32\odbcad32.exe is a 64-bit ODBC Drive Manager.

- 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 about **sslmode**, see **Table 7-24**.

- 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.
  - In versions earlier than V100R002C80SPC300, the database stores only SHA-256 hashes and no MD5 hashes. Therefore, MD5 cannot be used for user password authentication.
  - In V100R002C80SPC300 and later, 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. If your database is upgraded from a version earlier than V100R002C80SPC300, passwords in the old version will only have SHA-256 hashes and not support MD5 authentication.

  To solve this problem, perform the following operations:

  a. Set **password_encryption_type** to **1**. For details, see **Modifying Database Parameters**.

  b. Create a new database user for connection or reset the password of the existing database user.

     - If you use an administrator account, reset the password. For details, see **Password Reset**.
     - If you are a common user, use another client tool (such as Data Studio) to connect to the database and run the **ALTER USER** statement to change your password.

  c. Connect to the database.

- 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.

- FATAL: GSS authentication method is not allowed because XXXX user password is not disabled.

  In some cases, the error is: GSSAPI authentication not supported.

  In **pg_hba.conf** of the target CN, the authentication mode is set to **gss** for authenticating the IP address of the current client. However, this authentication algorithm cannot authenticate clients. Change the authentication algorithm to **sha256** and try again.

  Note that cross-node connection to the database in the cluster is not supported. If the error is caused by cross-node connection to the CN in the cluster, connect the service program to the database from a node outside the cluster and try again.

7.4.4 ODBC Development Example

Code for Common Functions

```
// The following example shows how to obtain data from GaussDB(DWS) 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;
SQLLEN        V_StrLen_or_IndPtr;
int main(int argc,char *argv[])
{
    // 1. Apply for 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);
    // 3. Apply for 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. Apply for a statement handle
    SQLAllocHandle(SQL_HANDLE_STMT, V_OD_hdbc, &V_OD_hstmt);
    // 8. Executes an SQL statement directly
    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. Execute the ready statement
```



```
    SQLExecute(V_OD_hstmt);
    SQLExecDirect(V_OD_hstmt,"select id from testtable",SQL_NTS);
    // 12. Obtain the attributes of a certain column in the result set

SQLColAttribute(V_OD_hstmt,1,SQL_DESC_TYPE_NAME,typename,sizeof(typename),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_StrLen_or_IndPtr);
    // 14. Collect data using SQLFetch
    V_OD_erg=SQLFetch(V_OD_hstmt);
    // 15. Obtain and return data using 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 from the data source 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

```
/*************************************************************************
* Set UseBatchProtocol to 1 in the data source and set the database parameter support_batch_bind
* to on.
* 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>

#include "util.c"

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);
   CHECK_ERROR(retcode, "SQLAllocHandle(SQL_HANDLE_STMT)",
               hstmt, SQL_HANDLE_STMT);

   // Prepare Statement
   retcode = SQLPrepare(hstmt, (SQLCHAR*) sql, SQL_NTS);
   sprintf((char*)loginfo, "SQLPrepare log: %s", (char*)sql);
   CHECK_ERROR(retcode, loginfo, hstmt, SQL_HANDLE_STMT);

   retcode = SQLExecute(hstmt);
   sprintf((char*)loginfo, "SQLExecute stmt log: %s", (char*)sql);
   CHECK_ERROR(retcode, loginfo, hstmt, SQL_HANDLE_STMT);

   retcode = SQLFreeHandle(SQL_HANDLE_STMT, hstmt);
   sprintf((char*)loginfo, "SQLFreeHandle stmt log: %s", (char*)sql);
   CHECK_ERROR(retcode, loginfo, hstmt, SQL_HANDLE_STMT);
}
```



```
int main ()
{
    SQLHENV  henv  = SQL_NULL_HENV;
    SQLHDBC  hdbc  = SQL_NULL_HDBC;
    int      batchCount = 1000;
    SQLLEN   rowsCount = 0;
    int      ignoreCount = 0;

    SQLRETURN   retcode;
    SQLCHAR     dsn[1024] = {'\0'};
    SQLCHAR     loginfo[2048];

// Interactively obtain data source names.
    getStr("Please input your DSN", (char*)dsn, sizeof(dsn), 'N');
// Interactively obtain the amount of data to be batch processed.
    getInt("batchCount", &batchCount, 'N', 1);
    do
    {
// Interactively obtain the amount of batch processing data that is not inserted into the database.
        getInt("ignoreCount", &ignoreCount, 'N', 1);
        if (ignoreCount > batchCount)
        {
            printf("ignoreCount(%d) should be less than batchCount(%d)\n", ignoreCount, batchCount);
        }
    }while(ignoreCount > batchCount);

    retcode = SQLAllocHandle(SQL_HANDLE_ENV, SQL_NULL_HANDLE, &henv);
    CHECK_ERROR(retcode, "SQLAllocHandle(SQL_HANDLE_ENV)",
                henv, SQL_HANDLE_ENV);

    // Set ODBC Verion
    retcode = SQLSetEnvAttr(henv, SQL_ATTR_ODBC_VERSION,
                                  (SQLPOINTER*)SQL_OV_ODBC3, 0);
    CHECK_ERROR(retcode, "SQLSetEnvAttr(SQL_ATTR_ODBC_VERSION)",
                henv, SQL_HANDLE_ENV);

    // Allocate Connection
    retcode = SQLAllocHandle(SQL_HANDLE_DBC, henv, &hdbc);
    CHECK_ERROR(retcode, "SQLAllocHandle(SQL_HANDLE_DBC)",
                henv, SQL_HANDLE_DBC);

    // Set Login Timeout
    retcode = SQLSetConnectAttr(hdbc, SQL_LOGIN_TIMEOUT, (SQLPOINTER)5, 0);
    CHECK_ERROR(retcode, "SQLSetConnectAttr(SQL_LOGIN_TIMEOUT)",
                hdbc, SQL_HANDLE_DBC);

    // Set Auto Commit
    retcode = SQLSetConnectAttr(hdbc, SQL_ATTR_AUTOCOMMIT,
                                  (SQLPOINTER)(1), 0);
    CHECK_ERROR(retcode, "SQLSetConnectAttr(SQL_ATTR_AUTOCOMMIT)",
                hdbc, SQL_HANDLE_DBC);

    // Connect to DSN
    sprintf(loginfo, "SQLConnect(DSN:%s)", dsn);
    retcode = SQLConnect(hdbc, (SQLCHAR*) dsn, SQL_NTS,
                           (SQLCHAR*) NULL, 0, NULL, 0);
    CHECK_ERROR(retcode, loginfo, hdbc, SQL_HANDLE_DBC);

    // 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;
    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.
That is, 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);
    CHECK_ERROR(retcode, "SQLAllocHandle(SQL_HANDLE_STMT)",
                hstmtinesrt, SQL_HANDLE_STMT);

    // 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);
    CHECK_ERROR(retcode, loginfo, hstmtinesrt, SQL_HANDLE_STMT);

    retcode = SQLSetStmtAttr(hstmtinesrt, SQL_ATTR_PARAMSET_SIZE, (SQLPOINTER)batchCount,
sizeof(batchCount));
    CHECK_ERROR(retcode, "SQLSetStmtAttr", hstmtinesrt, SQL_HANDLE_STMT);

    retcode = SQLBindParameter(hstmtinesrt, 1, SQL_PARAM_INPUT, SQL_C_SLONG, SQL_INTEGER,
sizeof(ids[0]), 0,&(ids[0]), 0, bufLenIds);
    CHECK_ERROR(retcode, "SQLBindParameter for id", hstmtinesrt, SQL_HANDLE_STMT);

    retcode = SQLBindParameter(hstmtinesrt, 2, SQL_PARAM_INPUT, SQL_C_CHAR, SQL_CHAR, 50, 50,
cols, 50, bufLenCols);
    CHECK_ERROR(retcode, "SQLBindParameter for cols", hstmtinesrt, SQL_HANDLE_STMT);

    retcode = SQLSetStmtAttr(hstmtinesrt, SQL_ATTR_PARAMS_PROCESSED_PTR, (SQLPOINTER)&process,
sizeof(process));
    CHECK_ERROR(retcode, "SQLSetStmtAttr for SQL_ATTR_PARAMS_PROCESSED_PTR", hstmtinesrt,
SQL_HANDLE_STMT);

    retcode = SQLSetStmtAttr(hstmtinesrt, SQL_ATTR_PARAM_STATUS_PTR, (SQLPOINTER)statusptr,
sizeof(statusptr[0]) * batchCount);
    CHECK_ERROR(retcode, "SQLSetStmtAttr for SQL_ATTR_PARAM_STATUS_PTR", hstmtinesrt,
```



```
SQL_HANDLE_STMT);

        retcode = SQLSetStmtAttr(hstmtinesrt, SQL_ATTR_PARAM_OPERATION_PTR, (SQLPOINTER)operptr,
sizeof(operptr[0]) * batchCount);
        CHECK_ERROR(retcode, "SQLSetStmtAttr for SQL_ATTR_PARAM_OPERATION_PTR", hstmtinesrt,
SQL_HANDLE_STMT);

        retcode = SQLExecute(hstmtinesrt);
        sprintf((char*)loginfo, "SQLExecute stmt log: %s", (char*)sql);
        CHECK_ERROR(retcode, loginfo, hstmtinesrt, SQL_HANDLE_STMT);

        retcode = SQLRowCount(hstmtinesrt, &rowsCount);
        CHECK_ERROR(retcode, "SQLRowCount execution", hstmtinesrt, SQL_HANDLE_STMT);

        if (rowsCount != (batchCount - ignoreCount))
        {
            sprintf(loginfo, "(batchCount - ignoreCount)(%d) != rowsCount(%d)", (batchCount - ignoreCount),
rowsCount);
            CHECK_ERROR(SQL_ERROR, loginfo, NULL, SQL_HANDLE_STMT);
        }
        else
        {
            sprintf(loginfo, "(batchCount - ignoreCount)(%d) == rowsCount(%d)", (batchCount - ignoreCount),
rowsCount);
            CHECK_ERROR(SQL_SUCCESS, loginfo, NULL, SQL_HANDLE_STMT);
        }

        if (rowsCount != process)
        {
            sprintf(loginfo, "process(%d) != rowsCount(%d)", process, rowsCount);
            CHECK_ERROR(SQL_ERROR, loginfo, NULL, SQL_HANDLE_STMT);
        }
        else
        {
            sprintf(loginfo, "process(%d) == rowsCount(%d)", process, rowsCount);
            CHECK_ERROR(SQL_SUCCESS, loginfo, NULL, SQL_HANDLE_STMT);
        }

        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]);
                    CHECK_ERROR(SQL_ERROR, loginfo, NULL, SQL_HANDLE_STMT);
                }
            }
            else if (statusptr[i] != SQL_PARAM_SUCCESS)
            {
                sprintf(loginfo, "statusptr[%d](%d) != SQL_PARAM_SUCCESS", i, statusptr[i]);
                CHECK_ERROR(SQL_ERROR, loginfo, NULL, SQL_HANDLE_STMT);
            }
        }

        retcode = SQLFreeHandle(SQL_HANDLE_STMT, hstmtinesrt);
        sprintf((char*)loginfo, "SQLFreeHandle hstmtinesrt");
        CHECK_ERROR(retcode, loginfo, hstmtinesrt, SQL_HANDLE_STMT);
    }


exit:
    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;
}
```

7.4.5 ODBC Interfaces

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).

7.4.5.1 SQLAllocEnv

In ODBC 3.x, **SQLAllocEnv** (an ODBC 2.x function) was deprecated and replaced with **SQLAllocHandle**. For details, see **SQLAllocHandle**.

7.4.5.2 SQLAllocConnect

In ODBC 3.x, **SQLAllocConnect** (an ODBC 2.x function) was deprecated and replaced with **SQLAllocHandle**. For details, see **SQLAllocHandle**.

7.4.5.3 SQLAllocHandle

Function

SQLAllocHandle allocates environment, connection, or statement handles. This function is a generic function for allocating handles that replaces the deprecated ODBC 2.x functions **SQLAllocEnv**, **SQLAllocConnect**, and **SQLAllocStmt**.

Prototype

```
SQLRETURN SQLAllocHandle(SQLSMALLINT   HandleType,
                         SQLHANDLE     InputHandle,
                         SQLHANDLE     *OutputHandlePtr);
```


Parameter

Table 7-25 SQLAllocHandle parameters

Keyword	Description
HandleType	The type of handle to be allocated by SQLAllocHandle. The value must be one of the following: • SQL_HANDLE_ENV (environment handle) • SQL_HANDLE_DBC (connection handle) • SQL_HANDLE_STMT (statement handle) • SQL_HANDLE_DESC (description handle) 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. • If **HandleType** is **SQL_HANDLE_ENV**, this is SQL_NULL_HANDLE. • If **HandleType** is **SQL_HANDLE_DBC**, this must be an environment handle. • If **HandleType** is **SQL_HANDLE_STMT** or **SQL_HANDLE_DESC**, it must be a connection handle.
OutputHandlePtr	**Output parameter**: Pointer to a buffer in which to return the handle to the newly allocated data structure.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

When allocating a non-environment handle, if **SQLAllocHandle** returns **SQL_ERROR**, it sets **OutputHandlePtr** to **SQL_NULL_HENV**, **SQL_NULL_HDBC**, **SQL_NULL_HSTMT**, or **SQL_NULL_HDESC**. The application can then call **SQLGetDiagRec**, with **HandleType** and **Handle** set to **IntputHandle**, to obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.4 SQLAllocStmt

In ODBC 3.x, **SQLAllocStmt** was deprecated and replaced with **SQLAllocHandle**. For details, see **SQLAllocHandle**.

7.4.5.5 SQLBindCol

Function

SQLBindCol is used to associate (bind) columns in a result set to an application data buffer.

Prototype

```
SQLRETURN SQLBindCol(SQLHSTMT       StatementHandle,
                     SQLUSMALLINT   ColumnNumber,
                     SQLSMALLINT    TargetType,
                     SQLPOINTER     TargetValuePtr,
                     SQLLEN         BufferLength,
                     SQLLEN         *StrLen_or_IndPtr);
```

Parameter

Table 7-26 SQLBindCol parameters

Keyword	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 at 1.
TargetType	The 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 available to store the column data.
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 Values

- SQL_SUCCESS indicates that the call succeeded.
- SQL_SUCCESS_WITH_INFO indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

If **SQLBindCol** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then 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.

Examples

See **Examples**.

7.4.5.6 SQLBindParameter

Function

SQLBindParameter is used to associate (bind) parameter markers in an SQL statement to a buffer.

Prototype

```
SQLRETURN SQLBindParameter(SQLHSTMT       StatementHandle,
                           SQLUSMALLINT   ParameterNumber,
                           SQLSMALLINT    InputOutputType,
                           SQLSMALLINT    ValuetType,
                           SQLSMALLINT    ParameterType,
                           SQLULEN        ColumnSize,
                           SQLSMALLINT    DecimalDigits,
                           SQLPOINTER     ParameterValuePtr,
                           SQLLEN         BufferLength,
                           SQLLEN         *StrLen_or_IndPtr);
```

Parameter

Table 7-27 SQLBindParameter

Keyword	Description
StatementHandle	Statement handle.
ParameterNumber	Parameter marker number, starting at 1 and increasing in an 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.

Keyword	Description
DecimalDigits	Digital number of the column or the 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 Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

If **SQLBindCol** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then 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.

Examples

See **Examples**.

7.4.5.7 SQLColAttribute

Function

SQLColAttribute returns the descriptor information about a column in the result set.

Prototype

```
SQLRETURN SQLColAttribute(SQLHSTMT        StatementHandle,
                          SQLUSMALLINT    ColumnNumber,
                          SQLUSMALLINT    FieldIdentifier,
                          SQLPOINTER      CharacterAtrributePtr,
                          SQLSMALLINT     BufferLength,
                          SQLSMALLINT     *StringLengthPtr,
                          SQLPOINTER      NumericAttributePtr);
```


Parameter

Table 7-28 SQLColAttribute parameter

Keyword	Description
StatementHandle	Statement handle.
ColumnNumber	Column number of the field to be queried, starting at 1 and increasing in an ascending order.
FieldIdentifier	Field identifier of **ColumnNumber** in IRD.
CharacterAttributePtr	**Output parameter**: pointer to the buffer that returns FieldIdentifier field value.
BufferLength	• **FieldIdentifier** indicates the length of the buffer if **FieldIdentifier** is an ODBC-defined field and **CharacterAttributePtr** points to a character string or a binary buffer. • 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 Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

If **SQLColAttribute** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_STMT** and **StatementHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.8 SQLConnect

Function

SQLConnect establishes a connection between a driver and a data source. After the connection, 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 7-29 SQLConnect parameters

Keyword	Description
ConnectionHandle	Connection handle, obtained from **SQLAllocHandle**.
ServerName	Name of the data source to connect to.
NameLength1	Length of **ServerName**.
UserName	User name 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 Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

Precautions

If **SQLConnect** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to

SQL_HANDLE_DBC and **ConnectionHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.9 SQLDisconnect

Function

SQLDisconnect closes the connection associated with the database connection handle.

Prototype

```
SQLRETURN SQLDisconnect(SQLHDBC    ConnectionHandle);
```

Parameter

Table 7-30 SQLDisconnect parameters

Keyword	Description
ConnectionHandle	Connection handle, obtained from **SQLAllocHandle**.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

If **SQLDisconnect** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_DBC** and **ConnectionHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.10 SQLExecDirect

Function

SQLExecDirect executes a prepared SQL statement specified in this parameter. This is the fastest execution method for executing only one SQL statement at a time.

Prototype

```
SQLRETURN SQLExecDirect(SQLHSTMT         StatementHandle,
                        SQLCHAR          *StatementText,
                        SQLINTEGER       TextLength);
```

Parameter

Table 7-31 SQLExecDirect parameters

Keyword	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 Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates some warning information is displayed.
- **SQL_NEED_DATA** indicates insufficient parameters provided before executing the SQL statement.
- **SQL_ERROR** indicates major errors, such as memory allocation and connection failures.
- **SQL_INVALID_HANDLE** indicates that invalid handles were called. Values returned by other APIs are similar to the preceding values.
- **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 then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_STMT** and **StatementHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.11 SQLExecute

Function

The **SQLExecute** function executes 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 7-32 SQLExecute parameters

Keyword	Description
StatementHandle	Statement handle to be executed.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates some warning information is displayed.
- **SQL_NEED_DATA** indicates insufficient parameters provided before executing the SQL statement.
- **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. Values returned by other APIs are similar to the preceding values.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

Precautions

If **SQLExecute** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_STMT** and **StatementHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.12 SQLFetch

Function

SQLFetch advances the cursor to the next row of the result set and retrieves any bound columns.

Prototype

```
SQLRETURN SQLFetch(SQLHSTMT    StatementHandle);
```

Parameter

Table 7-33 SQLFetch parameters

Keyword	Description
StatementHandle	Statement handle, obtained from **SQLAllocHandle**.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

Precautions

If **SQLFetch** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_STMT** and **StatementHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.13 SQLFreeStmt

In ODBC 3.x, **SQLFreeStmt** (an ODBC 2.x function) was deprecated and replaced with **SQLFreeHandle**. For details, see **SQLFreeHandle**.

7.4.5.14 SQLFreeConnect

In ODBC 3.x, **SQLFreeConnect** (an ODBC 2.x function) was deprecated and replaced with **SQLFreeHandle**. For details, see **SQLFreeHandle**.

7.4.5.15 SQLFreeHandle

Function

SQLFreeHandle releases 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 7-34 SQLFreeHandle parameters

Keyword	Description
HandleType	The type of handle to be freed by SQLFreeHandle. The value must be one of the following: • SQL_HANDLE_ENV • SQL_HANDLE_DBC • SQL_HANDLE_STMT • SQL_HANDLE_DESC If **HandleType** is not one of the preceding values, **SQLFreeHandle** returns **SQL_INVALID_HANDLE**.
Handle	The name of the handle to be freed.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

If **SQLFreeHandle** returns **SQL_ERROR**, the handle is still valid.

Examples

See **Examples**.

7.4.5.16 SQLFreeEnv

In ODBC 3.x, **SQLFreeEnv** (an ODBC 2.x function) was deprecated and replaced with **SQLFreeHandle**. For details, see **SQLFreeHandle**.

7.4.5.17 SQLPrepare

Function

SQLPrepare prepares an SQL statement to be executed.

Prototype

```
SQLRETURN SQLPrepare(SQLHSTMT      StatementHandle,
                     SQLCHAR       *StatementText,
                     SQLINTEGER    TextLength);
```

Parameter

Table 7-35 SQLPrepare parameters

Keyword	Description
StatementHandle	Statement handle.
StatementText	SQL text string.
TextLength	Length of **StatementText**.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

Precautions

If **SQLPrepare** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_STMT** and **StatementHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.18 SQLGetData

Function

SQLGetData retrieves data for a single column in the current row of 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 7-36 SQLGetData parameters

Keyword	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 buffer pointed to by **TargetValuePtr**.
StrLen_or_IndPtr	**Output parameter**: pointer to the buffer where the length or identifier value is returned.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.
- **SQL_STILL_EXECUTING** indicates that the statement is being executed.

Precautions

If **SQLFetch** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_STMT** and **StatementHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.19 SQLGetDiagRec

Function

SQLGetDiagRec returns the current values of multiple fields of 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);
```

Parameter

Table 7-37 SQLGetDiagRec parameters

Keyword	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: • SQL_HANDLE_ENV • SQL_HANDLE_DBC • SQL_HANDLE_STMT • 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 shared or non-shared environment handle.

Keyword	Description
RecNumber	Indicates the 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 Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

SQLGetDiagRec does not release diagnostic records for itself. It uses the following returned values to report execution results:

- **SQL_SUCCESS**: The function successfully returns diagnostic information.
- **SQL_SUCCESS_WITH_INFO**: The ***MessageText** buffer is too small to hold the requested diagnostic message. No diagnostic records are generated.
- **SQL_INVALID_HANDLE**: The handle indicated by **HandType** and **Handle** is not a valid handle.
- **SQL_ERROR**: **RecNumber** is smaller than or equal to zero, or **BufferLength** is smaller than zero.

If an ODBC function returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec** and obtain the **SQLSTATE** value. The possible **SQLSTATE** values are listed as follows:

Table 7-38 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 timed out	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.

Examples

See **Examples**.

7.4.5.20 SQLSetConnectAttr

Function

SQLSetConnectAttr sets connection attributes.

Prototype

```
SQLRETURN SQLSetConnectAttr(SQLHDBC      ConnectionHandle
                            SQLINTEGER   Attribute,
                            SQLPOINTER   ValuePtr,
                            SQLINTEGER   StringLength);
```


Parameter

Table 7-39 SQLSetConnectAttr parameters

Keyword	Description
StatementttHandle	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 **ValuePtr** parameter is driver-specific value, it may be signed integer.
StringLength	If **ValuePtr** points to a string or a binary buffer, this parameter should be the length of ***ValuePtr**. If **ValuePtr** points to an integer, **StringLength** is ignored.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

If **SQLSetConnectAttr** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_DBC** and **ConnectionHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

7.4.5.21 SQLSetEnvAttr

Function

SQLSetEnvAttr sets environment attributes.

Prototype

```
SQLRETURN SQLSetEnvAttr(SQLHENV      EnvironmentHandle
                        SQLINTEGER   Attribute,
                        SQLPOINTER   ValuePtr,
                        SQLINTEGER   StringLength);
```


Parameters

Table 7-40 SQLSetEnvAttr parameters

Keyword	Description
EnviromentHandle	Environment handle.
Attribute	Environment attribute to be set. Its value must be one of the following: • **SQL_ATTR_ODBC_VERSION**: ODBC version • **SQL_CONNECTION_POOLING**: connection pool attribute • **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, this parameter should be the length of ***ValuePtr**. If **ValuePtr** points to an integer, **StringLength** is ignored.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

If **SQLSetEnvAttr** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then 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.

Examples

See **Examples**.

7.4.5.22 SQLSetStmtAttr

Function

SQLSetStmtAttr sets attributes related to a statement.

Prototype

```
SQLRETURN SQLSetStmtAttr(SQLHSTMT      StatementHandle
                         SQLINTEGER    Attribute,
                         SQLPOINTER    ValuePtr,
                         SQLINTEGER    StringLength);
```

Parameter

Table 7-41 SQLSetStmtAttr parameters

Keyword	Description
StatementtHandle	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, and a driver-specified value. If **ValuePtr** parameter is driver-specific value, it may be signed integer.
StringLength	If **ValuePtr** points to a string or a binary buffer, this parameter should be the length of ***ValuePtr**. If **ValuePtr** points to an integer, **StringLength** is ignored.

Return Values

- **SQL_SUCCESS** indicates that the call succeeded.
- **SQL_SUCCESS_WITH_INFO** indicates 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. Values returned by other APIs are similar to the preceding values.

Precautions

If **SQLSetStmtAttr** returns **SQL_ERROR** or **SQL_SUCCESS_WITH_INFO**, the application can then call **SQLGetDiagRec**, set **HandleType** and **Handle** to **SQL_HANDLE_STMT** and **StatementHandle**, and obtain the **SQLSTATE** value. The **SQLSTATE** value provides the detailed function calling information.

Examples

See **Examples**.

8 Data Read

8.1 Querying a Single Table

Example table:

```
CREATE TABLE newproducts
(
product_id INTEGER NOT NULL,
product_name VARCHAR2(60),
category VARCHAR2(60),
quantity  INTEGER
)
WITH (ORIENTATION = COLUMN) DISTRIBUTE BY HASH(product_id);


INSERT INTO newproducts VALUES (1502, 'earphones', 'electronics',150);
INSERT INTO newproducts VALUES (1601, 'telescope', 'toys',80);
INSERT INTO newproducts VALUES (1666, 'Frisbee', 'toys',244);
INSERT INTO newproducts VALUES (1700, 'interface', 'books',100);
INSERT INTO newproducts VALUES (2344, 'milklotion', 'skin care',320);
INSERT INTO newproducts VALUES (3577, 'dumbbell', 'sports',550);
INSERT INTO newproducts VALUES (1210, 'necklace', 'jewels', 200);
```

Simple Queries

Run the **SELECT... FROM...** statement to obtain the result from the database.

```
SELECT category FROM newproducts;
  category
------------
 electr
 sports
 jewels
 toys
 books
 skin care
 toys
(7 rows)
```


Filtering Test Results

Run the **WHERE** statement to filter the query result and find the queried part.

```
SELECT * FROM newproducts WHERE category='toys';
 product_id | product_name | category | quantity
------------+--------------+----------+----------
       1601 | telescope    | toys     |       80
       1666 | Frisbee      | toys     |      244
(2 rows)
```

Sorting Results

Use the **ORDER BY** statement to sort query results.

```
SELECT product_id,product_name,category,quantity FROM newproducts ORDER BY quantity DESC;
 product_id | product_name |  category   | quantity
------------+--------------+-------------+----------
       3577 | dumbbell     | sports      |      550
       2344 | milklotion   | skin care   |      320
       1666 | Frisbee      | toys        |      244
       1210 | necklace     | jewels      |      200
       1502 | earphones    | electronics |      150
       1700 | interface    | books       |      100
       1601 | telescope    | toys        |       80
(7 rows)
```

Limiting the Number of Query Results

If you want the query to return only part of the result, you can use the **LIMIT** statement to limit the number of records returned in the query result.

```
SELECT product_id,product_name,category,quantity FROM newproducts ORDER BY quantity DESC limit 5;
 product_id | product_name |  category   | quantity
------------+--------------+-------------+----------
       3577 | dumbbell     | sports      |      550
       2344 | milklotion   | skin care   |      320
       1666 | Frisbee      | toys        |      244
       1210 | necklace     | jewels      |      200
       1502 | earphones    | electronics |      150
(5 rows)
```

Aggregated Query

If you want query data comprehensively, you can use the **GROUP BY** statement and aggregate functions to construct an aggregated query.

```
SELECT category, string_agg(quantity,',') FROM newproducts group by category;
  category   | string_agg
-------------+------------
 toys        | 80,244
 books       | 100
 sports      | 550
 jewels      | 200
 skin care   | 320
 electronics | 150
```


8.2 Querying Joined Tables

Join Types

Multiple joins are necessary for accomplishing complex queries. Joins are classified into inner joins and outer joins. Each type of joins have their subtypes.

- Inner join: inner join, cross join, and natural join.
- Outer join: left outer join, right outer join, and full join.

To better illustrate the differences between these joins, the following provides some examples.

Create the sample tables **student** and **math_score** and insert data into them. Set **enable_fast_query_shipping** to **off** (**on** by default), that is, the query optimizer uses the distributed framework. Set **explain_perf_mode** to **pretty** (default value) to specify the **EXPLAIN** display format.

```
CREATE TABLE student(
  id INTEGER,
  name varchar(50)
);

CREATE TABLE math_score(
  id INTEGER,
  score INTEGER
);

INSERT INTO student VALUES(1, 'Tom');
INSERT INTO student VALUES(2, 'Lily');
INSERT INTO student VALUES(3, 'Tina');
INSERT INTO student VALUES(4, 'Perry');

INSERT INTO math_score VALUES(1, 80);
INSERT INTO math_score VALUES(2, 75);
INSERT INTO math_score VALUES(4, 95);
INSERT INTO math_score VALUES(6, NULL);

SET enable_fast_query_shipping = off;
SET explain_perf_mode = pretty;
```

Inner Join

- Inner join

  Syntax:

  ```
  left_table [INNER] JOIN right_table [ ON join_condition | USING ( join_column )]
  ```

  Description: Rows that meet **join_condition** in the left table and the right table are joined and output. Tuples that do not meet **join_condition** are not output.

  Example 1: Query students' math scores.

  ```
  SELECT s.id, s.name, ms.score FROM student s JOIN math_score ms on s.id = ms.id;
   id | name  | score
  ----+-------+-------
    2 | Lily  |    75
    1 | Tom   |    80
    4 | Perry |    95
  (3 rows)
  ```



```
EXPLAIN SELECT s.id, s.name, ms.score FROM student s JOIN math_score ms on s.id = ms.id;
                                    QUERY PLAN
-------------------------------------------------------------------------------------------
 id |                operation                | E-rows | E-memory | E-width | E-costs
----+-----------------------------------------+--------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)            |      4 |          |      13 | 19.47
  2 |    ->  Hash Join (3,4)                  |      4 | 1MB      |      13 | 11.47
  3 |       ->  Seq Scan on math_score ms     |     30 | 1MB      |       8 | 10.10
  4 |       ->  Hash                          |     12 | 16MB     |       9 | 1.28
  5 |          ->  Streaming(type: BROADCAST) |     12 | 2MB      |       9 | 1.28
  6 |             ->  Seq Scan on student s   |      4 | 1MB      |       9 | 1.01

 Predicate Information (identified by plan id)
 -----------------------------------------------
   2 --Hash Join (3,4)
         Hash Cond: (ms.id = s.id)

   ====== Query Summary =====
 --------------------------------
 System available mem: 1761280KB
 Query Max mem: 1761280KB
 Query estimated mem: 4400KB
(19 rows)
```

- Cross join

  Syntax:

  ```
  left_table CROSS JOIN right_table
  ```

  Description: Each row in the left table is joined with each row in the right table. The number of final rows is the product of the number of rows on both sides. The product is also called Cartesian product.

  Example 2: Cross join of student tables and math score tables.

  ```
  SELECT s.id, s.name, ms.score FROM student s CROSS JOIN math_score ms;
   id | name  | score
  ----+-------+-------
    3 | Tina  |    80
    2 | Lily  |    80
    1 | Tom   |    80
    4 | Perry |    80
    3 | Tina  |
    2 | Lily  |
    1 | Tom   |
    4 | Perry |
    3 | Tina  |    95
    2 | Lily  |    95
    1 | Tom   |    95
    4 | Perry |    95
    2 | Lily  |    75
    3 | Tina  |    75
    1 | Tom   |    75
    4 | Perry |    75
  (16 rows)

  EXPLAIN SELECT s.id, s.name, ms.score FROM student s CROSS JOIN math_score ms;
                                      QUERY PLAN
  -------------------------------------------------------------------------------------------
   id |                operation                | E-rows | E-memory | E-width | E-costs
  ----+-----------------------------------------+--------+----------+---------+---------
    1 | ->  Streaming (type: GATHER)            |    120 |          |      13 | 19.89
    2 |    ->  Nested Loop (3,4)                |    120 | 1MB      |      13 | 11.89
    3 |       ->  Seq Scan on math_score ms     |     30 | 1MB      |       4 | 10.10
    4 |       ->  Materialize                   |     12 | 16MB     |       9 | 1.30
    5 |          ->  Streaming(type: BROADCAST) |     12 | 2MB      |       9 | 1.28
    6 |             ->  Seq Scan on student s   |      4 | 1MB      |       9 | 1.01

    ====== Query Summary =====
  --------------------------------
  System available mem: 1761280KB
  ```



```
 Query Max mem: 1761280KB
 Query estimated mem: 4144KB
(14 rows)
```

- Natural join

  Syntax:

  ```
  left_table NATURAL JOIN right_table
  ```

  Description: Columns with the same name in left table and right table are joined by equi-join, and the columns with the same name are merged into one column.

  Example 3: Natural join between the **student** table and the **math_score** table. The columns with the same name in the two tables are the **id** columns, therefore equivalent join is performed based on the **id** columns.

  ```
  SELECT * FROM student s NATURAL JOIN math_score ms;
   id | name  | score
  ----+-------+-------
    1 | Tom   |    80
    4 | Perry |    95
    2 | Lily  |    75
  (3 rows)

  EXPLAIN SELECT * FROM student s NATURAL JOIN math_score ms;
                                    QUERY PLAN
  ------------------------------------------------------------------------------------------
   id |                operation                | E-rows | E-memory | E-width | E-costs
  ----+-----------------------------------------+--------+----------+---------+---------
    1 | ->  Streaming (type: GATHER)            |      4 |          |      13 | 19.47
    2 |    ->  Hash Join (3,4)                  |      4 | 1MB      |      13 | 11.47
    3 |       ->  Seq Scan on math_score ms     |     30 | 1MB      |       8 | 10.10
    4 |       ->  Hash                          |     12 | 16MB     |       9 | 1.28
    5 |          ->  Streaming(type: BROADCAST) |     12 | 2MB      |       9 | 1.28
    6 |             ->  Seq Scan on student s   |      4 | 1MB      |       9 | 1.01

   Predicate Information (identified by plan id)
  -----------------------------------------------
    2 --Hash Join (3,4)
          Hash Cond: (ms.id = s.id)

    ====== Query Summary =====
  -------------------------------
  System available mem: 1761280KB
  Query Max mem: 1761280KB
  Query estimated mem: 4400KB
  (19 rows)
  ```

Outer Join

- Left Join

  Syntax:

  ```
  left_table LEFT [OUTER] JOIN right_table [ ON join_condition | USING ( join_column )]
  ```

  Description: The result set of a left outer join includes all rows of left table, not only the joined rows. If a row in the left table does not match any row in right table, the row will be **NULL** in the result set.

  Example 4: Perform left join on the **student** table and **math_score** table. The right table data corresponding to the row where ID is 3 in the **student** table is filled with **NULL** in the result set.

  ```
  SELECT s.id, s.name, ms.score FROM student s LEFT JOIN math_score ms on (s.id = ms.id);
   id | name  | score
  ----+-------+-------
    3 | Tina  |
    1 | Tom   |    80
  ```



```
 2 | Lily  |    75
 4 | Perry |    95
(4 rows)

EXPLAIN SELECT s.id, s.name, ms.score FROM student s LEFT JOIN math_score ms on (s.id = ms.id);
                                  QUERY PLAN
-------------------------------------------------------------------------------------------
 id |                 operation                  | E-rows | E-memory | E-width | E-costs
----+--------------------------------------------+--------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)               |      4 |          |      13 | 10.26
  2 |   ->  Hash Left Join (3, 5)                |      4 | 1MB      |      13 | 2.26
  3 |     ->  Streaming(type: REDISTRIBUTE)      |      4 | 2MB      |       9 | 1.11
  4 |       ->  Seq Scan on student s            |      4 | 1MB      |       9 | 1.01
  5 |     ->  Hash                               |      4 | 16MB     |       8 | 1.11
  6 |       ->  Streaming(type: REDISTRIBUTE)    |      4 | 2MB      |       8 | 1.11
  7 |         ->  Seq Scan on math_score ms      |      4 | 1MB      |       8 | 1.01

 Predicate Information (identified by plan id)
-----------------------------------------------
  2 --Hash Left Join (3, 5)
        Hash Cond: (s.id = ms.id)

  ====== Query Summary =====
-------------------------------
 System available mem: 901120KB
 Query Max mem: 901120KB
 Query estimated mem: 7520KB
(20 rows)
```

- Right join

  Syntax:

  ```
  left_table RIGHT [OUTER] JOIN right_table [ ON join_condition | USING ( join_column )]
  ```

  Description: Contrary to the left join, the result set of a right join includes all rows of the right table, not just the joined rows. If a row in the right table does not match any row in right table, the row will be **NULL** in the result set.

  Example 5: Perform right join on the **student** table and **math_score** table. The right table data corresponding to the row where ID is 6 in the **math_score** table is filled with **NULL** in the result set.

  ```
  SELECT ms.id, s.name, ms.score FROM student s RIGHT JOIN math_score ms on (s.id = ms.id);
   id | name  | score
  ----+-------+-------
   1 | Tom   |    80
   6 |       |
   4 | Perry |    95
   2 | Lily  |    75

  EXPLAIN SELECT ms.id, s.name, ms.score FROM student s RIGHT JOIN math_score ms on (s.id = ms.id);
                                  QUERY PLAN
  -------------------------------------------------------------------------------------------
   id |                 operation                  | E-rows | E-memory | E-width | E-costs
  ----+--------------------------------------------+--------+----------+---------+---------
    1 | ->  Streaming (type: GATHER)               |     30 |          |      13 | 19.47
    2 |   ->  Hash Left Join (3, 4)                |     30 | 1MB      |      13 | 11.47
    3 |     ->  Seq Scan on math_score ms          |     30 | 1MB      |       8 | 10.10
    4 |     ->  Hash                               |     12 | 16MB     |       9 | 1.28
    5 |       ->  Streaming(type: BROADCAST)       |     12 | 2MB      |       9 | 1.28
    6 |         ->  Seq Scan on student s          |      4 | 1MB      |       9 | 1.01

   Predicate Information (identified by plan id)
  -----------------------------------------------
    2 --Hash Left Join (3, 4)
          Hash Cond: (ms.id = s.id)

    ====== Query Summary =====
  -------------------------------
   System available mem: 1761280KB
  ```



```
 Query Max mem: 1761280KB
 Query estimated mem: 5424KB
(19 rows)
```

In a right join, **Left** is displayed in the join operator. This is because a right join is actually the process replacing the left table with the right table then performing left join.

- Full join

  Syntax:

  ```
  left_table FULL [OUTER] JOIN right_table [ ON join_condition | USING ( join_column )]
  ```

  Description: A full join is a combination of a left outer join and a right outer join. The result set of a full outer join includes all rows of the left table and the right table, not just the joined rows. If a row in the left table does not match any row in the right table, the row will be **NULL** in the result set. If a row in the right table does not match any row in right table, the row will be **NULL** in the result set.

  Example 6: Perform full outer join on the **student** table and **math_score** table. The right table data corresponding to the row where ID is 3 is filled with **NULL** in the result set. The left table data corresponding to the row where ID is 6 is filled with **NULL** in the result set.

  ```
  SELECT s.id, s.name, ms.id, ms.score FROM student s FULL JOIN math_score ms ON (s.id = ms.id);
   id | name  | id | score
  ----+-------+----+-------
    2 | Lily  |  2 |    75
    4 | Perry |  4 |    95
    1 | Tom   |  1 |    80
    3 | Tina  |    |
      |       |  6 |
  (5 rows)

  EXPLAIN SELECT s.id, s.name, ms.id, ms.score FROM student s FULL JOIN math_score ms ON (s.id =
  ms.id);
                                    QUERY PLAN
  ------------------------------------------------------------------------------------------------
    id |                 operation                 | E-rows | E-memory | E-width | E-costs
   ----+-------------------------------------------+--------+----------+---------+---------
     1 | ->  Streaming (type: GATHER)              |     30 |          |      17 | 20.24
     2 |   ->  Hash Full Join (3, 5)               |     30 | 1MB      |      17 | 12.24
     3 |     ->  Streaming(type: REDISTRIBUTE)     |     30 | 2MB      |       8 | 11.06
     4 |       ->  Seq Scan on math_score ms       |     30 | 1MB      |       8 | 10.10
     5 |     ->  Hash                              |      4 | 16MB     |       9 | 1.11
     6 |       ->  Streaming(type: REDISTRIBUTE)   |      4 | 2MB      |       9 | 1.11
     7 |         ->  Seq Scan on student s         |      4 | 1MB      |       9 | 1.01

   Predicate Information (identified by plan id)
   ------------------------------------------------
     2 --Hash Full Join (3, 5)
           Hash Cond: (ms.id = s.id)

     ====== Query Summary =====
  ------------------------------
   System available mem: 1761280KB
   Query Max mem: 1761280KB
   Query estimated mem: 6496KB
  (20 rows)
  ```

Differences Between the ON Condition and the WHERE Condition in Multi-Table Query

According to the preceding join syntax, except natural join and cross join, the **ON** condition (**USING** is converted to the **ON** condition during query parsing) is used

on the join result of both the two tables. Generally, the **WHERE** condition is used in the query statement to restrict the query result. The **ON** join condition and **WHERE** filter condition do not contain conditions that can be pushed down to tables. The differences between **ON** and **WHERE** are as follows:

- The **ON** condition is used for joining two tables.
- **WHERE** is used to filter the result set.

To sum up, the **ON** condition is used when two tables are joined. After the join result set of two tables is generated, the **WHERE** condition is used.

8.3 WITH Expression

The WITH expression is used to define auxiliary statements used in large queries. These auxiliary statements are usually called common table expressions (CTE), which can be understood as a named subquery. The subquery can be referenced multiple times by its name in the quey.

An auxiliary statement may use **SELECT**, **INSERT**, **UPDATE**, or **DELETE**. The **WITH** clause can be attached to a main statement, which can be a **SELECT**, **INSERT**, or **DELETE** statement.

SELECT in WITH

This section describes the usage of **SELECT** in a **WITH** clause.

Syntax

```
[WITH [RECURSIVE] with_query [, ...] ] SELECT ...
```

The syntax of **with_query** is as follows:

```
with_query_name [ ( column_name [, ...] ) ]AS ( {select | values | insert | update | delete} )
```


CAUTION

- The SQL statement specified by the AS statement of a CTE must be a statement that can return query results. It can be a common **SELECT** query statement or other data modification statements such as **INSERT**, **UPDATE**, **DELETE**, and **VALUES**. When using a data modification statement, you need to use the **RETURNING** clause to return tuples. Example:
  ```
  WITH s AS (INSERT INTO t VALUES(1) RETURNING a) SELECT * FROM s;
  ```
- A **WITH** expression indicates the CTE definition in a SQL statement block. Multiple CTEs can be defined at the same time. You can specify column names for each CTE or use the aliases of the columns in the query output. Example:
  ```
  WITH s1(a, b) AS (SELECT x, y FROM t1), s2 AS (SELECT x, y FROM t2) SELECT * FROM s1 JOIN s2 ON s1.a=s2.x;
  ```
  This statement defines two CTEs: **s1** and **s2**. **s1** specifies the column names **a** and **b**, and **s2** does not specify the column names. Therefore, the column names are the output column names **x** and **y**.
- Each CTE can be referenced zero, one, or more times in the main query.
- CTEs with the same name cannot exist in the same statement block. If CTEs with the same name exist in different statement blocks, the CTE in the nearest statement block is referenced.
- An SQL statement may contain multiple SQL statement blocks. Each statement block can contain a **WITH** expression. The CTE in each **WITH** expression can be referenced in the current statement block, subsequent CTEs of the current statement block, and sub-layer statement blocks, however, it cannot be referenced in the parent statement block. The definition of each CTE is also a statement block. Therefore, a WITH expression can also be defined in the statement block.

The purpose of SELECT in WITH is to break down complex queries into simple parts. Example:

```
WITH regional_sales AS (
    SELECT region, SUM(amount) AS total_sales
    FROM orders
    GROUP BY region
), top_regions AS (
    SELECT region
    FROM regional_sales
    WHERE total_sales > (SELECT SUM(total_sales)/10 FROM regional_sales)
)
SELECT region,
       product,
       SUM(quantity) AS product_units,
       SUM(amount) AS product_sales
FROM orders
WHERE region IN (SELECT region FROM top_regions)
GROUP BY region, product;
```

The **WITH** clause defines two auxiliary statements: **regional_sales** and **top_regions**. The output of **regional_sales** is used in **top_regions**, and the output of **top_regions** is used in the main **SELECT** query. This example can be written without **WITH**. In that case, it must be written with a two-layer nested sub-SELECT statement, making the query longer and difficult to maintain.

Recursive WITH Query

By declaring the keyword **RECURSIVE**, a WITH query can reference its own output.

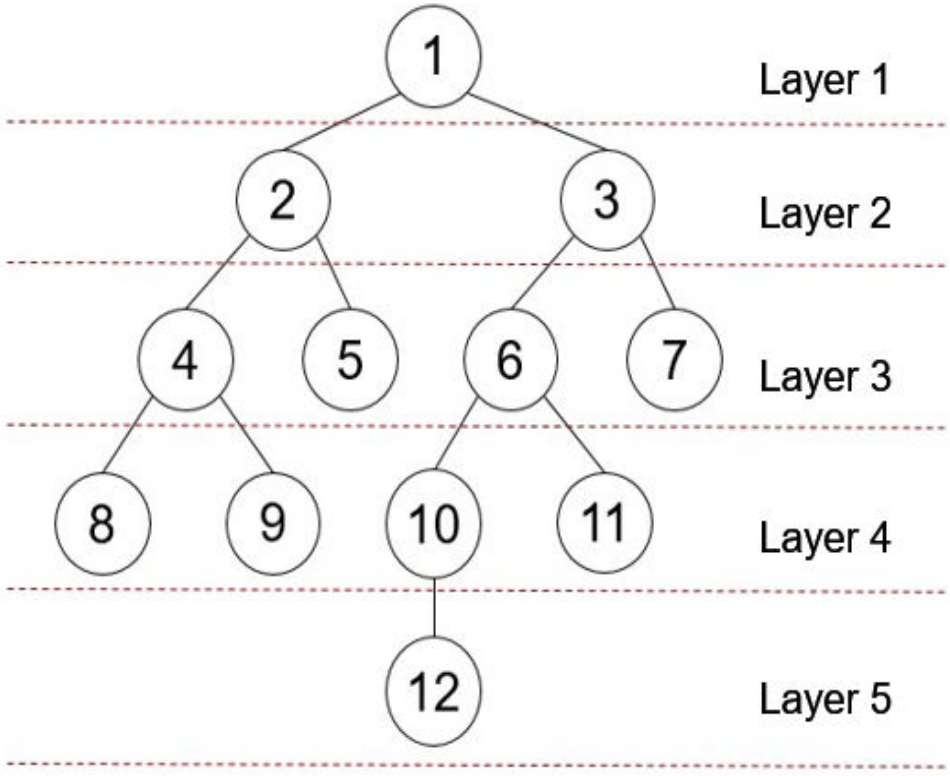
The common form of a recursive WITH query is as follows:

```
non_recursive_term UNION [ALL] recursive_term
```

UNION performs deduplication when merging sets, while **UNION ALLL** directly merges result sets without deduplication. Only recursive items can contain references to the output of the query itself.

When using recursive WITH, ensure that the recursive item of the query does not return a tuple. Otherwise, the query will loop infinitely.

The table **tree** is used to store information about all nodes in the following figure.



The table definition statement is as follows:

```
CREATE TABLE tree(id INT, parentid INT);
```

The data in the table is as follows:

```
INSERT INTO tree VALUES(1,0),(2,1),(3,1),(4,2),(5,2),(6,3),(7,3),(8,4),(9,4),(10,6),(11,6),(12,10);

SELECT * FROM tree;
 id | parentid
----+----------
  1 |        0
  2 |        1
  3 |        1
  4 |        2
  5 |        2
  6 |        3
  7 |        3
  8 |        4
  9 |        4
 10 |        6
 11 |        6
```



```
 12 |      10
(12 rows)
```

You can run the following **WITH RECURSIVE** statement to return the nodes and hierarchy information of the entire tree starting from node 1 at the top layer:

```
WITH RECURSIVE nodeset AS
(
-- recursive initializing query
SELECT id, parentid, 1 AS level FROM tree
WHERE id = 1
UNION ALL
-- recursive join query
SELECT tree.id, tree.parentid, level + 1 FROM tree, nodeset
WHERE tree.parentid = nodeset.id
)
SELECT * FROM nodeset ORDER BY id;
```

In the preceding query, a typical **WITH RECURSIVE** expression contains the CTE of at least one recursive query. The CTE is defined as a **UNION ALL** set operation. The first branch is the recursive start query, and the second branch is the recursive join query, the first part is referenced for continuous recursive join. When this statement is executed, the recursive start query is executed once, and the join query is executed several times. The results are added to the start query result set until the results of some join queries are empty.

The command output is as follows:

```
 id | parentid | level
----+----------+-------
  1 |        0 |     1
  2 |        1 |     2
  3 |        1 |     2
  4 |        2 |     3
  5 |        2 |     3
  6 |        3 |     3
  7 |        3 |     3
  8 |        4 |     4
  9 |        4 |     4
 10 |        6 |     4
 11 |        6 |     4
 12 |       10 |     5
(12 rows)
```

According to the returned result, the start query result contains the result set whose level is 1. The join query is executed for five times. The result sets whose levels are 2, 3, 4, and 5 are output for the first four times. During the fifth execution, there is no record whose parentid is the same as the output result set ID, that is, there is no redundant child node. Therefore, the query ends.

NOTE

GaussDB(DWS) supports distributed execution of **WITH RECURSIVE** expressions. **WITH RECURSIVE** involves cyclic calculation. Therefore, GaussDB(DWS) introduces the **max_recursive_times** parameter to control the maximum number of cycles of WITH RECURSIVE. The default value is **200**. If the number of cycles exceeds **200**, an error is reported.

Data Modification Statements in WITH

Use the **INSERT**, **UPDATE**, and **DELETE** commands in the WITH clause. This allows the user to perform multiple different operations in the same query. The following is an example:


```
WITH moved_tree AS (
    DELETE FROM tree
    WHERE parentid = 4
    RETURNING * )
 INSERT INTO tree_log
 SELECT * FROM moved_tree;
```

The preceding query example actually moves rows from **tree** to **tree_log**. The **DELETE** command in the **WITH** clause deletes the specified rows from **tree**, returns their contents through the **RETURNING** clause, and then the main query reads the output and inserts it into **tree_log**.

The data modification statement in the **WITH** clause must contain the **RETURNING** clause, which is used to return the modified content rather than the target table. The RETURNING clause forms a temporary table that can be referenced by the rest of the query. If a data modification statement in the **WITH** statement lacks a **RETURNING** clause, it cannot form a temporary table and cannot be referenced in the remaining queries.

If the **RECURSIVE** keyword is declare, recursive self-reference is not allowed in data modification statements. In some cases, you can bypass this restriction by referencing the output of recursive the **WITH** statement. For example:

```
WITH RECURSIVE included_parts(sub_part, part) AS (
    SELECT sub_part, part FROM parts WHERE part = 'our_product'
  UNION ALL
    SELECT p.sub_part, p.part
    FROM included_parts pr, parts p
    WHERE p.part = pr.sub_part
  )
DELETE FROM parts
  WHERE part IN (SELECT part FROM included_parts);
```

This query will remove all direct or indirect subparts of a product.

The substatements in the **WITH** clause are executed at the same time as the main query. Therefore, when using the data modification statement in a WITH statement, the actual update order is in an unpredictable manner. All statements are executed in the same snapshot, and the effect of the statements is invisible on the target table. This mitigates the unpredictability of the actual order of row updates and means that **RETURNING** data is the only way to convey changes between different **WITH** substatements and the main query.

In this example, the outer layer **SELECT** can return the data before the update.

```
WITH t AS (
    UPDATE tree SET id = id + 1
    RETURNING * )
SELECT * FROM tree;
```

In this example, the external SELECT returns the updated data.

```
WITH t AS (
UPDATE tree SET id = id + 1
    RETURNING * )
SELECT * FROM t;
```

The same row cannot be updated twice in a single statement. Otherwise, the update effect will be unpredictable. If only one update takes effect, it is difficult (and sometimes impossible) to predict which one takes effect.

9 User-Defined Functions

NOTE

- The hybrid data warehouse (deployed in standalone mode) does not support user-defined functions.
- The hybrid data warehouse (standalone) does 8.2.0.100 and later versions support OBS import and export.

9.1 PL/Java Functions

With the GaussDB(DWS) PL/Java functions, you can choose your favorite Java IDE to write Java methods and install the JAR files containing these methods into the GaussDB(DWS) database before invoking them. GaussDB(DWS) PL/Java is developed based on open-source PL/Java 1.5.5 and uses JRE 1.8.0_322.

Constraints

Java UDF can be used for some Java logical computing. You are not advised to encapsulate services in Java UDF.

- You are not advised to connect to a database in any way (for example, JDBC) in Java functions.
- Currently, only data types listed in **Table 9-1** are supported. Other data types, such as user-defined data types and complex data types (for example, Java array and its derived types) are not supported.
- Currently, UDAF and UDTF are not supported.

Examples

Before using PL/Java, you need to pack the implementation of Java methods into a JAR package and deploy it into the database. Then, create functions as a database administrator. For compatibility purposes, use JRE 1.8.0_322 for compilation.

Step 1 Compile a JAR package.

Java method implementation and JAR package archiving can be achieved in an integrated development environment (IDE). The following is a simple example of compilation and archiving through command lines. You can create a JAR package that contains a single method in the similar way.

First, prepare an **Example.java** file that contains a method for converting substrings to uppercase. In the following example, **Example** is the class name and **upperString** is the method name:

```
public class Example
{
   public static String upperString (String text, int beginIndex, int endIndex)
   {
      return text.substring(beginIndex, endIndex).toUpperCase();
   }
}
```

Then, create a **manifest.txt** file containing the following content:

```
Manifest-Version: 1.0
Main-Class: Example
Specification-Title: "Example"
Specification-Version: "1.0"
Created-By: 1.6.0_35-b10-428-11M3811
Build-Date: 08/14/2018 10:09 AM
```

Manifest-Version specifies the version of the **manifest** file. **Main-Class** specifies the main class used by the .jar file. **Specification-Title** and **Specification-Version** are the extended attributes of the package. **Specification-Title** specifies the title of the extended specification and **Specification-Version** specifies the version of the extended specification. **Created-By** specifies the person who created the file. **Build-Date** specifies the date when the file was created.

Finally, archive the .java file and package it into **javaudf-example.jar**.

```
javac Example.java
jar cfm javaudf-example.jar manifest.txt Example.class
```

NOTICE

JAR package names must comply with JDK rules. If a name contains invalid characters, an error occurs when a function is deployed or used.

Step 2 Deploy the JAR package.

Place the JAR package on the OBS server using the method described in For details, see "Uploading a File" in *Object Storage Service Console Operation Guide*.. Then, create the AK/SK. For details about how to obtain the AK/SK, see section **Creating Access Keys (AK and SK)**. Log in to the database and run the **gs_extend_library** function to import the file to GaussDB(DWS).

```
SELECT gs_extend_library('addjar', 'obs://bucket/path/javaudf-example.jar
accesskey=access_key_value_to_be_replaced  secretkey=secret_access_key_value_to_be_replaced
region=region_name libraryname=example');
```

For details about how to use the **gs_extend_library** function, see **Manage JAR packages and files**. Change the values of AK and SK as needed. Replace *region_name* with an actual region name.

Step 3 Use a PL/Java function.

Log in to the database as a user who has the **sysadmin** permission (for example, dbadmin) and create the **java_upperstring** function:

```
CREATE FUNCTION java_upperstring(VARCHAR, INTEGER, INTEGER)
    RETURNS VARCHAR
    AS 'Example.upperString'
LANGUAGE JAVA;
```

NOTE

- The data type defined in the java_upperstring function should be a type in GaussDB(DWS) and match the data type defined in **Step 1** in the upperString method in Java. For details about the mapping between GaussDB(DWS) and Java data types, see **Table 9-1**.
- The AS clause specifies the class name and static method name of the Java method invoked by the function. The format is *Class name*.*Method name*. The class name and method name must match the Java class and method defined in **Step 1**.
- To use PL/Java functions, set **LANGUAGE** to **JAVA**.
- For details about CREATE FUNCTION, see **Create functions**.

Execute the java_upperstring function.

```
SELECT java_upperstring('test', 0, 1);
```

The expected result is as follows:

```
 java_upperstring
--------------------
 T
(1 row)
```

Step 4 Authorize a common user to use the PL/Java function.

Create a common user named **udf_user**.

```
CREATE USER udf_user PASSWORD 'password';
```

This command grants user **udf_user** the permission for the java_upperstring function. Note that the user can use this function only if it also has the permission for using the schema of the function.

```
GRANT ALL PRIVILEGES ON SCHEMA public TO udf_user;
GRANT ALL PRIVILEGES ON FUNCTION java_upperstring(VARCHAR, INTEGER, INTEGER) TO udf_user;
```

Log in to the database as user **udf_user**.

```
SET SESSION SESSION AUTHORIZATION udf_user PASSWORD 'password';
```

Execute the java_upperstring function.

```
SELECT public.java_upperstring('test', 0, 1);
```

The expected result is as follows:

```
 java_upperstring
--------------------
 T
(1 row)
```

Step 5 Delete the function.

If you no longer need this function, delete it.

```
DROP FUNCTION java_upperstring;
```


Step 6 Uninstall the JAR package.

Use the gs_extend_library function to uninstall the JAR package.

```
SELECT gs_extend_library('rmjar', 'libraryname=example');
```

----End

SQL Definition and Usage

- **Manage JAR packages and files.**

  A database user having the **sysadmin** permission can use the gs_extend_library function to deploy, view, and delete JAR packages in the database. The syntax of the function is as follows:

  ```
  SELECT gs_extend_library('[action]', '[operation]');
  ```

  NOTE

  - **action**: operation action. The options are as follows:
    - **ls**: Displays JAR packages in the database and checks the MD5 value consistency of files on each node.
    - **addjar**: deploys a JAR package on the OBS server in the database.
    - **rmjar**: Deletes JAR packages from the database.
  - **operation**: operation string. The format can be either of the following:

    obs://[bucket]/[source_filepath] accesskey=[accesskey] secretkey=[secretkey] region=[region] libraryname=[libraryname]
    - **bucket**: name of the bucket to which the OBS file belongs. It is mandatory.
    - **source_filepath**: file path on the OBS server. Only .jar files are supported.
    - **accesskey**: key obtained for accessing the OBS service. It is mandatory.
    - **secret_key**: secret key obtained for the OBS service. It is mandatory.
    - **region**: region where the OBS bucket stored in the JAR package of a user-defined function belongs to. This parameter is mandatory.
    - **libraryname**: user-defined library name, which is used to invoke JAR files in GaussDB(DWS). If **action** is set to **addjar** or **rmjar**, **libraryname** must be specified. If **action** is set to **ls**, **libraryname** is optional. Note that a user-defined library name cannot contain the following characters: /|;&$<>\'{}"() []~*?!

- Create functions.

  PL/Java functions can be created using the **CREATE FUNCTION** syntax and are defined as **LANGUAGE JAVA**, including the **RETURNS** and **AS** clauses.

  - To use **CREATE FUNCTION**, specify the name and parameter type for the function to be created.
  - The **RETURNS** clause specifies the return type for the function.
  - The **AS** clause specifies the class name and static method name of the Java method to be invoked. If the **NULL** value needs to be transferred to the Java method as an input parameter, specify the name of the Java encapsulation class corresponding to the parameter type. For details, see **NULL Handling**.
  - For details about the syntax, see CREATE FUNCTION.

    ```
    CREATE [ OR REPLACE ] FUNCTION function_name
    ( [ { argname [ argmode ] argtype [ { DEFAULT | := | = } expression ]} [, ...] ])
    [ RETURNS rettype [ DETERMINISTIC ] ]
    LANGAUGE JAVA
    ```



```
[
   { IMMUTABLE | STATBLE | VOLATILE }
   | [ NOT ] LEAKPROOF
   | WINDOW
   | { CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT |STRICT }
   | {[ EXTERNAL ] SECURITY INVOKER | [ EXTERNAL ] SECURITY DEFINER | AUTHID DEFINER |
AUTHID CURRENT_USER}
   | { FENCED }
   | COST execution_cost
   | ROWS result_rows
   | SET configuration_parameter { {TO |=} value | FROM CURRENT}
] [...]
{
   AS 'class_name.method_name' ( { argtype } [, ...] )
}
```

- Use functions.

  During execution, PL/Java searches for the Java class specified by a function among all the deployed JAR packages, which are ranked by name in alphabetical order, invokes the Java method in the first found class, and returns results.

- Delete functions.

  PL/Java functions can be deleted by using the **DROP FUNCTION** syntax. For details about the syntax, see DROP FUNCTION.

  ```
  DROP FUNCTION [ IF EXISTS ] function_name [ ( [ {[ argmode ] [ argname ] argtype} [, ...] ] )
  [ CASCADE | RESTRICT ] ];
  ```

  To delete an overloaded function (for details, see **Overloaded Functions**), specify **argtype** in the function. To delete other functions, simply specify **function_name**.

- Authorize permissions for functions.

  Only user **sysadmin** can create PL/Java functions. It can also grant other users the permission to use the PL/Java functions. For details about the syntax, see GRANT.

  ```
  GRANT { EXECUTE | 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 ];
  ```

Mapping for Basic Data Types

Table 9-1 PL/Java mapping for default data types

GaussDB(DWS)	Java
BOOLEAN	boolean
"char"	byte
bytea	byte[]
SMALLINT	short
INTEGER	int
BIGINT	long
FLOAT4	float

GaussDB(DWS)	Java
FLOAT8	double
CHAR	java.lang.String
VARCHAR	java.lang.String
TEXT	java.lang.String
name	java.lang.String
DATE	java.sql.Timestamp
TIME	java.sql.Time (stored value treated as local time)
TIMETZ	java.sql.Time
TIMESTAMP	java.sql.Timestamp
TIMESTAMPTZ	java.sql.Timestamp

Array Type Processing

GaussDB(DWS) can convert basic array types. You only need to append a pair of square brackets ([]) to the data type when creating a function.

```
CREATE FUNCTION java_arrayLength(INTEGER[])
  RETURNS INTEGER
  AS 'Example.getArrayLength'
LANGUAGE JAVA;
```

Java code is similar to the following:

```
public class Example
{
  public static int getArrayLength(Integer[] intArray)
  {
    return intArray.length;
  }
}
```

Invoke the following statement:

```
SELECT java_arrayLength(ARRAY[1, 2, 3]);
```

The expected result is as follows:

```
java_arrayLength
----------------------
3
(1 row)
```

NULL Handling

NULL values cannot be handled for GaussDB(DWS) data types that are mapped and can be converted to simple Java types by default. If you use a Java function to obtain and process the **NULL** value transferred from GaussDB(DWS), specify the Java encapsulation class in the **AS** clause as follows:


```
CREATE FUNCTION java_countnulls(INTEGER[])
    RETURNS INTEGER
    AS 'Example.countNulls(java.lang.Integer[])'
LANGUAGE JAVA;
```

Java code is similar to the following:

```
public class Example
{
    public static int countNulls(Integer[] intArray)
    {
        int nullCount = 0;
        for (int idx = 0; idx < intArray.length; ++idx)
        {
            if (intArray[idx] == null)
            nullCount++;
        }
        return nullCount;
    }
}
```

Invoke the following statement:

```
SELECT java_countNulls(ARRAY[null, 1, null, 2, null]);
```

The expected result is as follows:

```
java_countNulls
--------------------
3
(1 row)
```

Overloaded Functions

PL/Java supports overloaded functions. You can create functions with the same name or invoke overloaded functions from Java code. The procedure is as follows:

Step 1 Create overloaded functions.

For example, create two Java methods with the same name, and specify the methods dummy(int) and dummy(String) with different parameter types.

```
public class Example
{
    public static int dummy(int value)
    {
        return value*2;
    }
    public static String dummy(String value)
    {
        return value;
    }
}
```

In addition, create two functions with the same names as the above two functions in GaussDB(DWS).

```
CREATE FUNCTION java_dummy(INTEGER)
    RETURNS INTEGER
    AS 'Example.dummy'
LANGUAGE JAVA;

CREATE FUNCTION java_dummy(VARCHAR)
    RETURNS VARCHAR
    AS 'Example.dummy'
LANGUAGE JAVA;
```


Step 2 Invoke the overloaded functions.

GaussDB(DWS) invokes the functions that match the specified parameter type. The results of invoking the above two functions are as follows:

```
SELECT java_dummy(5);
 java_dummy
-----------------
          10
(1 row)

SELECT java_dummy('5');
 java_dummy
---------------
5
(1 row)
```

Note that GaussDB(DWS) may implicitly convert data types. Therefore, you are advised to specify the parameter type when invoking an overloaded function.

```
SELECT java_dummy(5::varchar);
 java_dummy
---------------
5
(1 row)
```

In this case, the specified parameter type is preferentially used for matching. If there is no Java method matching the specified parameter type, the system implicitly converts the parameter and searches for Java methods based on the conversion result.

```
SELECT java_dummy(5::INTEGER);
 java_dummy
-----------------
10
(1 row)

DROP FUNCTION java_dummy(INTEGER);

SELECT java_dummy(5::INTEGER);
 java_dummy
---------------
5
(1 row)
```

NOTICE

Data types supporting implicit conversion are as follows:

- **SMALLINT**: It can be converted to the **INTEGER** type by default.
- **SMALLINT** and **INTEGER**: They can be converted to the **BIGINT** type by default.
- **TINYINT**, **SMALLINT**, **INTEGER**, and **BIGINT**: They can be converted to the **BOOL** type by default.
- **CHAR**, **NAME**, **BIGINT**, **INTEGER**, **SMALLINT**, **TINYINT**, **RAW**, **FLOAT4**, **FLOAT8**, **BPCHAR**, **VARCHAR**, **NVARCHAR2**, **DATE**, **TIMESTAMP**, **TIMESTAMPTZ**, **NUMERIC**, and **SMALLDATETIME**: They can be converted to the **TEXT** type by default.
- **TEXT**, **CHAR**, **BIGINT**, **INTEGER**, **SMALLINT**, **TINYINT**, **RAW**, **FLOAT4**, **FLOAT8**, **BPCHAR**, **DATE**, **NVARCHAR2**, **TIMESTAMP**, **NUMERIC**, and **SMALLDATETIME**: They can be converted to the **VARCHAR** type by default.

Step 3 Delete the overloaded functions.

To delete an overloaded function, specify the parameter type for the function. Otherwise, the function cannot be deleted.

```
DROP FUNCTION java_dummy(INTEGER);
```

----End

GUC Parameters

- **FencedUDFMemoryLimit**

  A session-level GUC parameter. It is used to specify the maximum virtual memory used by a single Fenced UDF Worker process initiated by a session.

  ```
  SET FencedUDFMemoryLimit='512MB';
  ```

  The value range of this parameter is (**150 MB**, **1G**). If the value is greater than **1G**, an error will be reported immediately. If the value is less than or equal to **150 MB**, an error will be reported during function invoking.

  NOTICE

  - If **FencedUDFMemoryLimit** is set to **0**, the virtual memory for a Fenced UDF Worker process will not be limited.
  - You are advised to use **udf_memory_limit** to control the physical memory used by Fenced UDF Worker processes. You are not advised to use **FencedUDFMemoryLimit**, especially when Java UDFs are used. If you are clear about the impact of this parameter, set it based on the following information:
    - After a C Fenced UDF Worker process is started, it will occupy about 200 MB virtual memory, and about 16 MB physical memory.
    - After a Java Fenced UDF Worker process is started, it will occupy about 2.5 GB virtual memory, and about 50 MB physical memory.

Exception Handling

If there is an exception in a JVM, PL/Java will export JVM stack information during the exception to a client.

Logging

PL/Java uses the standard Java Logger. Therefore, you can record logs as follows:

```
Logger.getAnonymousLogger().config( "Time is " + new
Date(System.currentTimeMillis()));
```

An initialized Java Logger class is set to the **CONFIG** level by default, corresponding to the **LOG** level in GaussDB(DWS). In this case, log messages generated by Java Logger are all redirected to the GaussDB(DWS) backend. Then, the log messages are written into server logs or displayed on the user interface. MPPDB server logs record information at the **LOG**, **WARNING**, and **ERROR** levels. The SQL user interface displays logs at the **WARNING** and **ERROR** levels. The following table lists mapping between Java Logger levels and GaussDB(DWS) log levels.

Table 9-2 PL/Java log levels

java.util.logging.Level	GaussDB(DWS) Log Level
SERVER	ERROR
WARNING	WARNING
CONFIG	LOG
INFO	INFO
FINE	DEBUG1
FINER	DEBUG2
FINEST	DEBUG3

You can change Java Logger levels. For example, if the Java Logger level is changed to **SEVERE** by the following Java code, log messages (**msg**) will not be recorded in GaussDB(DWS) logs during **WARNING** logging.

```
Logger log = Logger.getAnonymousLogger();
Log.setLevel(Level.SEVERE);
log.log(Level.WARNING, msg);
```

Security Issues

In GaussDB(DWS), PL/Java is an untrusted language. Only user **sysadmin** can create PL/Java functions. The user can grant other users the permission for using the PL/Java functions. For details, see **Authorize permissions for functions**.

In addition, PL/Java controls user access to file systems, forbidding users from reading most system files, or writing, deleting, or executing any system files in Java methods.

9.2 PL/pgSQL Functions

PL/pgSQL is similar to PL/SQL of Oracle. It is a loadable procedural language.

The functions created using PL/pgSQL can be used in any place where you can use built-in functions. For example, you can create calculation functions with complex conditions and use them to define operators or use them for index expressions.

SQL is used by most databases as a query language. It is portable and easy to learn. Each SQL statement must be executed independently by a database server.

In this case, when a client application sends a query to the server, it must wait for it to be processed, receive and process the results, and then perform some calculation before sending more queries to the server. If the client and server are not on the same machine, all these operations will cause inter-process communication and increase network loads.

PL/pgSQL enables a whole computing part and a series of queries to be grouped inside a database server. This makes procedural language available and SQL easier to use. In addition, the client/server communication cost is reduced.

- Extra round-trip communication between clients and servers is eliminated.
- Intermediate results that are not required by clients do not need to be sorted or transmitted between the clients and servers.
- Parsing can be skipped in multiple rounds of queries.

PL/pgSQL can use all data types, operators, and functions in SQL.

For details about the PL/pgSQL syntax for creating functions, see **CREATE FUNCTION**. As mentioned earlier, PL/pgSQL is similar to PL/SQL of Oracle and is a loadable procedural language. Its application method is similar to that of **Stored Procedures**. There is only one difference. Stored procedures have no return values but the functions have.

10 Stored Procedures

10.1 Stored Procedure

In GaussDB(DWS), business rules and logics are saved as stored procedures.

A stored procedure is a combination of SQL, PL/SQL, and Java statements, enabling business rule code to be moved from applications to databases and used by multiple programs at a time.

For details about how to create and call a stored procedure, see **CREATE PROCEDURE**.

The functions and stored procedures created by using PL/pgSQL in **PL/pgSQL Functions** are applicable to all the following sections.

10.2 Data Types

A data type refers to a value set and an operation set defined on the value set. A GaussDB(DWS) database consists of tables, each of which is defined by its own

columns. Each column corresponds to a data type. GaussDB(DWS) uses corresponding functions to perform operations on data based on data types. For example, GaussDB(DWS) can perform addition, subtraction, multiplication, and division operations on data of numeric values.

10.3 Data Type Conversion

Certain data types in the database support implicit data type conversions, such as assignments and parameters invoked by functions. For other data types, you can use the type conversion functions provided by GaussDB(DWS), such as the CAST function, to forcibly convert them.

Table 10-1 lists common implicit data type conversions in GaussDB(DWS).

NOTICE

The valid value range of DATE supported by GaussDB(DWS) is from 4713 B.C. to 294276 A.D.

Table 10-1 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 Data Type	Target Data Type	Remarks
RAW	VARCHAR2	-
CLOB	CHAR	-
CLOB	VARCHAR2	-
CLOB	NUMBER	Raw data must consist of digits.
INT4	CHAR	-

10.4 Arrays and Records

10.4.1 Arrays

Use of Array Types

Before the use of arrays, an array type needs to be defined:

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 [NOT NULL];
```

Its 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.
- **NOT NULL**: an optional constraint. It can be used to ensure that none of the elements in the array is **NULL**.

NOTE

- In GaussDB(DWS), an array automatically increases. If an access violation occurs, a null value will be returned, and no error message will be reported. If out-of-bounds write occurs in an array, the message **Subscript outside of limit** is displayed.
- 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(DWS) prefers the array type defined in a stored procedure to declare array variables.

In GaussDB(DWS) 8.1.0 and earlier versions, the system does not verify the length of array elements and out-of-bounds write because the array can automatically increase. This version adds related constraints to be compatible with Oracle databases. If out-of-bounds write exists, you can configure **varray_verification** in the parameter **behavior_compat_options** to be compatible with previously unverified operations.

Example:

```
-- Declare an array in a stored procedure.
CREATE OR REPLACE PROCEDURE array_proc
AS
	TYPE ARRAY_INTEGER IS VARRAY(1024) OF INTEGER;--Define the array type.
	TYPE ARRAY_INTEGER_NOT_NULL IS VARRAY(1024) OF INTEGER NOT NULL;-- Defines non-null array
types.
	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;
	DBMS_OUTPUT.PUT_LINE(ARRINT.COUNT);
	DBMS_OUTPUT.PUT_LINE(ARRINT(1));
	DBMS_OUTPUT.PUT_LINE(ARRINT(10));
	DBMS_OUTPUT.PUT_LINE(ARRINT(ARRINT.FIRST));
	DBMS_OUTPUT.PUT_LINE(ARRINT(ARRINT.last));
END;
/

-- Invoke the stored procedure.
CALL array_proc();
10
1
10
1
10
-- Delete the stored procedure.
DROP PROCEDURE array_proc;
```

Declaration and Use of Rowtype Arrays

In addition to the declaration and use of common arrays and non-null arrays in the preceding example, the array also supports the declaration and use of rowtype arrays.

Example:

```
-- Use the COUNT function on an array in a stored procedure.
CREATE TABLE tbl (a int, b int);
INSERT INTO tbl VALUES(1, 2),(2, 3),(3, 4);
CREATE OR REPLACE PROCEDURE array_proc
AS
   CURSOR all_tbl IS SELECT * FROM tbl ORDER BY a;
   TYPE tbl_array_type IS varray(50) OF tbl%rowtype; -- Defines the array of the rowtype type. tbl indicates
any table.
   tbl_array tbl_array_type;
   tbl_item tbl%rowtype;
   inx1 int;
BEGIN
   tbl_array := tbl_array_type();
   inx1 := 0;
   FOR tbl_item IN all_tbl LOOP
      inx1 := inx1 + 1;
      tbl_array(inx1) := tbl_item;
   END LOOP;
   WHILE inx1 IS NOT NULL LOOP
      DBMS_OUTPUT.PUT_LINE('tbl_array(inx1).a=' || tbl_array(inx1).a || ' tbl_array(inx1).b=' ||
tbl_array(inx1).b);
      inx1 := tbl_array.PRIOR(inx1);
   END LOOP;
END;
/
```

The execution output is as follows:


```
call array_proc();
tbl_array(inx1).a=3 tbl_array(inx1).b=4
tbl_array(inx1).a=2 tbl_array(inx1).b=3
tbl_array(inx1).a=1 tbl_array(inx1).b=2
```

Array Related Functions

GaussDB(DWS) supports Oracle-related array functions. You can use the following functions to obtain array attributes or perform operations on the array content.

COUNT

Returns the number of elements in the current array. Only the initialized elements or the elements extended by the EXTEND function are counted.

Use:

varray.**COUNT** or *varray*.**COUNT()**

Example:

```
-- Use the COUNT function on an array in a stored procedure.
CREATE OR REPLACE PROCEDURE test_varray
AS
    TYPE varray_type IS VARRAY(20) OF INT;
    v_varray varray_type;
BEGIN
    v_varray := varray_type(1, 2, 3);
    DBMS_OUTPUT.PUT_LINE('v_varray.count=' || v_varray.count);
    v_varray.extend;
    DBMS_OUTPUT.PUT_LINE('v_varray.count=' || v_varray.count);
END;
/
```

The execution output is as follows:

```
call test_varray();
v_varray.count=3
v_varray.count=4
```

FIRST and LAST

The FIRST function can return the subscript of the first element. The LAST function can return the subscript of the last element.

Use:

varray.**FIRST** or *varray*.**FIRST()**

varray.**LAST** or *varray*.**LAST()**

Example:

```
-- Use the FIRST and LAST functions on an array in a stored procedure.
CREATE OR REPLACE PROCEDURE test_varray
AS
    TYPE varray_type IS VARRAY(20) OF INT;
    v_varray varray_type;
BEGIN
    v_varray := varray_type(1, 2, 3);
    DBMS_OUTPUT.PUT_LINE('v_varray.first=' || v_varray.first);
    DBMS_OUTPUT.PUT_LINE('v_varray.last=' || v_varray.last);
END;
/
```


The execution output is as follows:

```
call test_varray();
v_varray.first=1
v_varray.last=3
```

EXTEND

> NOTE
>
> The EXTEND function is used to be compatible with two Oracle database operations. In GaussDB(DWS), an array automatically grows, and the EXTEND function is not necessary. For a newly written stored procedure, you do not need to use the EXTEND function.

The EXTEND function can extend arrays. The EXTEND function can be invoked in either of the following ways:

- Method 1:

  EXTEND contains an integer input parameter, indicating that the array size is extended by the specified length. After executing the EXTEND function, the values of the COUNT and LAST functions change accordingly.

  Use:

  varray.EXTEND(size)

  By default, one bit is added to the end of *varray*.**EXTEND**, which is equivalent to *varray*.**EXTEND(1)**.

- Method 2:

  EXTEND contains two integer input parameters. The first parameter indicates the length of the extended size. The second parameter indicates that the value of the extended array element is the same as that of the element with the **index** subscript.

  Use:

  varray.EXTEND(size, index)

Example:

```
-- Use the EXTEND function on an array in a stored procedure.
CREATE OR REPLACE PROCEDURE test_varray
AS
   TYPE varray_type IS VARRAY(20) OF INT;
   v_varray varray_type;
BEGIN
   v_varray := varray_type(1, 2, 3);
   v_varray.extend(3);
   DBMS_OUTPUT.PUT_LINE('v_varray.count=' || v_varray.count);
   v_varray.extend(2,3);
   DBMS_OUTPUT.PUT_LINE('v_varray.count=' || v_varray.count);
   DBMS_OUTPUT.PUT_LINE('v_varray(7)=' || v_varray(7));
   DBMS_OUTPUT.PUT_LINE('v_varray(8)=' || v_varray(7));
END;
/
```

The execution output is as follows:

```
call test_varray();
v_varray.count=6
v_varray.count=8
v_varray(7)=3
v_varray(8)=3
```


NEXT and PRIOR

The NEXT and PRIOR functions are used for cyclic array traversal. The NEXT function returns the subscript of the next array element based on the input parameter **index**. If the subscript reaches the maximum value, **NULL** is returned. The PRIOR function returns the subscript of the previous array element based on the input parameter **index**. If the minimum value of the array subscript is reached, **NULL** is returned.

Use:

varray.NEXT(index)

varray.PRIOR(index)

Example:

```
-- Use the NEXT and PRIOR functions on an array in a stored procedure.
CREATE OR REPLACE PROCEDURE test_varray
AS
    TYPE varray_type IS VARRAY(20) OF INT;
    v_varray varray_type;
    i int;
BEGIN
    v_varray := varray_type(1, 2, 3);

    i := v_varray.COUNT;
    WHILE i IS NOT NULL LOOP
        DBMS_OUTPUT.PUT_LINE('test prior v_varray('||i||')=' || v_varray(i));
        i := v_varray.PRIOR(i);
    END LOOP;

    i := 1;
    WHILE i IS NOT NULL LOOP
        DBMS_OUTPUT.PUT_LINE('test next v_varray('||i||')=' || v_varray(i));
        i := v_varray.NEXT(i);
    END LOOP;
END;
/
```

The execution output is as follows:

```
call test_varray();
test prior v_varray(3)=3
test prior v_varray(2)=2
test prior v_varray(1)=1
test next v_varray(1)=1
test next v_varray(2)=2
test next v_varray(3)=3
```

EXISTS

Determines whether an array subscript exists.

Use:

varray.EXISTS(index)

Example:

```
-- Use the EXISTS function on an array in a stored procedure.
CREATE OR REPLACE PROCEDURE test_varray
AS
    TYPE varray_type IS VARRAY(20) OF INT;
    v_varray varray_type;
BEGIN
```



```
    v_varray := varray_type(1, 2, 3);
    IF v_varray.EXISTS(1) THEN
        DBMS_OUTPUT.PUT_LINE('v_varray.EXISTS(1)');
    END IF;
    IF NOT v_varray.EXISTS(10) THEN
        DBMS_OUTPUT.PUT_LINE('NOT v_varray.EXISTS(10)');
    END IF;
END;
/
```

The execution output is as follows:

```
call test_varray();
v_varray.EXISTS(1)
NOT v_varray.EXISTS(10)
```

TRIM

Deletes a specified number of elements from the end of an array.

Use:

varray.TRIM(size)

varray.**TRIM** is equivalent to *varray*.**TRIM(1)**, because the default input parameter is **1**.

Example:

```
-- Use the TRIM function on an array in a stored procedure.
CREATE OR REPLACE PROCEDURE test_varray
AS
    TYPE varray_type IS VARRAY(20) OF INT;
    v_varray varray_type;
BEGIN
    v_varray := varray_type(1, 2, 3, 4, 5);
    v_varray.trim(3);
    DBMS_OUTPUT.PUT_LINE('v_varray.count' || v_varray.count);
    v_varray.trim;
    DBMS_OUTPUT.PUT_LINE('v_varray.count:' || v_varray.count);
END;
/
```

The execution output is as follows:

```
call test_varray();
v_varray.count:2
v_varray.count:1
```

DELETE

Deletes all elements from an array.

Use:

varray.**DELETE** or *varray*.**DELETE()**

Example:

```
-- Use the DELETE function on an array in a stored procedure.
CREATE OR REPLACE PROCEDURE test_varray
AS
    TYPE varray_type IS VARRAY(20) OF INT;
    v_varray varray_type;
BEGIN
    v_varray := varray_type(1, 2, 3, 4, 5);
```



```
    v_varray.delete;
    DBMS_OUTPUT.PUT_LINE('v_varray.count:' || v_varray.count);
END;
/
```

The execution output is as follows:

```
call test_varray();
v_varray.count:0
```

LIMIT

Returns the allowed maximum length of an array.

Use:

varray.**LIMIT** or *varray*.**LIMIT()**

Example:

```
-- Use the LIMIT function on an array in a stored procedure.
CREATE OR REPLACE PROCEDURE test_varray
AS
    TYPE varray_type IS VARRAY(20) OF INT;
    v_varray varray_type;
BEGIN
    v_varray := varray_type(1, 2, 3, 4, 5);
    DBMS_OUTPUT.PUT_LINE('v_varray.limit:' || v_varray.limit);
END;
/
```

The execution output is as follows:

```
call test_varray();
v_varray.limit:20
```

10.4.2 record

record Variables

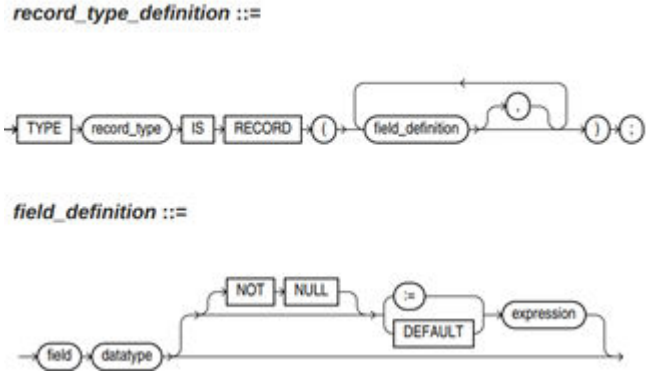
Perform the following operations to create a record variable:

Define a record type and use this type to declare a variable.

Syntax

For the syntax of the record type, see **Figure 10-1**.

Figure 10-1 Syntax of the record type



The syntax is described as follows:

- **record_type**: record name
- **field**: record columns
- **datatype**: record data type
- **expression**: expression for setting a default value

NOTE

In GaussDB(DWS):

- 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 a record type.
  - 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.

Examples

```
The table used in the following stored procedure is defined as follows:
CREATE TABLE emp_rec
(
    empno            numeric(4,0),
    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)
)
with (orientation = column,compression=middle)
distribute by hash (sal);
\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.
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 the 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;
END;
$$
LANGUAGE plpgsql;

-- Invoke the stored procedure.
CALL regress_record('abc');
INFO:  employer name: WARD , epno:18
INFO:  employer1 name: WARD , epno: 18
INFO:  employer1 name: <NULL> , epno: <NULL>
INFO:  employer2 name: SCOTT ,epno: 10
-- Delete the stored procedure.
DROP PROCEDURE regress_record;
```

10.5 Syntax

10.5.1 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:

- **DECLARE**: declares variables, types, cursors, and regional stored procedures and functions used in the PL/SQL block.
  ```
  DECLARE
  ```

  > NOTE
  >
  > This part is optional if no variable needs 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 part.

- **EXECUTION**: specifies procedure and SQL statements. It is the main part of a program. Mandatory
  ```
  BEGIN
  ```
- **EXCEPTION**: processes errors. 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 parameter **-r** is executed using the **gsql** tool.

Type

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 10-2**.
- Subprogram: a stored procedure, function, operator, or packages stored in a database. A subprogram created in a database can be called by other programs.

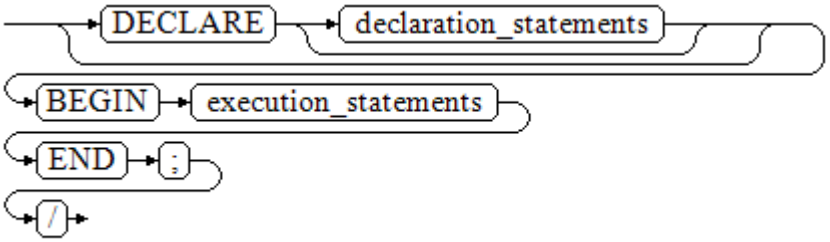
10.5.2 Anonymous Block

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 10-2 shows the syntax diagrams for an anonymous block.

Figure 10-2 anonymous_block::=



Details about the syntax diagram are as follows:

- The execute part 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. 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:
BEGIN
    NULL;
END;
/

-- Print information to the console:
BEGIN
    dbms_output.put_line('hello world!');
END;
/

-- Print variable contents to the console:
DECLARE
    my_var VARCHAR2(30);
BEGIN
    my_var :='world';
    dbms_output.put_line('hello'||my_var);
END;
/
```

10.5.3 Subprogram

A subprogram stores stored procedures, functions, operators, and advanced packages. A subprogram created in a database can be called by other programs.

10.6 Basic Statements

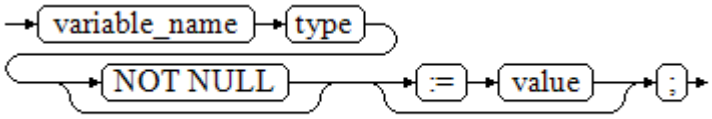
10.6.1 Variable Definition Statement

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 10-3**.

Figure 10-3 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:

```
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 a **my_name** variable that has the same data type as 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** even if you do not know 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
```

NOTICE

If multiple CNs are used, the %ROWTYPE and %TYPE attributes of temporary tables cannot be declared in a stored procedure, because a temporary table is valid only in the current session and is invisible to other CNs in the compilation phase. In this case, a message is displayed indicating that the temporary table does not exist.

Scope of a Variable

The scope of a variable indicates the accessibility and availability of a 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:

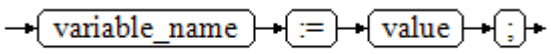
```
DECLARE
    emp_id  INTEGER :=7788; -- Define a variable and assign a value to it.
    outer_var  INTEGER :=6688; -- Define a variable and assign a value to it.
BEGIN
    DECLARE
        emp_id INTEGER :=7799; -- Define a variable and assign a value to it.
        inner_var  INTEGER :=6688; -- Define a variable and assign a value to it.
    BEGIN
        dbms_output.put_line('inner emp_id ='||emp_id); -- Display the value as 7799.
        dbms_output.put_line('outer_var ='||outer_var); -- Cite variables of an outer block.
    END;
    dbms_output.put_line('outer emp_id ='||emp_id); -- Display the value as 7788.
END;
/
```

10.6.2 Assignment Statement

Syntax

Figure 10-4 shows the syntax diagram for assigning a value to a variable.

Figure 10-4 assignment_value::=



The above syntax diagram is explained as follows:

- **variable_name** indicates 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**.

Examples

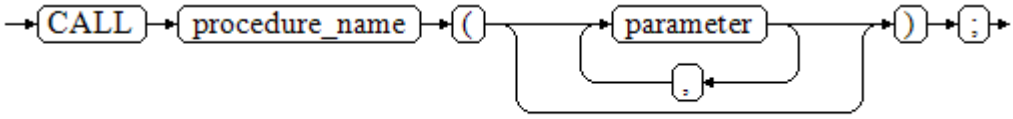
```
DECLARE
    emp_id  INTEGER := 7788; --Assignment
BEGIN
    emp_id := 5; --Assignment
    emp_id := 5*7784;
END;
/
```

10.6.3 Call Statement

Syntax

Figure 10-5 shows the syntax diagram for calling a clause.

Figure 10-5 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:
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 staffs where section_id = section;
END;
/

-- Create the stored procedure proc_return:
CREATE OR REPLACE PROCEDURE proc_return
AS
v_num NUMBER(8,2);
v_sum INTEGER;
BEGIN
proc_staffs(30, v_sum, v_num);  --Invoke a statement
dbms_output.put_line(v_sum||'#'||v_num);
RETURN;   --Return a statement
END;
/
```



```
-- Invoke a stored procedure proc_return:
CALL proc_return();

-- Delete a stored procedure:
DROP PROCEDURE proc_staffs;
DROP PROCEDURE proc_return;

--Create the function func_return.
CREATE OR REPLACE FUNCTION func_return returns void
language plpgsql
AS $$
DECLARE
v_num INTEGER := 1;
BEGIN
dbms_output.put_line(v_num);
RETURN;   --Return a statement
END $$;


-- Invoke the function func_return.
CALL func_return();
1

-- Delete the function:
DROP FUNCTION func_return;
```

10.7 Dynamic Statements

10.7.1 Executing Dynamic Query Statements

You can perform dynamic queries using **EXECUTE IMMEDIATE** or **OPEN FOR** in GaussDB(DWS). **EXECUTE IMMEDIATE** dynamically executes **SELECT** statements and **OPEN FOR** combines use of cursors. If you need to store query results in a data set, use **OPEN FOR**.

EXECUTE IMMEDIATE

Figure 10-6 shows the syntax diagram.

Figure 10-6 EXECUTE IMMEDIATE dynamic_select_clause::=

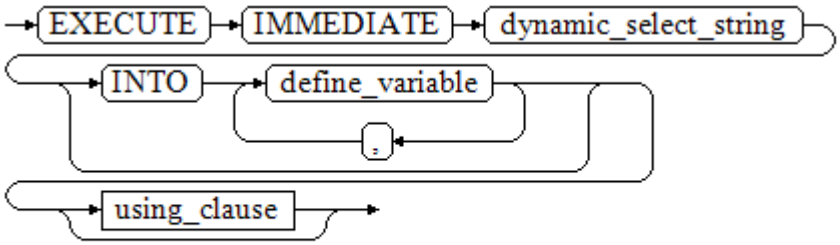
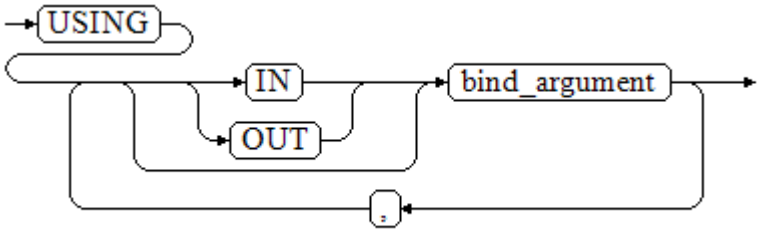


Figure 10-7 shows the syntax diagram for **using_clause**.

Figure 10-7 using_clause-1



The above syntax diagram is explained as follows:

- **define_variable**: specifies variables to store single-line query results.
- **USING IN bind_argument**: specifies where the variable passed to the dynamic SQL value is stored, that is, in the dynamic placeholder of **dynamic_select_string**.
- **USING OUT bind_argument**: specifies where the dynamic SQL returns the value of the variable.

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).
DECLARE
  staff_count  VARCHAR2(20);
BEGIN
  EXECUTE IMMEDIATE 'select count(*) from staffs'
    INTO staff_count;
  dbms_output.put_line(staff_count);
END;
/

--Pass and retrieve values (the INTO clause is used before the USING clause).
CREATE OR REPLACE PROCEDURE dynamic_proc
AS
  staff_id     NUMBER(6) := 200;
  first_name   VARCHAR2(20);
  salary       NUMBER(8,2);
BEGIN
```



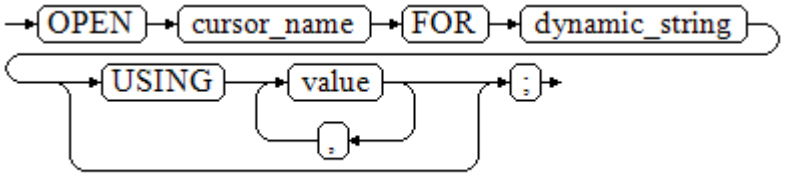
```
  EXECUTE IMMEDIATE 'select first_name, salary from staffs where staff_id = :1'
     INTO first_name, salary
     USING IN staff_id;
  dbms_output.put_line(first_name || ' ' || salary);
END;
/

-- Invoke the stored procedure.
CALL dynamic_proc();

-- Delete the stored procedure.
DROP PROCEDURE dynamic_proc;
```

OPEN FOR

Dynamic query statements can be executed by using **OPEN FOR** to open dynamic cursors.

For details about the syntax, see **Figure 10-8**.

Figure 10-8 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 use of cursors, see **Cursors**.

Example

```
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 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
        dbms_output.put_line(name||'#'||phone_number||'#'||salary);
        FETCH my_cur INTO name, phone_number, salary;
   END LOOP;
   CLOSE my_cur; -- Close the cursor.
END;
/
```


10.7.2 Executing Dynamic Non-query Statements

Syntax

Figure 10-9 shows the syntax diagram.

Figure 10-9 noselect::=

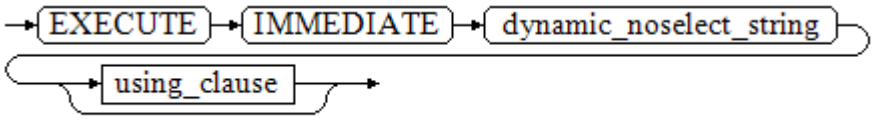
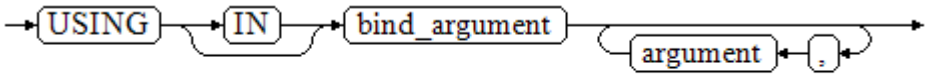


Figure 10-10 shows the syntax diagram for **using_clause**.

Figure 10-10 using_clause-2



The above syntax diagram is explained as follows:

USING IN bind_argument is used to specify the variable that transfers values to dynamic SQL statements. It 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:
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:
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:
SELECT * FROM sections_t1;

--Delete the table.
DROP TABLE sections_t1;
```

10.7.3 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 10-11 shows the syntax diagram.

Figure 10-11 call_procedure::=

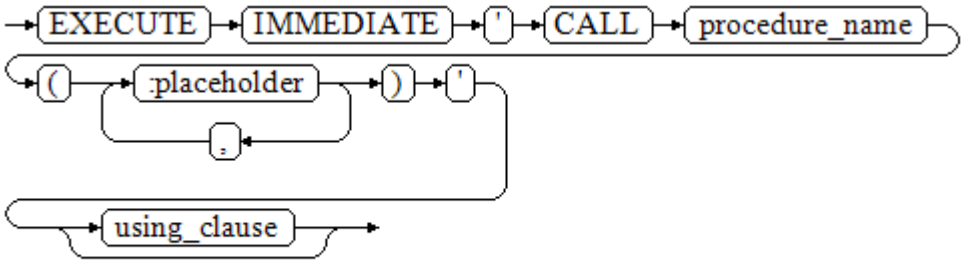
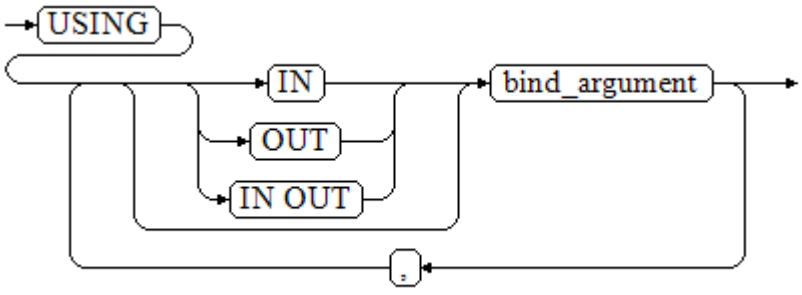


Figure 10-12 shows the syntax diagram for **using_clause**.

Figure 10-12 using_clause-3



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 the parameters are the same.
- **USING [IN|OUT|IN OUT]bind_argument**: specifies where the variable passed to the stored procedure parameter value is stored. The modifiers in front of **bind_argument** and of the corresponding parameter are the same.

Examples

```
--Create the stored procedure proc_add:
CREATE OR REPLACE PROCEDURE proc_add
(
    param1    in   INTEGER,
    param2    out  INTEGER,
    param3    in   INTEGER
)
AS
BEGIN
   param2:= param1 + param3;
END;
/

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;
    dbms_output.put_line('result is: '||to_char(param2));
END;
/

-- Delete the stored procedure.
DROP PROCEDURE proc_add;
```

10.7.4 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 10-13 shows the syntax diagram.

Figure 10-13 call_anonymous_block::=

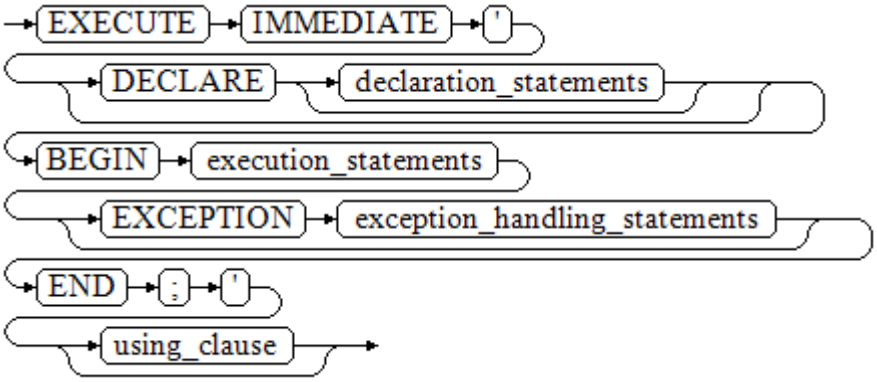
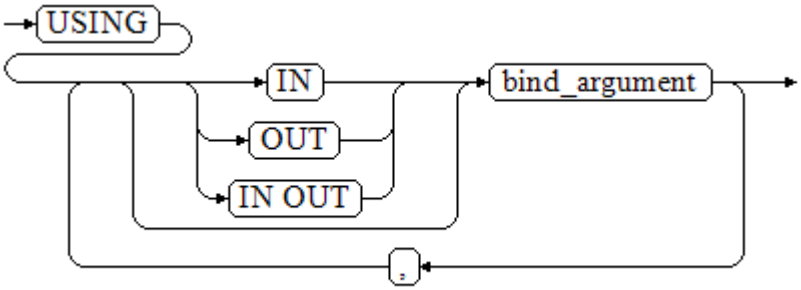


Figure 10-14 shows the syntax diagram for **using_clause**.

Figure 10-14 using_clause-4



The above syntax diagram is explained as follows:

- The execute part 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 where the variable passed to the stored procedure parameter value is stored. 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(DWS), when dynamic statements call anonymous blocks, placeholders cannot be used to pass input and output parameters in an **EXCEPTION** statement.

Example

```
--Create the stored procedure dynamic_proc.
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 staffs where
staff_id= :dno; end;'
       USING OUT first_name, OUT salary, IN staff_id;
  dbms_output.put_line(first_name|| ' ' || salary);
END;
/

-- Invoke the stored procedure.
CALL dynamic_proc();

-- Delete the stored procedure.
DROP PROCEDURE dynamic_proc;
```

10.8 Control Statements

10.8.1 RETURN Statements

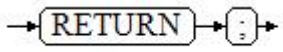
In GaussDB(DWS), data can be returned in either of the following ways: **RETURN**, **RETURN NEXT**, or **RETURN QUERY**. **RETURN NEXT** and **RETURN QUERY** are used only for functions and cannot be used for stored procedures.

10.8.1.1 RETURN

Syntax

Figure 10-15 shows the syntax diagram for a return statement.

Figure 10-15 return_clause::=



The syntax details are as follows:

This statement returns control from a stored procedure or function to a caller.

Example

```
-- Create the stored procedure proc_staffs:
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 staffs where section_id = section;
END;
/

-- Create the stored procedure proc_return:
CREATE OR REPLACE PROCEDURE proc_return
AS
v_num NUMBER(8,2);
v_sum INTEGER;
BEGIN
proc_staffs(30, v_sum, v_num);  --Invoke a statement
dbms_output.put_line(v_sum||'#'||v_num);
```



```
RETURN;   --Return a statement
END;
/

-- Invoke a stored procedure proc_return:
CALL proc_return();

-- Delete a stored procedure:
DROP PROCEDURE proc_staffs;
DROP PROCEDURE proc_return;

--Create the function func_return.
CREATE OR REPLACE FUNCTION func_return returns void
language plpgsql
AS $$
DECLARE
v_num INTEGER := 1;
BEGIN
dbms_output.put_line(v_num);
RETURN;   --Return a statement
END $$;


-- Invoke the function func_return.
CALL func_return();
1

-- Delete the function:
DROP FUNCTION func_return;
```

10.8.1.2 RETURN NEXT and RETURN QUERY

Syntax

When creating a function, specify **SETOF datatype** for the return values.

return_next_clause::=

return_query_clause::=

The syntax details are 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 **USING**.

Examples

```
CREATE TABLE t1(a int);
INSERT INTO t1 VALUES(1),(10);
```



```
--RETURN NEXT
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;
call fun_for_return_next();
 a
---
 1
 10
(2 rows)

-- RETURN QUERY
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;
call fun_for_return_next();
 a
---
 1
 10
(2 rows)
```

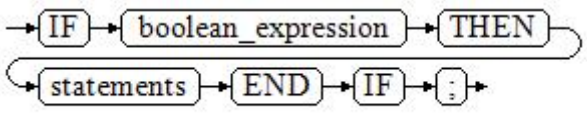
10.8.2 Conditional Statements

Conditional statements are used to decide whether given conditions are met. Operations are executed based on the decisions made.

GaussDB(DWS) supports five usages of **IF**:

- IF_THEN

  Figure 10-16 IF_THEN::=

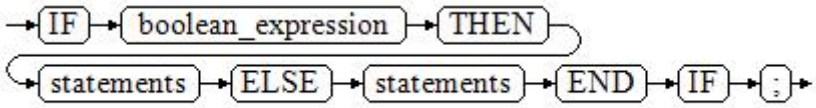
  IF_THEN is the simplest form of **IF**. If the condition is true, statements are executed. If it is false, they are skipped.

  Example

  ```
  IF v_user_id <> 0 THEN
      UPDATE users SET email = v_email WHERE user_id = v_user_id;
  END IF;
  ```

- IF_THEN_ELSE

Figure 10-17 IF_THEN_ELSE::=



IF-THEN-ELSE statements add **ELSE** branches and can be executed if the condition is **false**.

Example

```
IF parentid IS NULL OR parentid = ''
THEN
    RETURN;
ELSE
    hp_true_filename(parentid); -- Call the stored procedure.
END IF;
```

- IF_THEN_ELSE IF

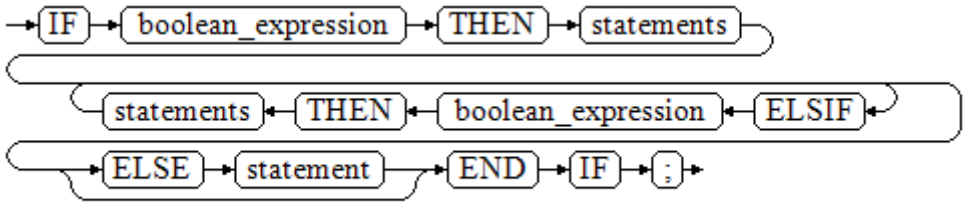
  IF statements can be nested in the following way:

  ```
  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 10-18 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**.

  Example

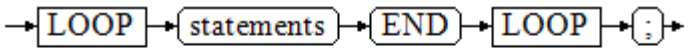

```
CREATE OR REPLACE PROCEDURE proc_control_structure(i in integer)
AS
   BEGIN
      IF i > 0 THEN
         raise info 'i:% is greater than 0. ',i;
      ELSIF i < 0 THEN
         raise info 'i:% is smaller than 0. ',i;
      ELSE
         raise info 'i:% is equal to 0. ',i;
      END IF;
      RETURN;
   END;
/

CALL proc_control_structure(3);

-- Delete the stored procedure:
DROP PROCEDURE proc_control_structure;
```

10.8.3 Loop Statements

Simple LOOP Statements

The syntax diagram is as follows.

Figure 10-19 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);
```

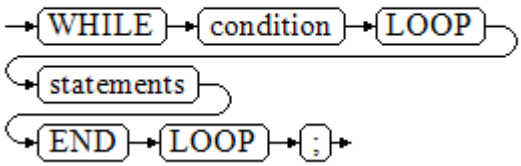
NOTICE

The loop must be exploited together with **EXIT**; otherwise, a dead loop occurs.

WHILE-LOOP Statements

The syntax diagram is as follows.

Figure 10-20 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.

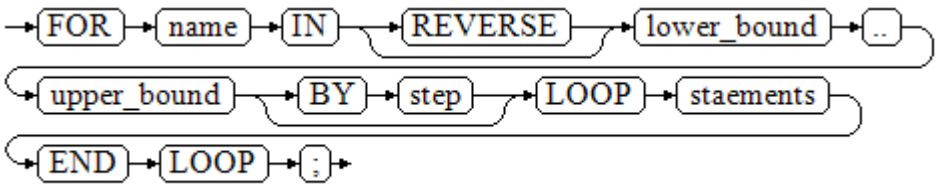
Examples

```
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*

The syntax diagram is as follows.

Figure 10-21 for_loop::=



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.

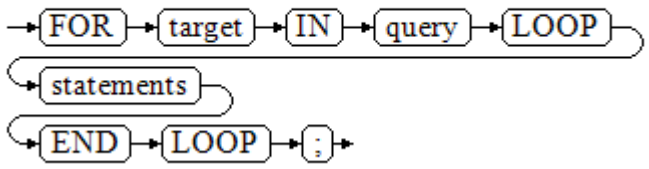
Example:


```
-- Loop from 0 to 5:
CREATE OR REPLACE PROCEDURE proc_for_loop()
AS
   BEGIN
   FOR I IN 0..5 LOOP
      DBMS_OUTPUT.PUT_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

The syntax diagram is as follows.

Figure 10-22 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.

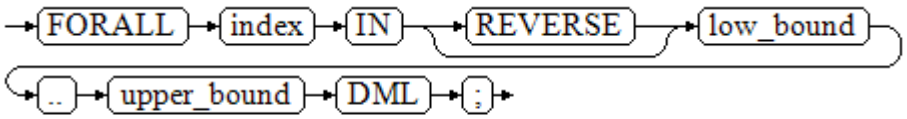
Example:

```
-- 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
   dbms_output.put_line(record);
   END LOOP;
END;
/

-- Invoke a function.
CALL proc_for_loop_query();

-- Delete the stored procedure.
DROP PROCEDURE proc_for_loop_query;
```

FORALL Batch Query Statements

The syntax diagram is as follows.

Figure 10-23 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 hdfs_t1 (
  title NUMBER(6),
  did VARCHAR2(20),
  data_peroid VARCHAR2(25),
  kind VARCHAR2(25),
  interval VARCHAR2(20),
  time DATE,
  isModified VARCHAR2(10)
)
DISTRIBUTE BY hash(did);

INSERT INTO hdfs_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
        insert into hdfs_t1(title) values(i);
END;
/

-- Invoke a function:
CALL proc_forall();

-- Query the invocation result of the stored procedure:
SELECT * FROM hdfs_t1 WHERE title BETWEEN 100 AND 120;

-- Delete the stored procedure and table:
DROP PROCEDURE proc_forall;
DROP TABLE hdfs_t1;
```

10.8.4 Branch Statements

Syntax

Figure 10-24 shows the syntax diagram.

Figure 10-24 case_when::=

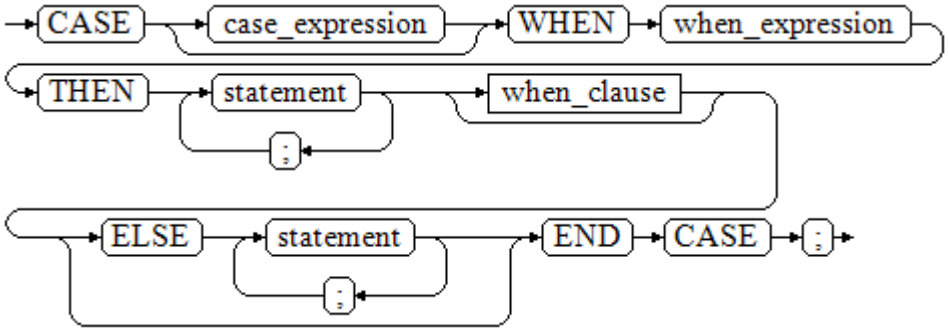
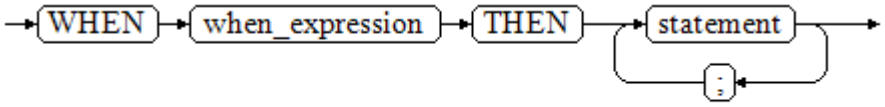


Figure 10-25 shows the syntax diagram for **when_clause**.

Figure 10-25 when_clause::=



Parameter description:

- **case_expression**: specifies the variable or expression.
- **when_expression**: specifies the constant or conditional expression.
- **statement**: specifies the statement to execute.

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);
```



```
-- Delete the stored procedure:
DROP PROCEDURE proc_case_branch;
```

10.8.5 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;
/
```

10.8.6 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 inside the executed statement, the statement rolls back and goes to the EXCEPTION list to find the first condition that matches the error. 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:

The error can be caught by an enclosing block with **EXCEPTION**, or if there is none it aborts processing of the function.

The *condition* can be any of those shown in SQL standard error codes. The special condition name **OTHERS** matches every error type except **QUERY_CANCELED**.

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);

CREATE FUNCTION merge_db(key INT, data TEXT) RETURNS VOID AS
$$
BEGIN
   LOOP
```



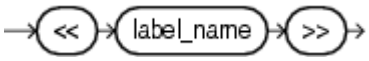
```
-- Try updating the key:
       UPDATE db SET b = data WHERE a = key;
       IF found THEN
          RETURN;
       END IF;
-- Not there, so try to insert the key. If someone else inserts the same key concurrently, we could get a
unique-key failure.
       BEGIN
          INSERT INTO db(a,b) VALUES (key, data);
          RETURN;
       EXCEPTION WHEN unique_violation THEN
       -- 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 ;
```

10.8.7 GOTO Statements

The **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 the **GOTO** statement, the labeled statement must be unique.

Syntax

label declaration ::=



goto statement ::=

Examples

```
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;
<<pos1>>
v1 := v1 + 10;
raise info 'v1 is %. ', v1;
END;
```



```
/

call GOTO_test();
DROP PROCEDURE GOTO_test();
```

Constraints

The **GOTO** statement has the following constraints:

- The **GOTO** statement does not allow multiple labeled statements even if they are in different blocks.

```
BEGIN
 GOTO pos1;
 <<pos1>>
 SELECT * FROM ...
 <<pos1>>
 UPDATE t1 SET ...
END;
```

- The **GOTO** statement cannot transfer control to the **IF**, **CASE**, or **LOOP** statement.

```
BEGIN
  GOTO pos1;
  IF valid THEN
    <<pos1>>
    SELECT * FROM ...
  END IF;
 END;
```

- The **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;
```

- The **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;
```

- The **GOTO** statement cannot transfer control from an **EXCEPTION** block to the current **BEGIN-END** block but can transfer to an outer **BEGIN-END** block.

```
BEGIN
  <<pos1>>
  UPDATE t1 SET ...
  EXCEPTION
    WHEN condition THEN
      GOTO pos1;
 END;
```

- If the labeled statement in the **GOTO** statement does not exist, you need to add the **NULL** statement.

```
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;
/
```

10.9 Other Statements

10.9.1 Lock Operations

GaussDB(DWS) provides multiple lock modes to control concurrent accesses to table data. These modes are used when Multi-Version Concurrency Control (MVCC) cannot give expected behaviors. Alike, most GaussDB(DWS) 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.

10.9.2 Cursor Operations

GaussDB(DWS) 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 them 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 **Explicit Cursor**.

10.10 Cursors

10.10.1 Overview

To process SQL statements, the stored procedure process assigns a memory segment to store context association. Cursors are handles or pointers to context areas. With cursors, stored procedures can control alterations in context areas.

NOTICE

If JDBC is used to call a stored procedure whose returned value is a cursor, the returned cursor is not available.

Cursors are classified into explicit cursors and implicit cursors. **Table 10-2** shows the usage conditions of explicit and implicit cursors for different SQL statements.

Table 10-2 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

10.10.2 Explicit Cursor

An explicit cursor is used to process query statements, particularly when the query results contain multiple records.

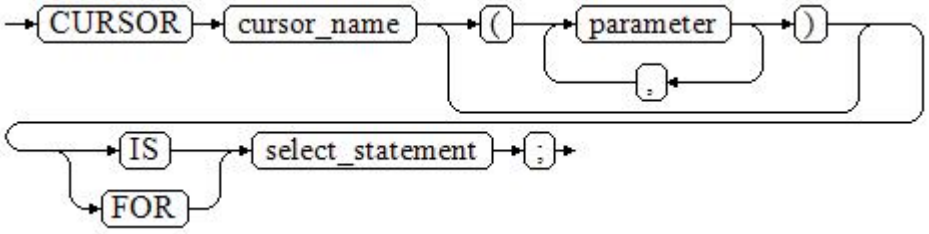
Procedure

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 10-26 shows the syntax diagram for defining a static cursor.

Figure 10-26 static_cursor_define::=



Parameter description:

- **cursor_name**: defines a cursor name.
- **parameter**: specifies cursor parameters. Only input parameters are allowed in the following format:
  ```
  parameter_name datatype
  ```
- **select_statement**: specifies a query statement.

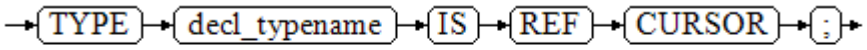
NOTE

The system automatically determines whether the cursor can be used for backward fetches 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.

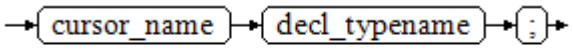
Figure 10-27 and Figure 10-28 show the syntax diagrams for defining a dynamic cursor.

Figure 10-27 cursor_typename::=



GaussDB(DWS) 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.

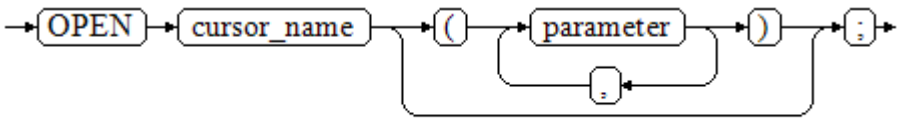
Figure 10-28 dynamic_cursor_define::=



Step 2 **Open the static cursor:** Execute the **SELECT** statement corresponding to the cursor. The query result is placed in the work area and the pointer directs to the head of the work area to identify the cursor result set. If the cursor query statement contains the **FOR UPDATE** option, the **OPEN** statement locks the data row corresponding to the cursor result set in the database table.

Figure 10-29 shows the syntax diagram for opening a static cursor.

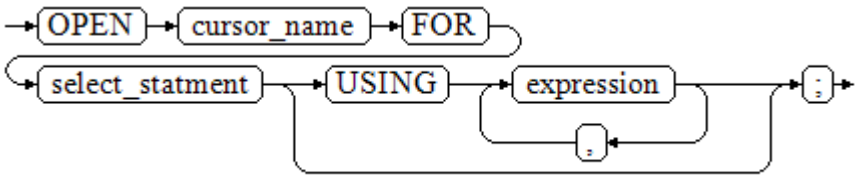
Figure 10-29 open_static_cursor::=



Open the dynamic cursor: Use the **OPEN FOR** statement to open the dynamic cursor and the SQL statement is dynamically bound.

Figure 10-30 shows the syntax diagram for opening a dynamic cursor.

Figure 10-30 open_dynamic_cursor::=

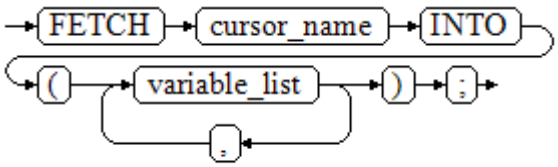


A PL/SQL program cannot use the **OPEN** statement to repeatedly open a cursor.

Step 3 **Fetch cursor data**: Retrieve data rows in the result set and place them in specified output variables.

Figure 10-31 shows the syntax diagram for fetching cursor data.

Figure 10-31 fetch_cursor::=



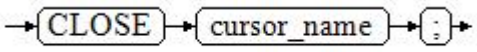
Step 4 Process the record.

Step 5 Continue to process until the active set has no record.

Step 6 **Close the cursor**: When fetching and finishing the data in the cursor result set, close the cursor immediately to release system resources used by the cursor and invalidate the work area of the cursor so that the **FETCH** statement cannot be used to fetch data any more. A closed cursor can be reopened using the **OPEN** statement.

Figure 10-32 shows the syntax diagram for closing a cursor.

Figure 10-32 close_cursor::=



----End

Attributes

Cursor attributes are used to control program procedures or learn about 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 sections WHERE section_id <= 50;
    CURSOR C2(sect_id INTEGER) IS
        SELECT section_name, place_id FROM 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;
        DBMS_OUTPUT.PUT_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;
        DBMS_OUTPUT.PUT_LINE(DEPT_NAME||'---'||DEPT_LOC);
    END LOOP;
    CLOSE C2;

    SQL_STR := 'SELECT section_name, place_id FROM 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;
        DBMS_OUTPUT.PUT_LINE(DEPT_NAME||'---'||DEPT_LOC);
    END LOOP;
    CLOSE C3;
END;
/

CALL cursor_proc1();

DROP PROCEDURE cursor_proc1;
-- Increase the salary of employees whose salary is lower than CNY3000 by CNY500:
CREATE TABLE staffs_t1 AS TABLE 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 staffs_t1;
BEGIN
  OPEN C;
  LOOP
    FETCH C INTO V_EMPNO, V_SAL;
    EXIT WHEN C%NOTFOUND;
    IF V_SAL<=3000 THEN
         UPDATE staffs_t1 SET salary =salary + 500 WHERE staff_id = V_EMPNO;
    END IF;
  END LOOP;
  CLOSE C;
END;
/

CALL cursor_proc2();

-- Drop the stored procedure:
DROP PROCEDURE cursor_proc2;
DROP TABLE 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 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;
  DBMS_OUTPUT.PUT_LINE(C1%ROWCOUNT);
  EXIT WHEN C1%NOTFOUND;
END LOOP;
END;
/

-- Drop the stored procedure:
DROP PROCEDURE proc_sys_ref;
```

10.10.3 Implicit Cursor

The system automatically sets implicit cursors for non-query statements, such as **ALTER** and **DROP**, and creates work areas for these statements. These implicit cursors are named SQL, which is defined by the system.

Overview

Implicit cursor operations, such as definition, opening, value-grant, and closing, are automatically performed by the system. Users can use only the attributes of implicit cursors to complete operations. The data stored in the work area of an implicit cursor is the latest SQL statement, and is not related to the user-defined explicit cursors.

Format call: SQL%

NOTE

INSERT, **UPDATE**, **DROP**, and **SELECT** statements do not require 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 executed.

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 staffs_t1 AS TABLE staffs;
CREATE TABLE sections_t1 AS TABLE sections;

CREATE OR REPLACE PROCEDURE proc_cursor3()
AS
   DECLARE
   V_DEPTNO NUMBER(4) := 100;
   BEGIN
      DELETE FROM staffs WHERE section_ID = V_DEPTNO;
      -- Proceed based on cursor status:
      IF SQL%NOTFOUND THEN
      DELETE FROM sections_t1 WHERE section_ID = V_DEPTNO;
      END IF;
   END;
/

CALL proc_cursor3();

-- Drop the stored procedure and the temporary table:
DROP PROCEDURE proc_cursor3;
DROP TABLE staffs_t1;
DROP TABLE sections_t1;
```

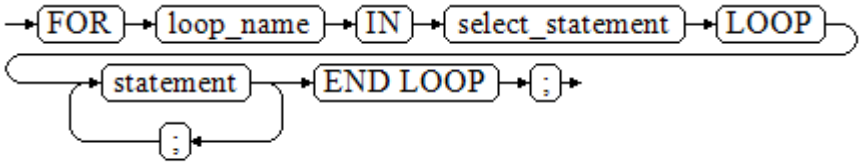
10.10.4 Cursor Loop

The use of cursors in **WHILE** and **LOOP** statements is called a cursor loop. Generally, **OPEN**, **FETCH**, and **CLOSE** statements are needed in cursor loop. The following describes a loop that is applicable to a static cursor loop without executing the four steps of a static cursor.

Syntax

Figure 10-33 shows the syntax diagram for the **FOR AS** loop.

Figure 10-33 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. The type and value of *loop_name* are the same as those of the query result of *select_statement*.
- The **%FOUND**, **%NOTFOUND**, and **%ROWCOUNT** attributes access the same internal variable in GaussDB(DWS). Transactions and anonymous blocks cannot be accessed by multiple cursors at the same time.

Examples

```
BEGIN
FOR ROW_TRANS IN
      SELECT first_name FROM staffs
```



```
    LOOP
        DBMS_OUTPUT.PUT_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 value of C1%FOUND and C2%FOUND is FALSE.
   FETCH C2 INTO PI_B; ----  The value of C1%FOUND and C2%FOUND is TRUE.
-- Determine the cursor status:
   IF C1%FOUND THEN
      IF C2%FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Dual cursor share paremeter.');
      END IF;
   END IF;
    CLOSE C1;-- Close the cursor.
   CLOSE C2;
END;
/

-- Drop the temporary table:
DROP TABLE integerTable1;
DROP TABLE integerTable2;
```

10.11 Advanced Packages

10.11.1 DBMS_LOB

Related Interfaces

Table 10-3 provides all interfaces supported by the **DBMS_LOB** package.

Table 10-3 DBMS_LOB

API	Description
DBMS_LOB.GETLENGTH	Obtains and returns the specified length of a LOB object.
DBMS_LOB.OPEN	Opens a LOB and returns a LOB descriptor.
DBMS_LOB.READ	Loads a part of LOB contents to BUFFER area according to the specified length and initial position offset.
DBMS_LOB.WRITE	Copies contents in BUFFER area to LOB according to the specified length and initial position offset.

API	Description
DBMS_LOB.WRITEAPPEND	Copies contents in BUFFER area to the end part of LOB according to the specified length.
DBMS_LOB.COPY	Copies contents in BLOB to another BLOB according to the specified length and initial position offset.
DBMS_LOB.ERASE	Deletes contents in BLOB according to the specified length and initial position offset.
DBMS_LOB.CLOSE	Closes a LOB descriptor.
DBMS_LOB.INSTR	Returns the position of the Nth occurrence of a character string in LOB.
DBMS_LOB.COMPARE	Compares two LOBs or a certain part of two LOBs.
DBMS_LOB.SUBSTR	Reads the substring of a LOB and returns the number of read bytes or the number of characters.
DBMS_LOB.TRIM	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.
DBMS_LOB.CREATETEMPORARY	Creates a temporary BLOB or CLOB.
DBMS_LOB.APPEND	Adds the content of a LOB to another LOB.

- DBMS_LOB.GETLENGTH

  Specifies the length of a LOB type object obtained and returned by the stored procedure **GETLENGTH**.

  The function prototype of **DBMS_LOB.GETLENGTH** is:

```
DBMS_LOB.GETLENGTH (
lob_loc    IN   BLOB)
RETURN INTEGER;

DBMS_LOB.GETLENGTH (
lob_loc    IN   CLOB)
RETURN INTEGER;
```

  Table 10-4 DBMS_LOB.GETLENGTH interface parameters

Parameter	Description
lob_loc	LOB type object whose length is to be obtained

- DBMS_LOB.OPEN

  A stored procedure opens a LOB and returns a LOB descriptor. This process is used only for compatibility.

  The function prototype of **DBMS_LOB.OPEN** is:


```
DBMS_LOB.LOB (
lob_loc INOUT BLOB,
open_mode IN BINARY_INTEGER);

DBMS_LOB.LOB (
lob_loc INOUT CLOB,
open_mode IN BINARY_INTEGER);
```

Table 10-5 DBMS_LOB.OPEN interface parameters

Parameter	Description
lob_loc	BLOB or CLOB descriptor that is opened
open_mode IN BINARY_INTEGER	Open mode (currently, DBMS_LOB.LOB_READWRITE is supported)

- DBMS_LOB.READ

  The stored procedure **READ** loads a part of LOB contents to BUFFER according to the specified length and initial position offset.

  The function prototype of **DBMS_LOB.READ** is:

```
DBMS_LOB.READ (
lob_loc     IN          BLOB,
amount      IN          INTEGER,
offset      IN          INTEGER,
buffer      OUT         RAW);

DBMS_LOB.READ (
lob_loc    IN           CLOB,
amount     IN OUT       INTEGER,
offset     IN           INTEGER,
buffer     OUT          VARCHAR2);
```

Table 10-6 DBMS_LOB.READ interface parameters

Parameter	Description
lob_loc	LOB type object to be loaded
amount	Load data length **NOTE** If the read length is negative, the error message "ERROR: argument 2 is null, invalid, or out of range." is displayed.
offset	Indicates where to start reading the LOB contents, that is, the offset bytes to initial position of LOB contents.
buffer	Target buffer to store the loaded LOB contents

- DBMS_LOB.WRITE

  The stored procedure **WRITE** copies contents in BUFFER to LOB variables according to the specified length and initial position offset.

  The function prototype of **DBMS_LOB.WRITE** is:

```
DBMS_LOB.WRITE (
lob_loc    IN OUT     BLOB,
```



```
amount     IN         INTEGER,
offset     IN         INTEGER,
buffer     IN         RAW);

DBMS_LOB.WRITE (
lob_loc   IN OUT      CLOB,
amount    IN          INTEGER,
offset    IN          INTEGER,
buffer    IN          VARCHAR2);
```

Table 10-7 DBMS_LOB.WRITE interface parameters

Parameter	Description
lob_loc	LOB type object to be written
amount	Write data length **NOTE** If the write data is shorter than 1 or longer than the contents to be written, an error is reported.
offset	Indicates where to start writing the LOB contents, that is, the offset bytes to initial position of LOB contents. **NOTE** If the offset is shorter than 1 or longer than the maximum length of LOB type contents, an error is reported.
buffer	Content to be written

- DBMS_LOB.WRITEAPPEND

  The stored procedure **WRITEAPPEND** copies contents in BUFFER to the end part of LOB according to the specified length.

  The function prototype of **DBMS_LOB.WRITEAPPEND** is:

```
DBMS_LOB.WRITEAPPEND (
lob_loc     IN OUT     BLOB,
amount      IN         INTEGER,
buffer      IN         RAW);

DBMS_LOB.WRITEAPPEND (
lob_loc     IN OUT     CLOB,
amount      IN         INTEGER,
buffer      IN         VARCHAR2);
```

Table 10-8 DBMS_LOB.WRITEAPPEND interface parameters

Parameter	Description
lob_loc	LOB type object to be written
amount	Write data length **NOTE** If the write data is shorter than 1 or longer than the contents to be written, an error is reported.
buffer	Content to be written

- DBMS_LOB.COPY

The stored procedure **COPY** copies contents in BLOB to another BLOB according to the specified length and initial position offset.

The function prototype of **DBMS_LOB.COPY** is:

```
DBMS_LOB.COPY (
dest_lob      IN OUT     BLOB,
src_lob       IN         BLOB,
amount        IN         INTEGER,
dest_offset   IN         INTEGER  DEFAULT 1,
src_offset    IN         INTEGER  DEFAULT 1);
```

Table 10-9 DBMS_LOB.COPY interface parameters

Parameter	Description
dest_lob	BLOB type object to be pasted
src_lob	BLOB type object to be copied
amount	Replication length. **NOTE** If the copied data is shorter than 1 or longer than the maximum length of BLOB type contents, an error is reported.
dest_offset	Indicates where to start pasting the BLOB contents, that is, the offset bytes to initial position of BLOB contents. **NOTE** If the offset is shorter than 1 or longer than the maximum length of BLOB type contents, an error is reported.
src_offset	Indicates where to start copying the BLOB contents, that is, the offset bytes to initial position of BLOB contents. **NOTE** If the offset is shorter than 1 or longer than the length of source BLOB, an error is reported.

- DBMS_LOB.ERASE

  The stored procedure **ERASE** deletes contents in BLOB according to the specified length and initial position offset.

  The function prototype of **DBMS_LOB.ERASE** is:

  ```
  DBMS_LOB.ERASE (
  lob_loc         IN OUT   BLOB,
  amount          IN OUT   INTEGER,
  offset          IN       INTEGER DEFAULT 1);
  ```

  Table 10-10 DBMS_LOB.ERASE interface parameters

Parameter	Description
lob_loc	BLOB type object whose contents are to be deleted
amount	Length of contents to be deleted **NOTE** If the deleted data is shorter than 1 or longer than the maximum length of BLOB type contents, an error is reported.

Parameter	Description
offset	Indicates where to start deleting the BLOB contents, that is, the offset bytes to initial position of BLOB contents. **NOTE** If the offset is shorter than 1 or longer than the maximum length of BLOB type contents, an error is reported.

- DBMS_LOB.CLOSE

  The procedure **CLOSE** disables the enabled contents of LOB according to the specified length and initial position offset.

  The function prototype of **DBMS_LOB.CLOSE** is:

```
DBMS_LOB.CLOSE(
src_lob       IN              BLOB);

DBMS_LOB.CLOSE (
src_lob      IN              CLOB);
```

Table 10-11 DBMS_LOB.CLOSE interface parameters

Parameter	Description
src_loc	LOB type object to be disabled

- DBMS_LOB.INSTR

  This function returns the Nth occurrence position in LOB. If invalid values are entered, **NULL** is returned. The invalid values include offset < 1 or offset > LOBMAXSIZE, nth < 1, and nth > LOBMAXSIZE.

  The function prototype of **DBMS_LOB.INSTR** is:

```
DBMS_LOB.INSTR (
lob_loc     IN      BLOB,
pattern     IN      RAW,
offset      IN      INTEGER := 1,
nth         IN      INTEGER := 1)
RETURN INTEGER;

DBMS_LOB.INSTR (
lob_loc    IN      CLOB,
pattern    IN      VARCHAR2 ,
offset     IN     INTEGER := 1,
nth        IN     INTEGER := 1)
RETURN INTEGER;
```

Table 10-12 DBMS_LOB.INSTR interface parameters

Parameter	Description
lob_loc	LOB descriptor to be searched for
pattern	Matched pattern. It is RAW for BLOB and TEXT for CLOB.
offset	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.

Parameter	Description
nth	Number of pattern matching times. The minimum value is 1.

- DBMS_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 CLOB is smaller than the second, **-1** is returned. If the first CLOB is larger than the second, **1** is returned.

  – If any of the **amount**, **offset_1**, and **offset_2** parameters is invalid, **NULL** is returned. The valid offset range is 1 to LOBMAXSIZE.

  The function prototype of **DBMS_LOB.READ** is:

```
DBMS_LOB.COMPARE (
lob_1     IN     BLOB,
lob_2     IN     BLOB,
amount    IN     INTEGER := DBMS_LOB.LOBMAXSIZE,
offset_1  IN     INTEGER := 1,
offset_2  IN     INTEGER := 1)
RETURN INTEGER;

DBMS_LOB.COMPARE (
lob_1     IN     CLOB,
lob_2     IN     CLOB,
amount    IN     INTEGER := DBMS_LOB.LOBMAXSIZE,
offset_1  IN     INTEGER := 1,
offset_2  IN     INTEGER := 1)
RETURN INTEGER;
```

Table 10-13 DBMS_LOB.COMPARE interface parameters

Parameter	Description
lob_1	First LOB descriptor to be compared
lob_2	Second LOB descriptor to be compared
amount	Number of characters or bytes to be compared. The maximum value is DBMS_LOB.LOBMAXSIZE.
offset_1	Offset of the first LOB descriptor. The initial position is 1.
offset_2	Offset of the second LOB descriptor. The initial position is 1.

- DBMS_LOB.SUBSTR

  This function reads the substring of a LOB and returns the number of read bytes or the number of characters. If amount > 1, amount < 32767, offset < 1, or offset > LOBMAXSIZE, **NULL** is returned.

  The function prototype of **DBMS_LOB.SUBSTR** is:

```
DBMS_LOB.SUBSTR (
lob_loc     IN     BLOB,
amount      IN     INTEGER := 32767,
```



```
offset      IN     INTEGER := 1)
RETURN RAW;

DBMS_LOB.SUBSTR (
lob_loc    IN     CLOB,
amount     IN     INTEGER := 32767,
offset     IN     INTEGER := 1)
RETURN VARCHAR2;
```

Table 10-14 DBMS_LOB.SUBSTR interface parameters

Parameter	Description
lob_loc	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.
offset	Number of bytes or characters to be read.
buffer	Number of characters or bytes offset from the start position.

- DBMS_LOB.TRIM

  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 LOB, an exception occurs.

  The function prototype of **DBMS_LOB.TRIM** is:

  ```
  DBMS_LOB.TRIM (
  lob_loc     IN OUT     BLOB,
  newlen      IN         INTEGER);

  DBMS_LOB.TRIM (
  lob_loc    IN          OUT CLOB,
  newlen     IN          INTEGER);
  ```

  Table 10-15 DBMS_LOB.TRIM interface parameters

Parameter	Description
lob_loc	BLOB type object 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.

- DBMS_LOB.CREATETEMPORARY

  This stored procedure creates a temporary BLOB or CLOB and is used only for syntax compatibility.

  The function prototype of **DBMS_LOB.CREATETEMPORARY** is:

  ```
  DBMS_LOB.CREATETEMPORARY (
  lob_loc    IN OUT      BLOB,
  cache      IN          BOOLEAN,
  dur        IN          INTEGER);
  ```



```
DBMS_LOB.CREATETEMPORARY (
lob_loc    IN OUT     CLOB,
cache      IN         BOOLEAN,
dur        IN         INTEGER);
```

Table 10-16 DBMS_LOB.CREATETEMPORARY interface parameters

Parameter	Description
lob_loc	LOB descriptor
cache	This parameter is used only for syntax compatibility.
dur	This parameter is used only for syntax compatibility.

- DBMS_LOB.APPEND

  The stored procedure **READ** loads a part of BLOB contents to BUFFER according to the specified length and initial position offset.

  The function prototype of **DBMS_LOB.APPEND** is:

```
DBMS_LOB.APPEND (
dest_lob    IN OUT      BLOB,
src_lob     IN          BLOB);

DBMS_LOB.APPEND (
dest_lob    IN OUT      CLOB,
src_lob     IN          CLOB);
```

Table 10-17 DBMS_LOB.APPEND interface parameters

Parameter	Description
dest_lob	LOB descriptor to be written
src_lob	LOB descriptor to be read

Examples

```
-- Obtain the length of the character string.
SELECT DBMS_LOB.GETLENGTH('12345678');

DECLARE
myraw  RAW(100);
amount INTEGER :=2;
buffer INTEGER :=1;
begin
DBMS_LOB.READ('123456789012345',amount,buffer,myraw);
dbms_output.put_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 := utl_raw.cast_to_raw(str);
amount := utl_raw.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;

DBMS_LOB.WRITE(dest, amount, 1, source);
DBMS_LOB.WRITEAPPEND(dest, amount, source);

DBMS_LOB.ERASE(dest, a, 1);
DBMS_OUTPUT.PUT_LINE(a);
DBMS_LOB.COPY(copyto, dest, amount, 10, 1);
DBMS_LOB.CLOSE(dest);
RETURN;
END;
/

--Delete the table.
DROP TABLE blob_Table;
DROP TABLE blob_Table_bak;
```

10.11.2 DBMS_RANDOM

Related Interfaces

Table 10-18 provides all interfaces supported by the **DBMS_RANDOM** package.

Table 10-18 DBMS_RANDOM interface parameters

API	Description
DBMS_RANDOM.SEED	Sets a seed for a random number.
DBMS_RANDOM.VALUE	Generates a random number between a specified low and a specified high.

- DBMS_RANDOM.SEED

  The stored procedure SEED is used to set a seed for a random number. The DBMS_RANDOM.SEED function prototype is:

  ```
  DBMS_RANDOM.SEED (seed  IN  INTEGER);
  ```

  Table 10-19 DBMS_RANDOM.SEED interface parameters

Parameter	Description
seed	Generates a seed for a random number.

- DBMS_RANDOM.VALUE

  The stored procedure VALUE generates a random number between a specified low and a specified high. The DBMS_RANDOM.VALUE function prototype is:

```
DBMS_RANDOM.VALUE(
low  IN  NUMBER,
high IN  NUMBER)
RETURN NUMBER;
```

Table 10-20 DBMS_RANDOM.VALUE interface parameters

Parameter	Description
low	Sets the low bound for a random number. The generated random number is greater than or equal to the low.
high	Sets the high bound for a random number. The generated random number is less than the high.

NOTE

The only requirement is that the parameter type is **NUMERIC** regardless of the right and left bound values.

Example

Generate a random number between 0 and 1:

```
SELECT DBMS_RANDOM.VALUE(0,1);
```

Generate a random integer ranging from 0 to 100. The random integer is greater than or equal to the specified value of low and less than the specified value of high.

```
SELECT TRUNC(DBMS_RANDOM.VALUE(0,100));
```

10.11.3 DBMS_OUTPUT

Related Interfaces

Table 10-21 provides all interfaces supported by the **DBMS_OUTPUT** package.

Table 10-21 DBMS_OUTPUT

API	Description
DBMS_OUTPUT.PUT_LINE	Outputs the specified text. The text length cannot exceed 32,767 bytes.
DBMS_OUTPUT.PUT	Outputs the specified text to the front of the specified text without adding a line break. The text length cannot exceed 32,767 bytes.

API	Description
DBMS_OUTPUT.ENABLE	Sets the buffer area size. If this interface is not specified, the maximum buffer size is 20,000 bytes and the minimum buffer size is 2000 bytes. If the specified buffer size is less than 2000 bytes, the default minimum buffer size is applied.

- DBMS_OUTPUT.PUT_LINE

The PUT_LINE procedure writes a row of text carrying a line end symbol in the buffer. The DBMS_OUTPUT.PUT_LINE function prototype is:

```
DBMS_OUTPUT.PUT_LINE (
item IN VARCHAR2);
```

Table 10-22 DBMS_OUTPUT.PUT_LINE interface parameters

Parameter	Description
item	Specifies the text that was written to the buffer.

- DBMS_OUTPUT.PUT

The stored procedure **PUT** outputs the specified text to the front of the specified text without adding a linefeed. The DBMS_OUTPUT.PUT function prototype is:

```
DBMS_OUTPUT.PUT (
item IN VARCHAR2);
```

Table 10-23 DBMS_OUTPUT.PUT interface parameters

Parameter	Description
item	Specifies the text that was written to the specified text.

- DBMS_OUTPUT.ENABLE

The stored procedure **ENABLE** sets the output buffer size. If the size is not specified, it contains a maximum of 20,000 bytes. The DBMS_OUTPUT.ENABLE function prototype is:

```
DBMS_OUTPUT.ENABLE (
buf IN INTEGER);
```

Table 10-24 DBMS_OUTPUT.ENABLE interface parameters

Parameter	Description
buf	Sets the buffer area size.

Examples

```
BEGIN
   DBMS_OUTPUT.ENABLE(50);
   DBMS_OUTPUT.PUT ('hello, ');
   DBMS_OUTPUT.PUT_LINE('database!');-- Displaying "hello, database!"
END;
/
```

10.11.4 UTL_RAW

Related Interfaces

Table 10-25 provides all interfaces supported by the **UTL_RAW** package.

Table 10-25 UTL_RAW

API	Description
UTL_RAW.CAST_FROM_BINARY_INTEGER	Converts an INTEGER type value to a binary representation (RAW type).
UTL_RAW.CAST_TO_BINARY_INTEGER	Converts a binary representation (RAW type) to an INTEGER type value.
UTL_RAW.LENGTH	Obtains the length of the RAW type object.
UTL_RAW.CAST_TO_RAW	Converts a VARCHAR2 type value to a binary expression (RAW type).

NOTICE

The external representation of the RAW type data is hexadecimal and its internal storage form is binary. For example, the representation of the **RAW** type data **11001011** is 'CB'. The input of the actual type conversion is 'CB'.

- UTL_RAW.CAST_FROM_BINARY_INTEGER

  The stored procedure **CAST_FROM_BINARY_INTEGER** converts an **INTEGER** type value to a binary representation (**RAW** type).

  The **UTL_RAW.CAST_FROM_BINARY_INTEGER** function prototype is:

  ```
  UTL_RAW.CAST_FROM_BINARY_INTEGER (
  n           IN  INTEGER,
  endianess   IN  INTEGER)
  RETURN RAW;
  ```

  Table 10-26 UTL_RAW.CAST_FROM_BINARY_INTEGER interface parameters

Parameter	Description
n	Specifies the INTEGER type value to be converted to the RAW type.

Parameter	Description
endianess	Specifies the **INTEGER** type value **1** or **2** of the byte sequence. (**1** indicates **BIG_ENDIAN** and **2** indicates **LITTLE-ENDIAN**.)

- UTL_RAW.CAST_TO_BINARY_INTEGER

  The stored procedure CAST_TO_BINARY_INTEGER converts an INTEGER type value in a binary representation (RAW type) to the INTEGER type.

  The UTL_RAW.CAST_TO_BINARY_INTEGER function prototype is:

```
UTL_RAW.CAST_TO_BINARY_INTEGER (
r          IN  RAW,
endianess  IN  INTEGER)
RETURN BINARY_INTEGER;
```

  Table 10-27 UTL_RAW.CAST_TO_BINARY_INTEGER interface parameters

Parameter	Description
r	Specifies an INTEGER type value in a binary representation (RAW type).
endianess	Specifies the **INTEGER** type value **1** or **2** of the byte sequence. (**1** indicates **BIG_ENDIAN** and **2** indicates **LITTLE-ENDIAN**.)

- UTL_RAW.LENGTH

  The stored procedure LENGTH returns the length of a RAW type object.

  The UTL_RAW.LENGTH function prototype is:

```
UTL_RAW.LENGTH(
r      IN RAW)
RETURN INTEGER;
```

  Table 10-28 UTL_RAW.LENGTH interface parameters

Parameter	Description
r	Specifies a RAW type object.

- UTL_RAW.CAST_TO_RAW

  The stored procedure CAST_TO_RAW converts a VARCHAR2 type object to the RAW type.

  The UTL_RAW.CAST_TO_RAW function prototype is:

```
UTL_RAW.CAST_TO_RAW(
c      IN VARCHAR2)
RETURN RAW;
```


Table 10-29 UTL_RAW.CAST_TO_RAW interface parameters

Parameter	Description
c	Specifies a VARCHAR2 type object to be converted.

Example

Perform operations on RAW data in a stored procedure:

```
CREATE OR REPLACE PROCEDURE proc_raw
AS
str varchar2(100) := 'abcdef';
source raw(100);
amount integer;
BEGIN
source := utl_raw.cast_to_raw(str);--Convert the type.
amount := utl_raw.length(source);--Obtain the length.
dbms_output.put_line(amount);
END;
/
```

Call the stored procedure:

```
CALL proc_raw();
```

10.11.5 DBMS_JOB

Related Interfaces

Table 10-30 lists all interfaces supported by the **DBMS_JOB** package.

Table 10-30 DBMS_JOB

Interface	Description
DBMS_JOB.SUBMIT	Submits a job to the job queue. The job number is automatically generated by the system.
DBMS_JOB.SUBMIT_NODE	Submits a job to the job queue. The execution node is specified by the user, and the job number is automatically generated by the system.
DBMS_JOB.ISUBMIT	Submits a job to the job queue. The job number is specified by the user.
DBMS_JOB.REMOVE	Removes a job from the job queue by job number.
DBMS_JOB.BROKEN	Disables or enables job execution.
DBMS_JOB.CHANGE	Modifies user-definable attributes of a job, including the job description, next execution time, and execution interval.
DBMS_JOB.WHAT	Modifies the job description of a job.

Interface	Description
DBMS_JOB.NEXT_DATE	Modifies the next execution time of a job.
DBMS_JOB.INTERVAL	Modifies the execution interval of a job.
DBMS_JOB.CHANGE_OWNER	Modifies the owner of a job.
DBMS_JOB.CHANGE_NODE	Modifies the execution node of the scheduled task.

- DBMS_JOB.SUBMIT

  The stored procedure **SUBMIT** submits a job provided by the system.

  A prototype of the DBMS_JOB.SUBMIT function is as follows:

```
DMBS_JOB.SUBMIT(
what         IN   TEXT,
next_date    IN   TIMESTAMP DEFAULT sysdate,
job_interval IN   TEXT  DEFAULT 'null',
job          OUT  INTEGER);
```

  NOTE

  When a job is created (using DBMS_JOB), the system binds the current database and the username to the job by default. This function can be invoked by using **call** or **select**. If you invoke this function by using **select**, there is no need to specify output parameters. To invoke this function within a stored procedure, use **perform**.

  Table 10-31 DBMS_JOB.SUBMIT interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
what	text	IN	No	SQL statement to be executed. One or multiple DMLs, anonymous blocks, and SQL statements that invoke stored procedures, or all three combined are supported.
next_date	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.

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
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 blank 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 number. The value ranges from 1 to 32767. When **dbms.submit** is invoked using **select**, this parameter can be skipped.

For example:

```
select DBMS_JOB.SUBMIT('call pro_xxx();', to_date('20180101','yyyymmdd'),'sysdate+1');

select DBMS_JOB.SUBMIT('call pro_xxx();', to_date('20180101','yyyymmdd'),'sysdate+1.0/24');

CALL DBMS_JOB.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);
```

- DBMS_JOB.SUBMIT_NODE

  The stored procedure **SUBMIT** submits a job provided by the system. The execution node is specified by the user. This interface is supported only by clusters of version 8.3.0 or later.

  The prototype of the DBMS_JOB.SUBMIT_NODE function is:

```
DMBS_JOB.SUBMIT_NODE(
what         IN   TEXT,
next_date    IN   TIMESTAMP DEFAULT sysdate,
job_interval IN   TEXT DEFAULT 'null',
job_node     IN   TEXT DEFAULT NULL,
job          OUT  INTEGER);
```

Table 10-32 DBMS_JOB.SUBMIT_NODE interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
what	text	IN	No	Specifies the SQL statement to be executed. One or multiple DMLs, anonymous blocks, and SQL statements that invoke stored procedures, or all three combined are supported.

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
next_date	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	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 blank or set to **null**, the job will be executed only once, and the job status will change to **'d'** afterward.
node	text	IN	Yes	Specifies the name of the job execution node.
job	integer	OUT	No	Specifies the job number. The value ranges from 1 to 32767. When **dbms.submit** is invoked using **select**, this parameter can be skipped.

For example:

```
select DBMS_JOB.SUBMIT_NODE('call pro_xxx();', to_date('20180101','yyyymmdd'),'sysdate
+1','coordinator1');

select DBMS_JOB.SUBMIT_NODE('call pro_xxx();', to_date('20180101','yyyymmdd'),'sysdate+1.0/24');

CALL DBMS_JOB.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)',
'coordinator1', :jobid);
```

- DBMS_JOB.ISUBMIT

  ISUBMIT has the same syntax function as **SUBMIT**, but the first parameter of **ISUBMIT** is an input parameter, that is, a specified job number. In contrast, that last parameter of **SUBMIT** is an output parameter, indicating the job number automatically generated by the system.

  For example:

  ```
  CALL dbms_job.isubmit(101, 'insert_msg_statistic1;', sysdate, 'sysdate+3.0/24');
  ```

- DBMS_JOB.REMOVE

  The stored procedure **REMOVE** deletes a specified job.

  A prototype of the DBMS_JOB.REMOVE function is as follows:

  ```
  REMOVE(job  IN  INTEGER);
  ```


Table 10-33 DBMS_JOB.REMOVE interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
job	integer	IN	No	Specifies the job number.

For example:

```
CALL dbms_job.remove(101);
```

- DBMS_JOB.BROKEN

  The stored procedure **BROKEN** sets the broken flag of a job.

  A prototype of the DBMS_JOB.BROKEN function is as follows:

```
DMBS_JOB.BROKEN(
job          IN   INTEGER,
broken       IN   BOOLEAN,
next_date    IN   TIMESTAMP  DEFAULT  sysdate);
```

Table 10-34 DBMS_JOB.BROKEN interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
job	integer	IN	No	Specifies the job number.
broken	boolean	IN	No	Specifies the status flag, **true** for broken and **false** for not broken. Setting this parameter to **true** or **false** updates the current job. If the parameter is left blank, the job status remains unchanged.
next_date	timestamp	IN	Yes	Specifies the next execution time. The default is the current system time. If **broken** is set to **true**, **next_date** is updated to **'4000-1-1'**. If **broken** is **false** and **next_date** is not empty, **next_date** is updated for the job. If **next_date** is empty, it will not be updated. This parameter can be omitted, and its default value will be used in this case.

For example:


```
CALL dbms_job.broken(101, true);
CALL dbms_job.broken(101, false, sysdate);
```

- DBMS_JOB.CHANGE

  The stored procedure **CHANGE** modifies user-definable attributes of a job, including the job content, next-execution time, and execution interval.

  A prototype of the DBMS_JOB.CHANGE function is as follows:

```
DMBS_JOB.CHANGE(
job          IN   INTEGER,
what         IN   TEXT,
next_date    IN   TIMESTAMP,
interval     IN   TEXT);
```

Table 10-35 DBMS_JOB.CHANGE interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
job	integer	IN	No	Specifies the job number.
what	text	IN	Yes	Specifies the name of the stored procedure or SQL statement block that is executed. If this parameter is left blank, 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 blank, the system does not update the **next_date** parameter for the specified job. Otherwise, the system updates the **next_date** parameter for the specified job.
interval	text	IN	Yes	Specifies the time expression for calculating the next time the job will be executed. If this parameter is left blank, the system does not update the **interval** parameter for the specified job. Otherwise, the system updates the **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.

For example:


```
CALL dbms_job.change(101, 'call userproc();', sysdate, 'sysdate + 1.0/1440');
CALL dbms_job.change(101, 'insert into tbl_a values(sysdate);', sysdate, 'sysdate + 1.0/1440');
```

- DBMS_JOB.WHAT

  The stored procedure **WHAT** modifies the procedures to be executed by a specified job.

  A prototype of the DBMS_JOB.WHAT function is as follows:

```
DMBS_JOB.WHAT(
job             IN     INTEGER,
what            IN     TEXT);
```

Table 10-36 DBMS_JOB.WHAT interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
job	integer	IN	No	Specifies the job number.
what	text	IN	No	Specifies the name of the stored procedure or SQL statement block that is executed.

NOTE

- If the value specified by the **what** 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 **what** parameter is a simple statement such as insert and update, a schema name must be added in front of the table name.

For example:

```
CALL dbms_job.what(101, 'call userproc();');
CALL dbms_job.what(101, 'insert into tbl_a values(sysdate);');
```

- DBMS_JOB.NEXT_DATE

  The stored procedure **NEXT_DATE** modifies the next-execution time attribute of a job.

  A prototype of the DBMS_JOB.NEXT_DATE function is as follows:

```
DMBS_JOB.NEXT_DATE(
job          IN    INTEGER,
next_date    IN    TIMESTAMP);
```

Table 10-37 DBMS_JOB.NEXT_DATE interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
job	integer	IN	No	Specifies the job number.

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
next_date	timestamp	IN	No	Specifies the next execution time.

NOTE

If the specified **next_date** value is earlier than the current date, the job is executed once immediately.

For example:

```
CALL dbms_job.next_date(101, sysdate);
```

- DBMS_JOB.INTERVAL

  The stored procedure **INTERVAL** modifies the execution interval attribute of a job.

  A prototype of the DBMS_JOB.INTERVAL function is as follows:

```
DMBS_JOB.INTERVAL(
job             IN   INTEGER,
interval         IN   TEXT);
```

Table 10-38 DBMS_JOB.INTERVAL interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
job	integer	IN	No	Specifies the job number.
interval	text	IN	Yes	Specifies the time expression for calculating the next time the job will be executed. If this parameter is left blank 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.

For example:

```
CALL dbms_job.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 **remove**, **change**, **next_date**, **what**, or **interval** to delete or modify job parameters.

- DBMS_JOB.CHANGE_OWNER

  The stored procedure **CHANGE_OWNER** modifies the owner of a job.

  A prototype of the DBMS_JOB.CHANGE_OWNER function is as follows:

  ```
  DMBS_JOB.CHANGE_OWNER(
  job             IN     INTEGER,
  new_owner       IN     NAME);
  ```

  Table 10-39 DBMS_JOB.CHANGE_OWNER interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
job	integer	IN	No	Specifies the job number.
new_owner	name	IN	No	Specifies the new username.

  For example:

  ```
  CALL dbms_job.change_owner(101, 'alice');
  ```

- DBMS_JOB.CHANGE_NODE

  The stored procedure **CHANGE_NODE** modifies the execution node of the scheduled task. This interface is supported only by clusters of version 8.3.0 or later.

  A prototype of the DBMS_JOB.CHANGE_NODE function is:

  ```
  DMBS_JOB.CHANGE_NODE(
  job             IN     INTEGER,
  new_node        IN     text);
  ```

  Table 10-40 DBMS_JOB.CHANGE_OWNER interface parameters

Parameter	Type	Input/Output Parameter	Can Be Empty	Description
job	integer	IN	No	Specifies the job number.
new_node	text	IN	No	Specifies the new execution node.

  For example:

  ```
  CALL dbms_job.change_node(101, 'coordinator2');
  ```

Constraints

1. After a new job is created, this job belongs to the current coordinator only, that is, this job can be scheduled and executed only on the current

coordinator. Other coordinators will not schedule or execute this job. All coordinators can query, modify, and delete jobs created on other CNs.

2. Create, update, and delete jobs only using the procedures provided by the DBMS_JOB package. These procedures synchronize job information between different CNs and associate primary keys between the **pg_jobs** tables. If you use DML statements to add, delete, or modify records in the **pg_jobs** table, job information will become inconsistent between CNs and system tables may fail to be associated, compromising internal job management.
3. Each user-created task is bound to a CN. If the automatic migration function is not enabled, task statuses cannot be updated in real time when the CN is faulty during task execution. When a CN fails, all jobs on this CN cannot be scheduled or executed until the CN is restored manually. Enable the automatic migration function on CNs, so that jobs on the faulty CN will be migrated to other CNs for scheduling.
4. For each job, the hosting CN updates the real-time job information (including the job status, last execution start time, last execution end time, next execution start time, the number of execution failures if any) to the **pg_jobs** table, and synchronizes the information to other CNs, ensuring consistent job information between different CNs. In the case of CN failures, job information synchronization is reattempted by the hosting CNs, which increases job execution time. Although job information fails to be synchronized between CNs, job information can still be properly updated in the **pg_jobs** table on the hosting CNs, and jobs can be executed successfully. After a CN recovers, job information such as job execution time and status in its **pg_jobs** table may be incorrect and will be updated only after the jobs are executed again on related CNs.
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.
6. The length of the SQL statement to be executed in a job is limited. The maximum length is 8 KB.

10.11.6 DBMS_SQL

Related Interfaces

Table 10-41 lists interfaces supported by the **DBMS_SQL** package.

Table 10-41 DBMS_SQL

API	Description
DBMS_SQL.OPEN_CURSOR	Opens a cursor.
DBMS_SQL.CLOSE_CURSOR	Closes an open cursor.
DBMS_SQL.PARSE	Transmits a group of SQL statements to a cursor. Currently, only the **SELECT** statement is supported.

API	Description
DBMS_SQL.EXECUTE	Performs a set of dynamically defined operations on the cursor.
DBMS_SQL.FETCHE_ROWS	Reads a row of cursor data.
DBMS_SQL.DEFINE_COLUMN	Dynamically defines a column.
DBMS_SQL.DEFINE_COLUMN_CHAR	Dynamically defines a column of the CHAR type.
DBMS_SQL.DEFINE_COLUMN_INT	Dynamically defines a column of the INT type.
DBMS_SQL.DEFINE_COLUMN_LONG	Dynamically defines a column of the LONG type.
DBMS_SQL.DEFINE_COLUMN_RAW	Dynamically defines a column of the RAW type.
DBMS_SQL.DEFINE_COLUMN_TEXT	Dynamically defines a column of the TEXT type.
DBMS_SQL.DEFINE_COLUMN_UNKNOWN	Dynamically defines a column of an unknown type.
DBMS_SQL.COLUMN_VALUE	Reads a dynamically defined column value.
DBMS_SQL.COLUMN_VALUE_CHAR	Reads a dynamically defined column value of the CHAR type.
DBMS_SQL.COLUMN_VALUE_INT	Reads a dynamically defined column value of the INT type.
DBMS_SQL.COLUMN_VALUE_LONG	Reads a dynamically defined column value of the LONG type.
DBMS_SQL.COLUMN_VALUE_RAW	Reads a dynamically defined column value of the RAW type.
DBMS_SQL.COLUMN_VALUE_TEXT	Reads a dynamically defined column value of the TEXT type.
DBMS_SQL.COLUMN_VALUE_UNKNOWN	Reads a dynamically defined column value of an unknown type.
DBMS_SQL.IS_OPEN	Checks whether a cursor is opened.

NOTE

- You are advised to use **dbms_sql.define_column** and **dbms_sql.column_value** to define columns.
- If the size of the result set is greater than the value of **work_mem**, the result set will be flushed to disk. The value of **work_mem** must be no greater than 512 MB.

- DBMS_SQL.OPEN_CURSOR

  This function opens a cursor and is the prerequisite for the subsequent dbms_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 function prototype of **DBMS_SQL.OPEN_CURSOR** is:

```
DBMS_SQL.OPEN_CURSOR (
)
RETURN INTEGER;
```

- DBMS_SQL.CLOSE_CURSOR

  This function closes a cursor. It is the end of each dbms_sql operation. If this function is not invoked 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 function prototype of **DBMS_SQL.CLOSE_CURSOR** is:

```
DBMS_SQL.CLOSE_CURSOR (
cursorid     IN INTEGER
)
RETURN INTEGER;
```

  Table 10-42 DBMS_SQL.CLOSE_CURSOR interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be closed

- DBMS_SQL.PARSE

  This function parses the query statement of a given cursor. 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 function prototype of **DBMS_SQL.PARSE** is:

```
DBMS_SQL.PARSE (
cursorid     IN INTEGER,
query_string IN TEXT,
label        IN INTEGER
)
RETURN BOOLEAN;
```


Table 10-43 DBMS_SQL.PARSE interface parameters

Parameter Name	Description
cursorid	ID of the cursor whose query statement is parsed
query_string	Query statements to be parsed
language_flag	Version language number. Currently, only **1** is supported.

- DBMS_SQL.EXECUTE

  This function executes a given cursor. This function receives a cursor ID. The obtained data after is used for subsequent operations. Currently, only the **SELECT** query statement can be executed.

  The function prototype of **DBMS_SQL.EXECUTE** is:

```
DBMS_SQL.EXECUTE(
cursorid     IN INTEGER,
)
RETURN INTEGER;
```

Table 10-44 DBMS_SQL.EXECUTE interface parameters

Parameter Name	Description
cursorid	ID of the cursor whose query statement is parsed

- DBMS_SQL.FETCHE_ROWS

  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 function prototype of **DBMS_SQL.FETCHE_ROWS** is:

```
DBMS_SQL.FETCHE_ROWS(
cursorid     IN INTEGER,
)
RETURN INTEGER;
```

Table 10-45 DBMS_SQL.FETCH_ROWS interface parameters

Parameter Name	Description
curosorid	ID of the cursor to be executed

- DBMS_SQL.DEFINE_COLUMN

  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 the input variable determines the column type.

  The function prototype of **DBMS_SQL.DEFINE_COLUMN** is:

```
DBMS_SQL.DEFINE_COLUMN(
cursorid     IN INTEGER,
```



```
position     IN INTEGER,
column_ref   IN ANYELEMENT,
column_size      IN INTEGER default 1024
)
RETURN INTEGER;
```

Table 10-46 DBMS_SQL.DEFINE_COLUMN interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	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.
column_size	Length of a defined column

- DBMS_SQL.DEFINE_COLUMN_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 the input variable determines the column type.

  The function prototype of **DBMS_SQL.DEFINE_COLUMN_CHAR** is:

```
DBMS_SQL.DEFINE_COLUMN_CHAR(
cursorid     IN INTEGER,
position     IN INTEGER,
column       IN TEXT,
column_size      IN INTEGER
)
RETURN INTEGER;
```

Table 10-47 DBMS_SQL.DEFINE_COLUMN_CHAR interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query
column	Parameter to be defined
column_size	Length of a dynamically defined column

- DBMS_SQL.DEFINE_COLUMN_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 the input variable determines the column type.

  The function prototype of **DBMS_SQL.DEFINE_COLUMN_INT** is:


```
DBMS_SQL.DEFINE_COLUMN_INT(
cursorid     IN INTEGER,
position     IN INTEGER
)
RETURN INTEGER;
```

Table 10-48 DBMS_SQL.DEFINE_COLUMN_INT interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query

- DBMS_SQL.DEFINE_COLUMN_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 the input variable determines the column type. The maximum size of a long column is 1 GB.

  The function prototype of **DBMS_SQL.DEFINE_COLUMN_LONG** is:

```
DBMS_SQL.DEFINE_COLUMN_LONG(
cursorid     IN INTEGER,
position     IN INTEGER
)
RETURN INTEGER;
```

Table 10-49 DBMS_SQL.DEFINE_COLUMN_LONG interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query

- DBMS_SQL.DEFINE_COLUMN_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 the input variable determines the column type.

  The function prototype of **DBMS_SQL.DEFINE_COLUMN_RAW** is:

```
DBMS_SQL.DEFINE_COLUMN_RAW(
cursorid     IN INTEGER,
position     IN INTEGER,
column       IN BYTEA,
column_size     IN INTEGER
)
RETURN INTEGER;
```


Table 10-50 DBMS_SQL.DEFINE_COLUMN_RAW interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query
column	Parameter of the RAW type
column_size	Column length

- DBMS_SQL.DEFINE_COLUMN_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 the input variable determines the column type.

  The function prototype of **DBMS_SQL.DEFINE_COLUMN_TEXT** is:

```
DBMS_SQL.DEFINE_COLUMN_CHAR(
cursorid     IN INTEGER,
position     IN INTEGER,
max_size     IN INTEGER
)
RETURN INTEGER;
```

Table 10-51 DBMS_SQL.DEFINE_COLUMN_TEXT interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query
max_size	Maximum length of the defined TEXT type

- DBMS_SQL.DEFINE_COLUMN_UNKNOWN

  This function processes columns of unknown data types returned from a given cursor and is used only for the system to report an error and exist when the type cannot be identified.

  The function prototype of **DBMS_SQL.DEFINE_COLUMN_UNKNOWN** is:

```
DBMS_SQL.DEFINE_COLUMN_CHAR(
cursorid     IN INTEGER,
position     IN INTEGER,
column       IN TEXT
)
RETURN INTEGER;
```

Table 10-52 DBMS_SQL.DEFINE_COLUMN_UNKNOWN interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed

Parameter Name	Description
position	Position of a dynamically defined column in the query
column	Dynamically defined parameter

- DBMS_SQL.COLUMN_VALUE

  This function returns the cursor element value specified by a cursor and accesses the data obtained by DBMS_SQL.FETCH_ROWS.

  The function prototype of **DBMS_SQL.COLUMN_VALUE** is:

```
DBMS_SQL.COLUMN_VALUE(
cursorid              IN    INTEGER,
position              IN    INTEGER,
column_value             INOUT ANYELEMENT
)
RETURN ANYELEMENT;
```

  Table 10-53 DBMS_SQL.COLUMN_VALUE interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query
column_value	Return value of a defined column

- DBMS_SQL.COLUMN_VALUE_CHAR

  This function returns the value of the CHAR type in a specified position of a cursor and accesses the data obtained by DBMS_SQL.FETCH_ROWS.

  The function prototype of **DBMS_SQL.COLUMN_VALUE_CHAR** is:

```
DBMS_SQL.COLUMN_VALUE_CHAR(
cursorid              IN    INTEGER,
position              IN    INTEGER,
column_value             INOUT CHARACTER,
err_num                INOUT NUMERIC default 0,
actual_length           INOUT INTEGER default 1024
)
RETURN RECORD;
```

  Table 10-54 DBMS_SQL.COLUMN_VALUE_CHAR interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query
column_value	Return value

Parameter Name	Description
err_num	Error No. It is an output parameter and the argument must be a variable. Currently, the output value is **–1** regardless of the argument.
actual_length	Length of a return value

- DBMS_SQL.COLUMN_VALUE_INT

  This function returns the value of the INT type in a specified position of a cursor and accesses the data obtained by DBMS_SQL.FETCH_ROWS. The function prototype of **DBMS_SQL.COLUMN_VALUE_INT** is:

```
DBMS_SQL.COLUMN_VALUE_INT(
cursorid              IN    INTEGER,
position              IN    INTEGER
)
RETURN INTEGER;
```

  Table 10-55 DBMS_SQL.COLUMN_VALUE_INT interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query

- DBMS_SQL.COLUMN_VALUE_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 DBMS_SQL.FETCH_ROWS.

  The function prototype of **DBMS_SQL.COLUMN_VALUE_LONG** is:

```
DBMS_SQL.COLUMN_VALUE_LONG(
cursorid              IN    INTEGER,
position              IN    INTEGER,
length                IN    INTEGER,
off_set               IN    INTEGER,
column_value              INOUT TEXT,
actual_length             INOUT INTEGER default 1024
)
RETURN RECORD;
```

  Table 10-56 DBMS_SQL.COLUMN_VALUE_LONG interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query
length	Length of a return value
off_set	Start position of a return value

Parameter Name	Description
column_value	Return value
actual_length	Length of a return value

- DBMS_SQL.COLUMN_VALUE_RAW

  This function returns the value of the RAW type in a specified position of a cursor and accesses the data obtained by DBMS_SQL.FETCH_ROWS.

  The function prototype of **DBMS_SQL.COLUMN_VALUE_RAW** is:

```
DBMS_SQL.COLUMN_VALUE_RAW(
cursorid              IN    INTEGER,
position              IN    INTEGER,
column_value            INOUT BYTEA,
err_num               INOUT NUMERIC default 0,
actual_length           INOUT INTEGER default 1024
)
RETURN RECORD;
```

Table 10-57 DBMS_SQL.COLUMN_VALUE_RAW interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query
column_value	Returned column value
err_num	Error No. It is an output parameter and the argument must be a variable. Currently, the output value is **–1** regardless of the argument.
actual_length	Length of a return value. The value longer than this length will be truncated.

- DBMS_SQL.COLUMN_VALUE_TEXT

  This function returns the value of the TEXT type in a specified position of a cursor and accesses the data obtained by DBMS_SQL.FETCH_ROWS.

  The function prototype of **DBMS_SQL.COLUMN_VALUE_TEXT** is:

```
DBMS_SQL.COLUMN_VALUE_TEXT(
cursorid              IN    INTEGER,
position              IN    INTEGER
)
RETURN TEXT;
```

Table 10-58 DBMS_SQL.COLUMN_VALUE_TEXT interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed

Parameter Name	Description
position	Position of a dynamically defined column in the query

- DBMS_SQL.COLUMN_VALUE_UNKNOWN

  This function returns the value of an unknown type in a specified position of a cursor. This is an error handling interface when the type is not unknown.

  The function prototype of **DBMS_SQL.COLUMN_VALUE_UNKNOWN** is:

```
DBMS_SQL.COLUMN_VALUE_UNKNOWN(
cursorid              IN    INTEGER,
position              IN    INTEGER,
COLUMN_TYPE             IN    TEXT
)
RETURN TEXT;
```

  Table 10-59 DBMS_SQL.COLUMN_VALUE_UNKNOWN interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be executed
position	Position of a dynamically defined column in the query
column_type	Returned parameter type

- DBMS_SQL.IS_OPEN

This function returns the status of a cursor: **open**, **parse**, **execute**, or **define**. The value is **TRUE**. If the status is unknown, an error is reported. In other cases, the value is **FALSE**.

The function prototype of **DBMS_SQL.IS_OPEN** is:

```
DBMS_SQL.IS_OPEN(
cursorid              IN    INTEGER
)
RETURN BOOLEAN;
```

Table 10-60 DBMS_SQL.IS_OPEN interface parameters

Parameter Name	Description
cursorid	ID of the cursor to be queried

Examples

```
-- Perform operations on RAW data in a stored procedure.
create or replace procedure pro_dbms_sql_all_02(in_raw raw,v_in int,v_offset int)
as
cursorid 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_dbms_sql_all_tb1_02 ;
create table pro_dbms_sql_all_tb1_02(a int ,b blob);
insert into pro_dbms_sql_all_tb1_02 values(1,HEXTORAW('DEADBEEE'));
insert into pro_dbms_sql_all_tb1_02 values(2,in_raw);
query := 'select * from pro_dbms_sql_all_tb1_02 order by 1';
-- Open a cursor.
cursorid := dbms_sql.open_cursor();
-- Compile the cursor.
dbms_sql.parse(cursorid, query, 1);
-- Define a column.
define_column_ret:= dbms_sql.define_column(cursorid,1,v_id);
define_column_ret_raw:= dbms_sql.define_column_raw(cursorid,2,v_info,10);
-- Execute the cursor.
execute_ret := dbms_sql.execute(cursorid);
loop
exit when (dbms_sql.fetch_rows(cursorid) <= 0);
-- Obtain values.
dbms_sql.column_value(cursorid,1,v_id);
dbms_sql.column_value_raw(cursorid,2,v_info,v_in,v_offset);
-- Output the result.
dbms_output.put_line('id:'|| v_id || ' info:' || v_info);
end loop;
-- Close the cursor.
dbms_sql.close_cursor(cursorid);
end;
/
-- Invoke the stored procedure.
call pro_dbms_sql_all_02(HEXTORAW('DEADBEEF'),0,1);

-- Delete the stored procedure.
DROP PROCEDURE pro_dbms_sql_all_02;
```

10.12 Debugging

Syntax

RAISE has the following five syntax formats:

Figure 10-34 raise_format::=

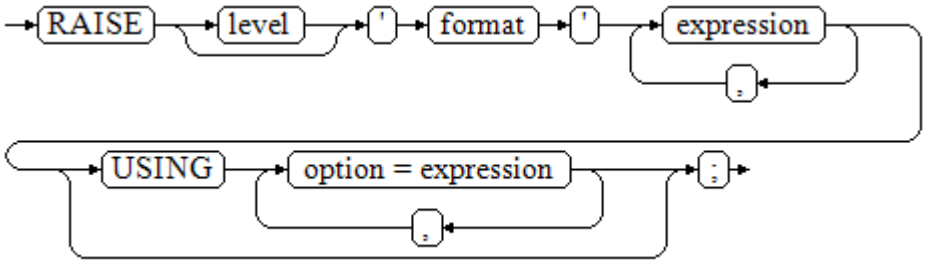


Figure 10-35 raise_condition::=

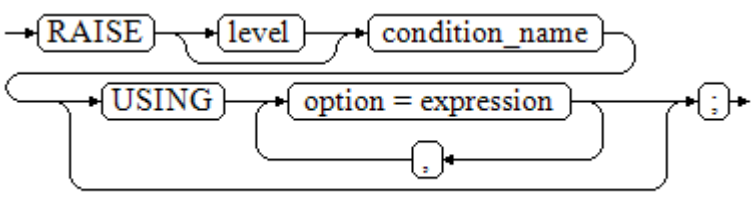


Figure 10-36 raise_sqlstate::=

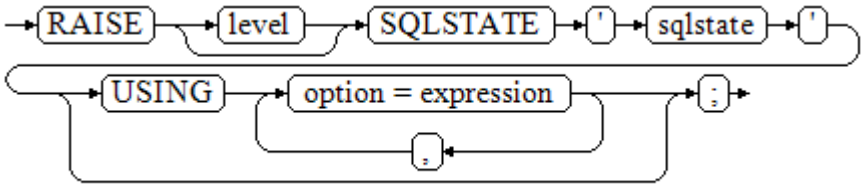


Figure 10-37 raise_option::=

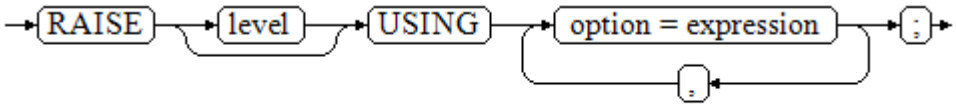
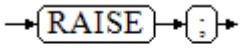


Figure 10-38 raise::=



Parameter description:

- The level option is used to specify the error level, that is, **DEBUG**, **LOG**, **INFO**, **NOTICE**, **WARNING**, or **EXCEPTION** (default). **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, a format character string. The format character string can be appended with an expression for insertion to the message text. In a format character string, **%** is replaced by the parameter value attached to format and **%%** is used to print **%**. For example:

```
--v_job_id replaces % in the character 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 character 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: prints 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 an **SQLSTATE** is designated 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 the **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 this kind of error codes are type codes and can be captured by the whole category.

NOTE

The syntax described in **Figure 10-38** 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
LOCATION:  exec_stmt_raise, pl_exec.cpp:3482
```

If the main parameter is a condition name or **SQLSTATE**, the following applies:

RAISE division_by_zero;

RAISE SQLSTATE '22012';

For 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;
```


11 Hot and Cold Data Management

Introduction to Hot and Cold Data

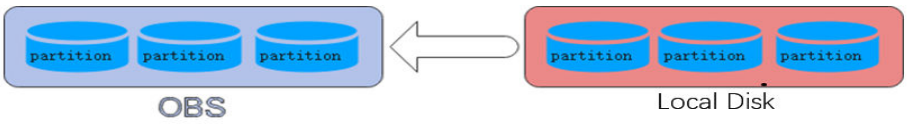
In massive big data scenarios, as services and data volume increase, data storage and consumption increase. The need for data may vary in different time periods, therefore, data is managed in a hierarchical manner, improving data analysis performance and reducing service costs.

For example, in a network traffic analysis system, users may be interested in security events and network access in the last month, but seldom pay attention to data generated several months ago. In such scenarios, data can be classified into hot data and cold data based on time periods.

Hot and cold data is classified based on the data access frequency and update frequency.

- Hot data: Data that is frequently accessed and updated, has a high probability of being invoked in the future, and has high requirements on access response time.
- Cold: Data that cannot be updated or is seldom updated, seldom accessed, and has low requirements on response time.

You can define cold and hot management tables to switch cold data that meets the specified rules to OBS for storage. Cold and hot data can be automatically determined and migrated by partition.



Hot and Cold Data Migration

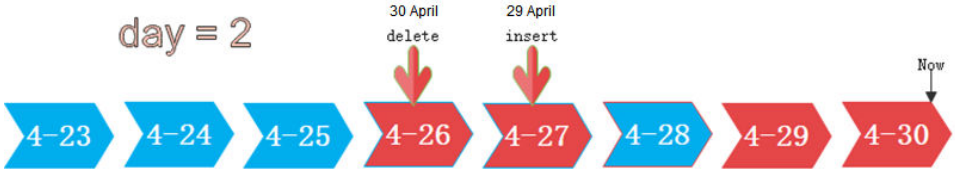
When data is inserted to GaussDB(DWS) column-store tables, the data is first stored in hot partitions. As data accumulates, you can manually or automatically migrate the cold data to OBS for storage. The metadata, description tables, and indexes of the migrated cold data are stored locally to ensure the read performance.

Cold/Hot Switchover Policies

Currently, the hot and cold partitions can be switched based on LMT (Last Modify Time) and HPN (Hot Partition Number) policies. LMT indicates that the switchover is performed based on the last update time of the partition, and HPN indicates that the switchover is performed based on the number of reserved hot partitions.

- **LMT**: Switch the hot partition data that is not updated in the last *[day]* days to the OBS tablespace as cold partition data. *[day]* is an integer ranging from 0 to 36500, in days.

  In the following figure, *day* is set to **2**, indicating that the partitions modified in the last two days are retained as the hot partitions, while the rest is retained as the cold partitions. Assume that the current time is April 30. The delete operation is performed on the partition **[4-26]** on April 30, and the insert operation is performed on the partition **[4-27]** on April 29. Therefore, partitions **[4-26]** **[4-27]** **[4-29]** **[4-30]** are retained as hot partitions.

- HPN: indicates the number of hot partitions to be reserved. The partitions are sequenced based on partition sequence IDs. The sequence ID of a partition is a built-in sequence number generated based on the partition boundary values and is not shown. For a range partition, a larger boundary value indicates a larger sequence ID. For a list partition, a larger maximum enumerated value of the partition boundary indicates a larger sequence ID. During the cold and hot switchover, data needs to be migrated to OBS. HPN is an integer ranging from 0 to 1600. If HPN is set to **0**, hot partitions are not reserved. During a cold/hot switchover, all partitions with data are converted to cold partitions and stored on OBS.

  In the following figure, HPN is set to 3, indicating that the last three partitions with data are retained as the hot partitions with the rest as the cold partitions during hot and cold partition switchover.

Hot and cold data management supports the following functions:

- Supports DML operations on cold and hot tables, such as **INSERT**, **COPY**, **DELETE**, **UPDATE**, and **SELECT**.
- Supports DCL operations such as permission management on cold and hot tables.
- Supports ANALYZE, VACUUM, MERGE INTO, and PARTITION operations on cold and hot tables.
- Supports common column-store partitioned tables to be upgraded to hot and cold data tables.

- Supports upgrade, scale-out, scale-in, and redistribution operations on tables with cold and hot data management enabled.
- Supports conversion between cold and hot partitions. This function is supported only in 8.3.0 or later.

Restrictions on Hot and Cold Data Management

- Currently, cold and hot tables support only column-store partitioned tables of version 2.0. Foreign tables do not support cold and hot partitions.
- If you insert data into a cold partition again, the data is directly stored in OBS. It does not turn the cold table into a hot table.
- A partition on a DN is either hot or cold. For a partition across DNs, its data on some DNs may be hot, and some may be cold.
- If a table has both cold and hot partitions, the query becomes slow because cold data is stored on OBS and the read/write speed are lower than those of local queries.
- Only the cold and hot switchover policies can be modified. The tablespace of cold data in cold and hot tables cannot be modified.
- Restrictions on partitioning cold and hot tables:
  - Data in cold partitions cannot be exchanged.
  - **MERGE PARTITION** supports only the merge of hot-hot partitions and cold-cold partitions.
  - Partition operations, such as **ADD**, **MERGE**, and **SPLIT**, cannot be performed on an OBS tablespace.
  - Tablespaces of cold and hot table partitions cannot be specified or modified during table creation.
- Cold and hot data switchover is not performed immediately upon conditions are met. Data switchover is performed only after users manually, or through a scheduler, invoke the switchover command. Currently, the automatic scheduling time is 00:00 every day and can be modified.
- Currently, only the LMT and HPN switchover rules are supported.
- Cold and hot data tables do not support physical fine-grained backup and restoration. Only hot data is backed up during physical backup. Cold data on OBS does not change. The backup and restoration does not support file deletion statements, such as **TRUNCATE TABLE** and **DROP TABLE**.

Examples

1. Create column-store cold and hot tables and set the hot data validity period LMT to 100 days.

```
CREATE TABLE lifecycle_table(i int, val text) WITH (ORIENTATION = COLUMN, storage_policy =
'LMT:100')
PARTITION BY RANGE (i)
(
PARTITION P1 VALUES LESS THAN(5),
PARTITION P2 VALUES LESS THAN(10),
PARTITION P3 VALUES LESS THAN(15),
PARTITION P8 VALUES LESS THAN(MAXVALUE)
)ENABLE ROW MOVEMENT;
```

2. Switch cold data to the OBS tablespace.
   - Automatic switchover: The scheduler automatically triggers the switchover at 00:00 every day.

The automatic switchover time can be customized. For example, the time can be changed to 06:30 every morning.

```
SELECT * FROM pg_obs_cold_refresh_time('lifecycle_table', '06:30:00');
```

- Manual switchover

  Perform the following operations to manually switch a single table:

  ```
  ALTER TABLE lifecycle_table refresh storage;
  ```

  Perform the following operations to switch over all cold and hot tables in batches:

  ```
  SELECT pg_catalog.pg_refresh_storage();
  ```

3. Convert cold partition data into hot partition data. This function is supported only in 8.3.0 or later.

   Convert all cold partitions in the cold and hot tables to hot partitions.

   ```
   SELECT pg_catalog.reload_cold_partition('lifecycle_table');
   ```

   Run the following command to convert a specified cold partition in a cold or hot table to a hot partition:

   ```
   SELECT pg_catalog.reload_cold_partition('lifecycle_table', 'cold_partition_name');
   ```

4. View data distribution in hot and cold tables.

   View the data distribution in a single table:

   ```
   SELECT * FROM pg_catalog.pg_lifecycle_table_data_distribute('lifecycle_table');
   ```

   View data distribution in all hot and cold tables.

   ```
   SELECT * FROM pg_catalog.pg_lifecycle_node_data_distribute();
   ```

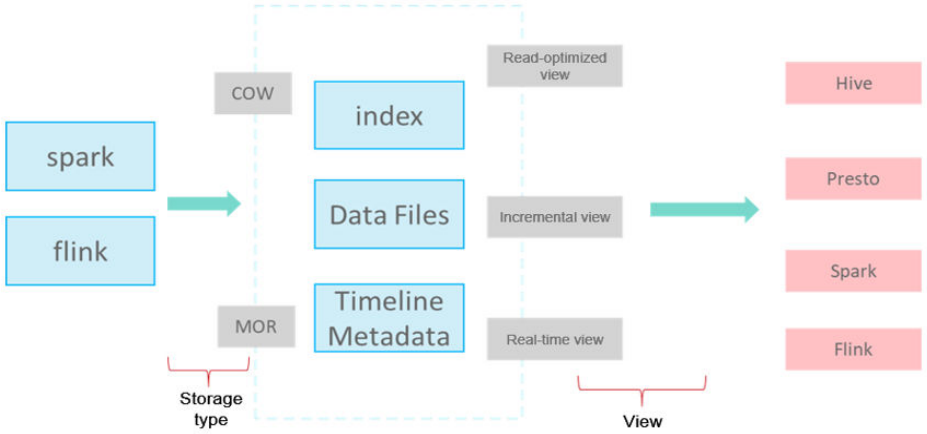

12 SQL on Hudi

This feature is supported only by 8.2.1.100 and later versions.

12.1 Introduction to Hudi

Apache Hudi indicates Hadoop Upserts Deletes and Incrementals. It is used to manage large analysis data sets stored on the DFS in Hadoop.

Hudi is not just a data format. It is also a set of data access methods (similar to the access layer of GaussDB(DWS) storage). In Apache Hudi 0.9, big data components such as Spark and Flink have their own clients. The following figure shows the logical storage of Hudi.



- Write Mode

  COW: copy-on-write, applicable to scenarios with few updates.

  MOR: replication on read. For UPDATE & DELETE, delta log files are written incrementally. During analysis, base and delta log files are compacted asynchronously.

- Storage Format

  index: index of the primary key. The default value is bloomfilter at the file group level.

  data files: base file + delta log file (for updating and deleting base files)

  timeline metadata: manages version logs.

- Views

  Read-optimized view: reads the base file generated after compaction. The reading of data that is not compacted has some latency (efficient read).

  Real-time view: reads the latest data. The base file and delta file are combined during the read (frequent updates).

  Incremental view: reads the incremental data written to Hudi, similar to CDC (stream and batch integration).

12.2 Preparations Before Using Hudi

Prerequisites

You have created an OBS agency and OBS data source. For details, see **Managing OBS Data Sources**.

Authorizing the Use of OBS Data Sources

Run the **GRANT** command to grant a user the permission to use OBS data sources.

```
GRANT USAGE ON FOREIGN SERVER server_name TO role_name;
```

Example:

Run the following command to grant user **sbi_fnd** the permission to access data source **obs_hudi**:

```
GRANT USAGE ON FOREIGN SERVER obs_hudi TO sbi_fnd;
```

Granting Permissions for Using Foreign Tables

Run the following command to grant a user the permission to use foreign tables:

```
ALTER USER role_name USEFT;
```

Example:

Run the following command to grant the foreign table access permission to user **sbi_fnd**:

```
ALTER USER sbi_fnd USEFT;
```


12.3 Hudi User Interfaces

Querying Real-Time Views and Incremental Views

GaussDB (DWS) provides table-level parameters similar to spark-sql to support real-time and incremental views.

The parameters are described as follows. Replace **SCHEMA.FOREIGN_TABLE** with the actual schema name and foreign table name.

Table 12-1 Parameters for querying real-time views and incremental views

Parameter	Value	Description
hoodie.SCHEMA.FOREIGN_TABLE .consume.mode	SNAPSHOT	Queries the real-time view.
	INCREMENTAL	Queries the incremental view.
hoodie.SCHEMA.FOREIGN_TABLE .consume. start.timestamp	hudi timestamp	Specifies the start commit of incremental synchronization.
hoodie.SCHEMA.FOREIGN_TABLE .consume. ending.timestamp	hudi timestamp	Specifies the end commit of incremental synchronization. If this parameter is not specified, the latest commit is used.

NOTE

- The preceding parameters can be set by running the set command and are valid only in the current session. You can run the reset command to restore the default values.
- You can use the system function **pg_catalog.pg_show_custom_settings()** to query the parameter setting details.
- When querying the incremental view of the MOR table, you need to use the **WHERE** condition to filter the **_hoodie_commit_time** column to prevent the log file data that is not compacted from being read. This operation is not required for the COW table.

Querying Hudi Foreign Table and Automatically Synchronizing Tasks

GaussDB(DWS) provides a series of system functions to obtain Hudi foreign table information and create Hudi automatic synchronization tasks. The automatic Hudi synchronization task periodically synchronizes data from Hudi foreign tables to GaussDB(DWS) internal tables.

Table 12-2 Hudi system functions

No.	Function	Type	Functionality
1	pg_show_custom_settings()	Built-in functions	Queries details about the parameter settings of an HUDI foreign table.
2	hudi_get_options(regclass)	Built-in functions	Queries the attributes of an HUDI foreign table (hoodie.properties).
3	hudi_get_max_commit(regclass)	Built-in functions	Obtains the latest commit timestamp of the current HUDI foreign table.
4	hudi_sync_task_submit(regclass, regclass)	Built-in functions	Submits the HUDI automatic synchronization task.
	hudi_sync_task_submit(regclass, regclass, text, text)		
5	hudi_show_sync_state()	Built-in functions	Obtains the synchronization status of the HUDI automatic synchronization task.
6	hudi_sync(regclass, regclass)	Stored procedure	Specifies the entry for invoking the HUDI automatic synchronization task.
7	hudi_sync_custom(regclass, regclass, text)	Stored procedure	Specifies the entry for invoking the HUDI automatic synchronization task. Users can define the mapping between fields in the target table and data source table.
8	hudi_set_sync_commit(regclass, regclass, text)	Built-in functions	Sets the start timestamp of the first synchronization of the HUDI automatic synchronization task to prevent resynchronization.
	hudi_set_sync_commit(text, text)		Sets the start timestamp of the next synchronization of a HUDI automatic synchronization task. You can use it to sync historical data again or to skip some data.

12.4 Creating a Hudi Data Description (Foreign Table)

A foreign table maps data on OBS. GaussDB(DWS) accesses Hudi data on OBS through foreign tables. For details, see section **CREATE FOREIGN TABLE (SQL on OBS or Hadoop)**.

Compared with OBS foreign tables, you do not need to specify many parameters for Hudi foreign tables. You only need to set **format** to **hudi**.

Obtaining the Definitions of Tables on MRS.

Hudi foreign tables on GaussDB(DWS) are read-only. Before creating a foreign table, you need to specify the number of fields defined in the target data and the type of each field. A Hudi foreign table supports a maximum of 5000 columns.

For example, for a Hudi table on MRS, you can use spark-sql to query the original table definitions:

```
SHOW create table rtd_mfdt_int_currency_t;
```

Compiling GaussDB(DWS) Table Definitions

Copy the definitions of all columns in the MRS table, perform proper type conversion to adapt to the GaussDB(DWS) syntax, and create an OBS foreign table.

```
CREATE FOREIGN TABLE rtd_mfdt_int_currency_ft(
_hoodie_commit_time text,
_hoodie_commit_seqno text,
_hoodie_record_key text,
_hoodie_partition_path text,
_hoodie_file_name text,
...
)SERVER obs_server OPTIONS (
foldername '/erpgc-obs-test-01/s000/sbi_fnd/rtd_mfdt_int_currency_t/',
format 'hudi',
encoding 'utf-8'
)distribute by roundrobin;
```

foldername indicates the storage path of the Hudi data on OBS, which corresponds to **LOCATION** in the Spark-sql table definitions of MRS. The path must end with a slash (/).

12.5 Synchronizing Hudi Tasks

Creating a Hudi Task

- Migration

  If data has been imported to the GaussDB(DWS) table using CDL, use SQL on Hudi to migrate data. Alternatively, use CDM to perform full initialization and then use SQL on Hudi to synchronize incremental data.

  1. To create the **hudi.hudi_sync_state** synchronization status table, you must have the administrator permission.

  ```
  SELECT pg_catalog.create_hudi_sync_table();
  ```


Generally, hudi.hudi_sync_state is created only once in each database.

2. To set the CDL synchronization progress, you must have the INSERT and UPDATE permissions on the target table and the SELECT permission on the HUDI foreign table. Otherwise, the synchronization progress cannot be set.

```
SELECT hudi_set_sync_commit('SCHEMA.TABLE', 'SCHEMA.FOREIGN_TABLE', 'LATEST_COMMIT');
```

Where:

SCHEMA.TABLE indicates the name and schema of the target table for data synchronization.

SCHEMA.FOREIGN_TABLE indicates the name and schema of the OBS foreign table.

LATEST_COMMIT indicates the end time of the Hudi synchronization.

Example:

The target table public.in_rel has synchronized data from hudi by **20220913152131**. Use SQL on Hudi to continue to export data from the OBS foreign table **hudi_read1**.

```
SELECT hudi_set_sync_commit('public.in_rel', 'public.hudi_read1', '20220913152131');
```

3. Submit the Hudi synchronization task.

```
SELECT hudi_sync_task_submit('SCHEMA.TABLE', 'SCHEMA.FOREIGN_TABLE');
```

Example:

Use SQL on Hudi to continue to export data from the OBS foreign table **hudi_read1** to the target table **public.in_rel**.

```
SELECT hudi_sync_task_submit('public.in_rel', 'public.hudi_read1');
```

- Creation

  If the GaussDB(DWS) table is empty and data is synchronized from Hudi for the first time, run the following command to create a task:

  ```
  SELECT hudi_sync_task_submit('SCHEMA.TABLE', 'SCHEMA.FOREIGN_TABLE');
  ```

Querying Hudi Synchronization Tasks

Query a Hudi synchronization task. In the query result, **task_id uniquely** identifies a Hudi synchronization task.

```
SELECT * FROM pg_task_show('SQLonHudi');
```

Suspending Hudi Synchronization Tasks

Query the Hudi task, obtain the task ID, and run the following command:

```
SELECT pg_task_pause('task_id');
```

Example:

Suspend the synchronization task whose **task_id** is 6**4479410-a04c-0700-d150-3037d700fffe**.

```
SELECT pg_task_pause('64479410-a04c-0700-d150-3037d700fffe');
```

Resuming Hudi Synchronization Tasks

Query the Hudi task, obtain the task ID, and run the following command:

```
SELECT pg_task_resume('task_id');
```


Example:

Resume the synchronization task whose **task_id** is **64479410-a04c-0700-d150-3037d700fffe**.

```
SELECT pg_task_resume('64479410-a04c-0700-d150-3037d700fffe');
```

Deleting a Hudi Synchronization Task

Query the Hudi task, obtain the task ID, and run the following command:

```
SELECT pg_task_remove('task_id');
```

Example:

Delete the synchronization task whose **task_id** is **64479410-a04c-0700-d150-3037d700fffe**.

```
SELECT pg_task_remove('64479410-a04c-0700-d150-3037d700fffe');
```

Querying the Synchronization Status

Use the **hudi_show_sync_state()** function to query the status of the Hud synchronization task.

```
SELECT * FROM hudi_show_sync_state();
```

12.6 Querying a Hudi Foreign Table

You can query data in a Hudi foreign table. By default, it gives you a real-time view. You can set parameters to query the incremental data.

Querying Incremental Data

You can set incremental query parameters to implement incremental query.

```
SET hoodie.SCHEMA.FOREIGN_TABLE.consume.mode=incremental;
SET hoodie.SCHEMA.FOREIGN_TABLE.consume.start.timestamp=start_timestamp;
SET hoodie.SCHEMA.FOREIGN_TABLE.consume.ending.timestamp=end_timestamp;
SELECT * FROM SCHEMA.FOREIGN_TABLE;
```

Example:

Query the incremental data of the MOR hudi foreign table **public.rtd_mfdt_int_currency_ft** from **20221207164617** to **20221207170234**. Where:

```
SET hoodie.public.rtd_mfdt_int_currency_ft.consume.mode=incremental;
SET hoodie.public.rtd_mfdt_int_currency_ft.consume.start.timestamp=20221207164617;
SET hoodie.public.rtd_mfdt_int_currency_ft.consume.ending.timestamp=20221207170234;
SELECT * FROM public.rtd_mfdt_int_currency_ft where _hoodie_commit_time>20221207164617 and
_hoodie_commit_time<=20221207170234;
```

Querying the Configured Incremental Parameters

You can use the following function to check the incremental parameter configuration.

```
SELECT * FROM pg_show_custom_settings();
```


Querying the Properties of a Hudi Foreign Table (hoodie.properties)

Run the following command to query the **hoodie.properties** of the Hudi data on OBS:

```
SELECT * FROM hudi_get_options('SCHEMA.FOREIGN_TABLE');
```

Example: Query the hudi properties of the OBS foreign table **rtd_mfdt_int_unit_ft** in the current schema.

```
SELECT * FROM hudi_get_options('rtd_mfdt_int_unit_ft');
```

Querying the Maximum Timeline of a Hudi Foreign Table

Run the following command to query the maximum timeline of the hudi data on OBS, that is, the latest submitted data:

```
SELECT * FROM hudi_get_max_commit('SCHEMA.FOREIGN_TABLE');
```

Example: Query the maximum timeline of the OBS foreign table **rtd_mfdt_int_unit_ft** in the current schema.

```
SELECT * FROM hudi_get_max_commit('rtd_mfdt_int_unit_ft');
```


13 PostGIS Extension

13.1 PostGIS

NOTE

- The third-party software that the PostGIS Extension depends on needs to be installed separately. If you need to use PostGIS, submit a service ticket or contact technical support to submit an application.
- If the error message "ERROR: EXTENSION is not yet supported." is displayed, the PostGIS software package is not installed. Contact technical support.

GaussDB(DWS) provides PostGIS Extension (PostGIS-2.4.2 and PostGIS-3.2.2). PostGIS Extension is a spatial database extender for PostgreSQL. It provides the following spatial information services: spatial objects, spatial indexes, spatial functions, and spatial operators. PostGIS Extension complies with the OpenGIS specifications.

In GaussDB(DWS), PostGIS Extension depends on the listed third-party open-source software.

- PostGIS 2.4.2 depends on the following third-party open-source software:
  - Geos 3.6.2
  - Proj 4.9.2
  - Json 0.12.1
  - Libxml2 2.7.1
  - Gdal 1.11.0
- PostGIS 3.2.2 depends on the following third-party open-source software:
  - Geos-3.11.0
  - Proj-6.0.0

- Json 0.12.1
- Libxml2 2.7.1
- Sqlite3

13.2 Using PostGIS

NOTE

- The third-party software that the PostGIS Extension depends on needs to be installed separately. If you need to use PostGIS, submit a service ticket or contact technical support to submit an application.
- If the error message "ERROR: EXTENSION is not yet supported." is displayed, the PostGIS software package is not installed. Contact technical support.

Creating PostGIS Extension

Run the **CREATE EXTENSION** command to create PostGIS Extension.

```
CREATE EXTENSION postgis;
```

Using PostGIS Extension

Use the following function to invoke a PostGIS Extension:

```
SELECT GisFunction (Param1, Param2,.....);
```

GisFunction is the function, and **Param1** and **Param2** are function parameters. The following SQL statements are a simple illustration for PostGIS use. For details about related functions, see ***PostGIS 2.4.2 Manual***.

Example 1: Create a geometry table.

```
CREATE TABLE cities ( id integer, city_name varchar(50) );
SELECT AddGeometryColumn('cities', 'position', 4326, 'POINT', 2);
```

Example 2: Insert geometry data.

```
INSERT INTO cities (id, position, city_name) VALUES (1,ST_GeomFromText('POINT(-9.5 23)',4326),'CityA');
INSERT INTO cities (id, position, city_name) VALUES (2,ST_GeomFromText('POINT(-10.6 40.3)',4326),'CityB');
INSERT INTO cities (id, position, city_name) VALUES (3,ST_GeomFromText('POINT(20.8 30.3)',4326), 'CityC');
```

Example 3: Calculate the distance between any two cities among three cities.

```
SELECT p1.city_name,p2.city_name,ST_Distance(p1.position,p2.position) FROM cities AS p1, cities AS p2
WHERE p1.id > p2.id;
```

Deleting PostGIS Extension

Run the following command to delete PostGIS Extension from GaussDB(DWS):

```
DROP EXTENSION postgis [CASCADE];
```

NOTE

If PostGIS Extension is the dependee of other objects (for example, geometry tables), you need to add the **CASCADE** keyword to delete all these objects.

13.3 PostGIS Support and Constraints

Supported Data Types

In GaussDB(DWS), PostGIS Extension support the following data types:

- box2d
- box3d
- geometry_dump
- geometry
- geography
- raster

NOTE

If PostGIS is used by a user other than the creator of the PostGIS, set the following GUC parameters:

```
SET behavior_compat_options = 'bind_procedure_searchpath';
```

Supported Operators and Functions

NOTE

The **ST_Intersects** function in PostGIS uses a caching strategy that enables a high cache hit ratio for the spatial data structures of foreign tables. When there is a significant disparity in the width between the inner and foreign tables, caching the wider table's data avoid the repeated loading of large objects, leading to significant performance enhancements. Practically, leveraging **Join Order Hints** to designate a wider table as the foreign table ensures that the execution plan is optimized for such scenarios.

Table 13-1 Operators and functions supported by PostGIS2.4.2

Category	Function
Management functions	AddGeometryColumn, DropGeometryColumn, DropGeometryTable, PostGIS_Full_Version, PostGIS_GEOS_Version, PostGIS_Liblwgeom_Version, PostGIS_Lib_Build_Date, PostGIS_Lib_Version, PostGIS_PROJ_Version, PostGIS_Scripts_Build_Date, PostGIS_Scripts_Installed, PostGIS_Version, PostGIS_LibXML_Version, PostGIS_Scripts_Released, Populate_Geometry_Columns, UpdateGeometrySRID

Category	Function
Geometry constructors	ST_BdPolyFromText, ST_BdMPolyFromText, ST_Box2dFromGeoHash, ST_GeogFromText, ST_GeographyFromText, ST_GeogFromWKB, ST_GeomCollFromText, ST_GeomFromEWKB, ST_GeomFromEWKT, ST_GeometryFromText, ST_GeomFromGeoHash, ST_GeomFromGML, ST_GeomFromGeoJSON, ST_GeomFromKML, ST_GMLToSQL, ST_GeomFromText, ST_GeomFromWKB, ST_LineFromMultiPoint, ST_LineFromText, ST_LineFromWKB, ST_LinestringFromWKB, ST_MakeBox2D, ST_3DMakeBox, ST_MakeEnvelope, ST_MakePolygon, ST_MakePoint, ST_MakePointM, ST_MLineFromText, ST_MPointFromText, ST_MPolyFromText, ST_Point, ST_PointFromGeoHash, ST_PointFromText, ST_PointFromWKB, ST_Polygon, ST_PolygonFromText, ST_WKBToSQL, ST_WKTToSQL
Geometry accessors	GeometryType, ST_Boundary, ST_CoordDim, ST_Dimension, ST_EndPoint, ST_Envelope, ST_ExteriorRing, ST_GeometryN, ST_GeometryType, ST_InteriorRingN, ST_IsClosed, ST_IsCollection, ST_IsEmpty, ST_IsRing, ST_IsSimple, ST_IsValid, ST_IsValidReason, ST_IsValidDetail, ST_M, ST_NDims, ST_NPoints, ST_NRings, ST_NumGeometries, ST_NumInteriorRings, ST_NumInteriorRing, ST_NumPatches, ST_NumPoints, ST_PatchN, ST_PointN, ST_SRID, ST_StartPoint, ST_Summary, ST_X, ST_XMax, ST_XMin, ST_Y, ST_YMax, ST_YMin, ST_Z, ST_ZMax, ST_Zmflag, ST_ZMin
Geometry editors	ST_AddPoint, ST_Affine, ST_Force2D, ST_Force3D, ST_Force3DZ, ST_Force3DM, ST_Force4D, ST_ForceCollection, ST_ForceSFS, ST_ForceRHR, ST_LineMerge, ST_CollectionExtract, ST_CollectionHomogenize, ST_Multi, ST_RemovePoint, ST_Reverse, ST_Rotate, ST_RotateX, ST_RotateY, ST_RotateZ, ST_Scale, ST_Segmentize, ST_SetPoint, ST_SetSRID, ST_SnapToGrid, ST_Snap, ST_Transform, ST_Translate, ST_TransScale
Geometry outputs	ST_AsBinary, ST_AsEWKB, ST_AsEWKT, ST_AsGeoJSON, ST_AsGML, ST_AsHEXEWKB, ST_AsKML, ST_AsLatLonText, ST_AsSVG, ST_AsText, ST_AsX3D, ST_GeoHash
Operators	&&, &&&, &<, &<|, &>, <<, <<|, =, >>, @, |&>, |>>, ~, ~=, <->, <#>

Category	Function
Spatial relationships and measurements	ST_3DClosestPoint, ST_3DDistance, ST_3DDWithin, ST_3DDFullyWithin, ST_3DIntersects, ST_3DLongestLine, ST_3DMaxDistance, ST_3DShortestLine, ST_Area, ST_Azimuth, ST_Centroid, ST_ClosestPoint, ST_Contains, ST_ContainsProperly, ST_Covers, ST_CoveredBy, ST_Crosses, ST_LineCrossingDirection, ST_Disjoint, ST_Distance, ST_HausdorffDistance, ST_MaxDistance, ST_DistanceSphere, ST_DistanceSpheroid, ST_DFullyWithin, ST_DWithin, ST_Equals, ST_HasArc, ST_Intersects, ST_Length, ST_Length2D, ST_3DLength, ST_Length_Spheroid, ST_Length2D_Spheroid, ST_3DLength_Spheroid, ST_LongestLine, ST_OrderingEquals, ST_Overlaps, ST_Perimeter, ST_Perimeter2D, ST_3DPerimeter, ST_PointOnSurface, ST_Project, ST_Relate, ST_RelateMatch, ST_ShortestLine, ST_Touches, ST_Within
Geometry processing	ST_Buffer, ST_BuildArea, ST_Collect, ST_ConcaveHull, ST_ConvexHull, ST_CurveToLine, ST_DelaunayTriangles, ST_Difference, ST_Dump, ST_DumpPoints, ST_DumpRings, ST_FlipCoordinates, ST_Intersection, ST_LineToCurve, ST_MakeValid, ST_MemUnion, ST_MinimumBoundingCircle, ST_Polygonize, ST_Node, ST_OffsetCurve, ST_RemoveRepeatedPoints, ST_SharedPaths, ST_Shift_Longitude, ST_Simplify, ST_SimplifyPreserveTopology, ST_Split, ST_SymDifference, ST_Union, ST_UnaryUnion
Linear referencing	ST_LineInterpolatePoint, ST_LineLocatePoint, ST_LineSubstring, ST_LocateAlong, ST_LocateBetween, ST_LocateBetweenElevations, ST_InterpolatePoint, ST_AddMeasure
Miscellaneous functions	ST_Accum, Box2D, Box3D, ST_Expand, ST_Extent, ST_3Dextent, Find_SRID, ST_MemSize
Exceptional functions	PostGIS_AddBBox, PostGIS_DropBBox, PostGIS_HasBBox
Raster Management Functions	AddRasterConstraints, DropRasterConstraints, AddOverviewConstraints, DropOverviewConstraints, PostGIS_GDAL_Version, PostGIS_Raster_Lib_Build_Date, PostGIS_Raster_Lib_Version, and ST_GDALDrivers, and UpdateRasterSRID
Raster Constructors	ST_AddBand, ST_AsRaster, ST_Band, ST_MakeEmptyRaster, ST_Tile, and ST_FromGDALRaster

Category	Function
Raster Accessors	ST_GeoReference, ST_Height, ST_IsEmpty, ST_MetaData, ST_NumBands, ST_PixelHeight, ST_PixelWidth, ST_ScaleX, ST_ScaleY, ST_RasterToWorldCoord, ST_RasterToWorldCoordX, ST_RasterToWorldCoordY, ST_Rotation, ST_SkewX, ST_SkewY, ST_SRID, ST_Summary, ST_UpperLeftX, ST_UpperLeftY, ST_Width, ST_WorldToRasterCoord, ST_WorldToRasterCoordX, ST_WorldToRasterCoordY
Raster Band Accessors	ST_BandMetaData, ST_BandNoDataValue, ST_BandIsNoData, ST_BandPath, ST_BandPixelType, and ST_HasNoBand
Raster Pixel Accessors and Setters	ST_PixelAsPolygon, ST_PixelAsPolygons, ST_PixelAsPoint, ST_PixelAsPoints, ST_PixelAsCentroid, ST_PixelAsCentroids, ST_Value, ST_NearestValue, ST_Neighborhood, ST_SetValue, ST_SetValues, ST_DumpValues, and ST_PixelOfValue
Raster Editors	ST_SetGeoReference, ST_SetRotation, ST_SetScale, ST_SetSkew, ST_SetSRID, ST_SetUpperLeft, ST_Resample, ST_Rescale, ST_Reskew, and ST_SnapToGrid, ST_Resize, and ST_Transform
Raster Band Editors	ST_SetBandNoDataValue and ST_SetBandIsNoData
Raster Band Statistics and Analytics	ST_Count, ST_CountAgg, ST_Histogram, ST_Quantile, ST_SummaryStats, ST_SummaryStatsAgg, and ST_ValueCount
Raster Outputs	ST_AsBinary, ST_AsGDALRaster, ST_AsJPEG, ST_AsPNG, and ST_AsTIFF
Raster Processing	ST_Clip, ST_ColorMap, ST_Intersection, ST_MapAlgebra, ST_Reclass, and ST_Union ST_Distinct4ma, ST_InvDistWeight4ma, ST_Max4ma, ST_Mean4ma, ST_Min4ma, ST_MinDist4ma, ST_Range4ma, ST_StdDev4ma, and ST _Sum4ma, ST_Aspect, ST_HillShade, ST_Roughness, ST_Slope, ST_TPI, ST_TRI, Box3D, ST_ConvexHull, ST_DumpAsPolygons, and ST_ Envelope, ST_MinConvexHull, ST_Polygon, ST_Contains, ST_ContainsProperly, ST_Covers, ST_CoveredBy, ST_Disjoint, ST_Intersects, and ST_Overlaps, ST_Touches, ST_SameAlignment, ST_NotSameAlignmentReason, ST_Within, ST_DWithin, and ST_DFullyWithin
Raster Operators	&&, &<, &>, =, @, ~=, and ~

Table 13-2 Operators and functions supported by PostGIS3.2.2

Category	Function
Management functions	AddGeometryColumn, DropGeometryColumn, DropGeometryTable, PostGIS_Full_Version, PostGIS_GEOS_Version, PostGIS_Liblwgeom_Version, PostGIS_Lib_Build_Date, PostGIS_Lib_Version, PostGIS_PROJ_Version, PostGIS_Scripts_Build_Date, PostGIS_Scripts_Installed, PostGIS_Version, PostGIS_LibXML_Version, PostGIS_Scripts_Released, Populate_Geometry_Columns, UpdateGeometrySRID
Geometry constructors	ST_BdPolyFromText, ST_BdMPolyFromText, ST_Box2dFromGeoHash, ST_GeogFromText, ST_GeneratePoints, ST_GeographyFromText, ST_GeogFromWKB, ST_GeomCollFromText, ST_GeomFromEWKB, ST_GeomFromEWKT, ST_GeometryFromText, ST_GeomFromGeoHash, ST_GeomFromGML, ST_GeomFromGeoJSON, ST_GeomFromKML, ST_GMLToSQL, ST_GeomFromText, ST_GeomFromWKB, ST_LineFromMultiPoint, ST_LineFromText, ST_LineFromWKB, ST_LinestringFromWKB, ST_MakeBox2D, ST_3DMakeBox, ST_MakeEnvelope, ST_MakePolygon, ST_MakePoint, ST_MakePointM, ST_MLineFromText, ST_MPointFromText, ST_MPolyFromText, ST_Point, ST_Points, ST_PointFromGeoHash, ST_PointFromText, ST_PointFromWKB, ST_Polygon, ST_PolygonFromText, ST_WKBToSQL, ST_WKTToSQL
Geometry accessors	GeometryType, ST_Boundary, ST_CoordDim, ST_Dimension, ST_EndPoint, ST_Envelope, ST_ExteriorRing, ST_GeometryN, ST_GeometryType, ST_InteriorRingN, ST_IsClosed, ST_IsCollection, ST_IsEmpty, ST_IsPolygonCCW, ST_IsPolygonCW, ST_IsRing, ST_IsSimple, ST_IsValid, ST_IsValidReason, ST_IsValidDetail, ST_M, ST_NDims, ST_NPoints, ST_NRings, ST_NumGeometries, ST_NumInteriorRings, ST_NumInteriorRing, ST_NumPatches, ST_NumPoints, ST_PatchN, ST_PointN, ST_SRID, ST_StartPoint, ST_Summary, ST_X, ST_XMax, ST_XMin, ST_Y, ST_YMax, ST_YMin, ST_Z, ST_ZMax, ST_Zmflag, ST_ZMin
Geometry editors	ST_AddPoint, ST_Affine, ST_Force2D, ST_Force3D, ST_Force3DZ, ST_Force3DM, ST_Force4D, ST_ForceCollection, ST_ForcePolygonCCW, ST_ForcePolygonCW, ST_ForceSFS, ST_ForceRHR, ST_LineMerge, ST_CollectionExtract, ST_CollectionHomogenize, ST_Multi, ST_Normalize, ST_RemovePoint, ST_Reverse, ST_Rotate, ST_RotateX, ST_RotateY, ST_RotateZ, ST_Scale, ST_Segmentize, ST_SetPoint, ST_SetSRID, ST_SnapToGrid, ST_Snap, ST_Transform, ST_Translate, ST_TransScale

Category	Function
Geometry outputs	ST_AsBinary, ST_AsEWKB, ST_AsEWKT, ST_AsGeoJSON, ST_AsGML, ST_AsHEXEWKB, ST_AsKML, ST_AsLatLonText, ST_AsSVG, ST_AsText, ST_AsTwkb, ST_AsX3D, ST_GeoHash
Operators	&&, &&&, &<, &<|, &>, <<, <<|, =, >>, @, |&>, |>>, ~, ~=, <->, <#>
Spatial relationships and measurements	ST_3DClosestPoint, ST_3DDistance, ST_3DDWithin, ST_3DDFullyWithin, ST_3DIntersects, ST_3DLongestLine, ST_3DMaxDistance, ST_3DShortestLine, ST_Area, ST_Azimuth, ST_Centroid, ST_ClosestPoint, ST_Contains, ST_ContainsProperly, ST_Covers, ST_CoveredBy, ST_Crosses, ST_LineCrossingDirection, ST_Disjoint, ST_Distance, ST_HausdorffDistance, ST_MaxDistance, ST_DistanceSphere, ST_DistanceSpheroid, ST_DFullyWithin, ST_DWithin, ST_Equals, ST_HasArc, ST_Intersects, ST_Length, ST_Length2D, ST_3DLength, ST_LengthSpheroid, ST_Length2DSpheroid, ST_LongestLine, ST_MinimumBoundingRadius, ST_OrderingEquals, ST_Overlaps, ST_Perimeter, ST_Perimeter2D, ST_3DPerimeter, ST_PointOnSurface, ST_Project, ST_Relate, ST_RelateMatch, ST_ShortestLine, ST_Touches, ST_Within
Geometry processing	ST_Buffer, ST_BuildArea, ST_ClipByBox2D, ST_ClusterDBSCAN, ST_ClusterIntersecting, ST_ClusterKMeans, ST_ClusterWithin, ST_Collect, ST_ConcaveHull, ST_ConvexHull, ST_CurveToLine, ST_DelaunayTriangles, ST_Difference, ST_Dump, ST_DumpPoints, ST_DumpRings, ST_FlipCoordinates, ST_Intersection, ST_LineToCurve, ST_MakeValid, ST_MemUnion, ST_MinimumBoundingCircle, ST_Polygonize, ST_Node, ST_OffsetCurve, ST_RemoveRepeatedPoints, ST_SharedPaths, ST_ShiftLongitude, ST_Simplify, ST_SimplifyPreserveTopology, ST_Split, ST_Subdivide, ST_SymDifference, ST_Union, ST_UnaryUnion
Linear referencing	ST_LineInterpolatePoint, ST_LineLocatePoint, ST_LineSubstring, ST_LocateAlong, ST_LocateBetween, ST_LocateBetweenElevations, ST_InterpolatePoint, ST_AddMeasure
Miscellaneous functions	Array_Agg, Box2D, Box3D, ST_Expand, ST_Extent, ST_3Dextent, Find_SRID, ST_MemSize
Exceptional functions	PostGIS_AddBBox, PostGIS_DropBBox, PostGIS_HasBBox

Spatial Indexes

In GaussDB(DWS), PostGIS Extension supports Generalized Search Tree (GIST) spatial indexes. This index type is inapplicable to partitioned tables. Different from

B-tree indexes, GIS indexes are adaptable to all kinds of irregular data structures, which can effectively improve the retrieval efficiency for geometry and geographic data.

Run the following command to create a GiST index:

```
CREATE INDEX indexname ON tablename USING GIST ( geometryfield );
```

Extension Constraints

- Only row-store tables are supported.
- Only Oracle-compatible databases are supported.
- The topology object management module, Topology, is not supported.
- BRIN indexes are not supported.
- The **spatial_ref_sys** table can only be queried during scale-out.

13.4 OPEN SOURCE SOFTWARE NOTICE (For PostGIS)

This document contains open source software notice for the product. And this document is confidential information of copyright holder. Recipient shall protect it in due care and shall not disseminate it without permission.

Warranty Disclaimer

This document is provided "as is" without any warranty whatsoever, including the accuracy or comprehensiveness. Copyright holder of this document may change the contents of this document at any time without prior notice, and copyright holder disclaims any liability in relation to recipient's use of this document.

Open source software is provided by the author "as is" and any express or implied warranties, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose are disclaimed. In no event shall the author be liable for any direct, indirect, incidental, special, exemplary, or consequential damages (including, but not limited to, procurement of substitute goods or services; loss of data or profits; or business interruption) however caused and on any theory of liability, whether in contract, strict liability, or tort (including negligence or otherwise) arising in any way out of the use of open source software, even if advised of the possibility of such damage.

Copyright Notice And License Texts

Software: postgis-2.4.2

Copyright notice:

"Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (C) 1989, 1991 Free Software Foundation, Inc.,

51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Copyright 2008 Kevin Neufeld

Copyright (c) 2009 Walter Bruce Sinclair

Copyright 2006-2013 Stephen Woodbridge.

Copyright (c) 2008 Walter Bruce Sinclair

Copyright (c) 2012 TJ Holowaychuk <tj@vision-media.ca>

Copyright (c) 2008, by Attractive Chaos <attractivechaos@aol.co.uk>

Copyright (c) 2001-2012 Walter Bruce Sinclair

Copyright (c) 2010 Walter Bruce Sinclair

Copyright 2006 Stephen Woodbridge

Copyright 2006-2010 Stephen Woodbridge.

Copyright (c) 2006-2014 Stephen Woodbridge.

Copyright (c) 2017, Even Rouault <even.rouault at spatialys.com>

Copyright (C) 2004-2015 Sandro Santilli <strk@kbt.io>

Copyright (C) 2008-2011 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2008 Mark Cave-Ayland <mark.cave-ayland@siriusit.co.uk>

Copyright 2015 Nicklas Avén <nicklas.aven@jordogskog.no>

Copyright 2008 Paul Ramsey

Copyright (C) 2012 Sandro Santilli <strk@kbt.io>

Copyright 2012 Sandro Santilli <strk@kbt.io>

Copyright (C) 2014 Sandro Santilli <strk@kbt.io>

Copyright 2013 Olivier Courtin <olivier.courtin@oslandia.com>

Copyright 2009 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright 2008 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright 2011 Sandro Santilli <strk@kbt.io>

Copyright 2015 Daniel Baston

Copyright 2009 Olivier Courtin <olivier.courtin@oslandia.com>

Copyright 2014 Kashif Rasul <kashif.rasul@gmail.com> and

Shoaib Burq <saburq@gmail.com>

Copyright 2013 Sandro Santilli <strk@kbt.io>

Copyright 2010 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2017 Sandro Santilli <strk@kbt.io>

Copyright (C) 2015 Sandro Santilli <strk@kbt.io>

Copyright (C) 2009 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2011 Sandro Santilli <strk@kbt.io>

Copyright 2010 Olivier Courtin <olivier.courtin@oslandia.com>

Copyright 2014 Nicklas Avén

Copyright 2011-2016 Regina Obe

Copyright (C) 2008 Paul Ramsey

Copyright (C) 2011-2015 Sandro Santilli <strk@kbt.io>

Copyright 2010-2012 Olivier Courtin <olivier.courtin@oslandia.com>

Copyright (C) 2015 Daniel Baston <dbaston@gmail.com>

Copyright (C) 2013 Nicklas Avén

Copyright (C) 2016 Sandro Santilli <strk@kbt.io>

Copyright 2017 Darafei Praliaskouski <me@komzpa.net>

Copyright (c) 2016, Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2011-2012 Sandro Santilli <strk@kbt.io>

Copyright (C) 2011 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2007-2008 Mark Cave-Ayland

Copyright (C) 2001-2006 Refractions Research Inc.

Copyright 2015 Daniel Baston <dbaston@gmail.com>

Copyright 2009 David Skea <David.Skea@gov.bc.ca>

Copyright (C) 2012-2015 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2012-2015 Sandro Santilli <strk@kbt.io>

Copyright 2001-2006 Refractions Research Inc.

Copyright (C) 2004 Refractions Research Inc.

Copyright 2011-2014 Sandro Santilli <strk@kbt.io>

Copyright 2009-2010 Sandro Santilli <strk@kbt.io>

Copyright 2015-2016 Daniel Baston <dbaston@gmail.com>

Copyright 2011-2015 Sandro Santilli <strk@kbt.io>

Copyright 2007-2008 Mark Cave-Ayland

Copyright 2012-2013 Oslandia <infos@oslandia.com>

Copyright (C) 2015-2017 Sandro Santilli <strk@kbt.io>

Copyright (C) 2001-2003 Refractions Research Inc.

Copyright 2016 Sandro Santilli <strk@kbt.io>

Copyright 2011 Kashif Rasul <kashif.rasul@gmail.com>

Copyright (C) 2014 Nicklas Avén

Copyright (C) 2010 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2010-2015 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2011 Sandro Santilli <strk@kbt.io>

Copyright (C) 2011-2014 Sandro Santilli <strk@kbt.io>

Copyright (C) 1984, 1989-1990, 2000-2015 Free Software Foundation, Inc.

Copyright (C) 2011 Paul Ramsey

Copyright 2001-2003 Refractions Research Inc.

Copyright 2009-2010 Olivier Courtin <olivier.courtin@oslandia.com>

Copyright 2010-2012 Oslandia

Copyright 2006 Corporacion Autonoma Regional de Santander

Copyright 2013 Nicklas Avén

Copyright 2011-2016 Arrival 3D, Regina Obe

Copyright (C) 2009 David Skea <David.Skea@gov.bc.ca>

Copyright (C) 2017 Sandro Santilli <strk@kbt.io>

Copyright (C) 2009-2012 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2010 - Oslandia

Copyright (C) 2006 Mark Leslie <mark.leslie@lisasoft.com>

Copyright (C) 2008-2009 Mark Cave-Ayland <mark.cave-ayland@siriusit.co.uk>

Copyright (C) 2009-2015 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2010 Olivier Courtin <olivier.courtin@camptocamp.com>

Copyright 2010 Nicklas Avén

Copyright 2012 Paul Ramsey

Copyright 2011 Nicklas Avén

Copyright 2002 Thamer Alharbash

Copyright 2011 OSGeo

Copyright (C) 2009-2011 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2008 Mark Cave-Ayland <mark.cave-ayland@siriusit.co.uk>

Copyright (C) 2004-2007 Refractions Research Inc.

Copyright 2010 LISAsoft Pty Ltd

Copyright 2010 Mark Leslie

Copyright (c) 1999, Frank Warmerdam

Copyright 2009 Mark Cave-Ayland <mark.cave-ayland@siriusit.co.uk>

Copyright (c) 2007, Frank Warmerdam

Copyright 2008 OpenGeo.org

Copyright (C) 2008 OpenGeo.org

Copyright (C) 2009 Mark Cave-Ayland <mark.cave-ayland@siriusit.co.uk>

Copyright 2010 LISAsoft

Copyright (C) 2010 Mark Cave-Ayland <mark.cave-ayland@siriusit.co.uk>

Copyright (c) 1999, 2001, Frank Warmerdam

Copyright (C) 2016-2017 Bj?rn Harrtell <bjorn@wololo.org>

Copyright (C) 2017 Danny G?tte <danny.goette@fem.tu-ilmenau.de>

Copyright 2009-2011 Paul Ramsey <pramsey@cleverelephant.ca>

^copyright^

Copyright 2012 (C) Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2006 Refractions Research Inc.

Copyright 2009 Paul Ramsey <pramsey@opengeo.org>

Copyright 2001-2009 Refractions Research Inc.

Copyright (C) 2010 Olivier Courtin <olivier.courtin@oslandia.com>

By Nathan Wagner, copyright disclaimed,

this entire file is in the public domain

Copyright 2009-2011 Olivier Courtin <olivier.courtin@oslandia.com>

Copyright (C) 2001-2005 Refractions Research Inc.

Copyright 2001-2011 Refractions Research Inc.

Copyright 2009-2014 Sandro Santilli <strk@kbt.io>

Copyright (C) 2008 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2010 Sandro Santilli <strk@kbt.io>

Copyright 2012 J Smith <dark.panda@gmail.com>

Copyright 2009 - 2010 Oslandia

Copyright 2009 Oslandia

Copyright 2001-2005 Refractions Research Inc.

Copyright 2016 Paul Ramsey <pramsey@cleverelephant.ca>

Copyright 2016 Daniel Baston <dbaston@gmail.com>

Copyright (C) 2011 OpenGeo.org

Copyright (c) 2003-2017, Troy D. Hanson http:troydhanson.github.com/uthash/

Copyright (C) 2011 Regents of the University of California

Copyright (C) 2011-2013 Regents of the University of California

Copyright (C) 2010-2011 Jorge Arevalo <jorge.arevalo@deimos-space.com>

Copyright (C) 2010-2011 David Zwarg <dzwarg@azavea.com>

Copyright (C) 2009-2011 Pierre Racine <pierre.racine@sbf.ulaval.ca>

Copyright (C) 2009-2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2008-2009 Sandro Santilli <strk@kbt.io>

Copyright (C) 2013 Nathaneil Hunter Clay <clay.nathaniel@gmail.com

Copyright (C) 2013 Nathaniel Hunter Clay <clay.nathaniel@gmail.com>

Copyright (C) 2013 Bborie Park <dustymugs@gmail.com>

Copyright (C) 2013 Nathaniel Hunter Clay <clay.nathaniel@gmail.com>

(C) 2009 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2009 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2009-2010 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2009-2010 Jorge Arevalo <jorge.arevalo@deimos-space.com>

Copyright (C) 2012 Regents of the University of California

Copyright (C) 2013 Regents of the University of California

Copyright (C) 2012-2013 Regents of the University of California

Copyright (C) 2009 Sandro Santilli <strk@kbt.io>

"

License: The GPL v2 License.

GNU GENERAL PUBLIC LICENSE

Version 2, June 1991

Copyright (C) 1989, 1991 Free Software Foundation, Inc.

51 Franklin St, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Preamble

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change free software--to make sure the software is free for all its users. This General Public License applies to most of the Free Software Foundation's software and to any other program whose authors commit to using it. (Some other Free Software Foundation software is covered by the GNU Library General Public License instead.) You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish), that you receive source code or can get it if you want it, that you can change the software

or use pieces of it in new free programs; and that you know you can do these things.

To protect your rights, we need to make restrictions that forbid anyone to deny you these rights or to ask you to surrender the rights. These restrictions translate to certain responsibilities for you if you distribute copies of the software, or if you modify it.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must give the recipients all the rights that you have. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

We protect your rights with two steps: (1) copyright the software, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the software.

Also, for each author's protection and ours, we want to make certain that everyone understands that there is no warranty for this free software. If the software is modified by someone else and passed on, we want its recipients to know that what they have is not the original, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that redistributors of a free program will individually obtain patent licenses, in effect making the program proprietary. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.

The precise terms and conditions for copying, distribution and modification follow.?

GNU GENERAL PUBLIC LICENSE

TERMS AND CONDITIONS FOR COPYING, DISTRIBUTION AND MODIFICATION

0. This License applies to any program or other work which contains a notice placed by the copyright holder saying it may be distributed under the terms of this General Public License. The "Program", below, refers to any such program or work, and a "work based on the Program" means either the Program or any derivative work under copyright law: that is to say, a work containing the Program or a portion of it, either verbatim or with modifications and/or translated into another language. (Hereinafter, translation is included without limitation in the term "modification".) Each licensee is addressed as "you".

Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running the Program is not restricted, and the output from the Program is covered only if its contents constitute a work based on the Program (independent of having been made by running the Program). Whether that is true depends on what the Program does.

1. You may copy and distribute verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and give any other recipients of the Program a copy of this License along with the Program.

You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Program or any portion of it, thus forming a work based on the Program, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions:

a) You must cause the modified files to carry prominent notices stating that you changed the files and the date of any change.

b) You must cause any work that you distribute or publish, that in whole or in part contains or is derived from the Program or any part thereof, to be licensed as a whole at no charge to all third parties under the terms of this License.

c) If the modified program normally reads commands interactively when run, you must cause it, when started running for such interactive use in the most ordinary way, to print or display an announcement including an appropriate copyright notice and a notice that there is no warranty (or else, saying that you provide a warranty) and that users may redistribute the program under these conditions, and telling the user how to view a copy of this License. (Exception: if the Program itself is interactive but does not normally print such an announcement, your work based on the Program is not required to print an announcement.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Program, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Program, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Program.

In addition, mere aggregation of another work not based on the Program with the Program (or with a work based on the Program) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

3. You may copy and distribute the Program (or a work based on it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you also do one of the following:

a) Accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,

b) Accompany it with a written offer, valid for at least three years, to give any third party, for a charge no more than your cost of physically performing source distribution, a complete machine-readable copy of the corresponding source code, to be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or,

c) Accompany it with the information you received as to the offer to distribute corresponding source code. (This alternative is allowed only for noncommercial distribution and only if you received the program in object code or executable form with such an offer, in accord with Subsection b above.)

The source code for a work means the preferred form of the work for making modifications to it. For an executable work, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the executable. However, as a special exception, the source code distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

If distribution of executable or object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place counts as distribution of the source code, even though third parties are not compelled to copy the source along with the object code.

4. You may not copy, modify, sublicense, or distribute the Program except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense or distribute the Program is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

5. You are not required to accept this License, since you have not signed it. However, nothing else grants you permission to modify or distribute the Program or its derivative works. These actions are prohibited by law if you do not accept this License. Therefore, by modifying or distributing the Program (or any work based on the Program), you indicate your acceptance of this License to do so, and all its terms and conditions for copying, distributing or modifying the Program or works based on it.

6. Each time you redistribute the Program (or any work based on the Program), the recipient automatically receives a license from the original licensor to copy, distribute or modify the Program subject to these terms and conditions. You may not impose any further restrictions on the recipients' exercise of the rights granted herein. You are not responsible for enforcing compliance by third parties to this License.

7. If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Program at all. For example, if a patent license would not permit royalty-free redistribution of the Program by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Program.

If any portion of this section is held invalid or unenforceable under any particular circumstance, the balance of the section is intended to apply and the section as a whole is intended to apply in other circumstances.

It is not the purpose of this section to induce you to infringe any patents or other property right claims or to contest validity of any such claims; this section has the sole purpose of protecting the integrity of the free software distribution system, which is implemented by public license practices. Many people have made generous contributions to the wide range of software distributed through that system in reliance on consistent application of that system; it is up to the author/donor to decide if he or she is willing to distribute software through any other system and a licensee cannot impose that choice.

This section is intended to make thoroughly clear what is believed to be a consequence of the rest of this License.

8. If the distribution and/or use of the Program is restricted in certain countries either by patents or by copyrighted interfaces, the original copyright holder who places the Program under this License may add an explicit geographical distribution limitation excluding those countries, so that distribution is permitted only in or among countries not thus excluded. In such case, this License incorporates the limitation as if written in the body of this License.

9. The Free Software Foundation may publish revised and/or new versions of the General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies a version number of this License which applies to it and "any later version", you have the option of following the terms and conditions either of that version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of this License, you may choose any version ever published by the Free Software Foundation.

10. If you wish to incorporate parts of the Program into other free programs whose distribution conditions are different, write to the author to ask for permission. For software which is copyrighted by the Free Software Foundation, write to the Free Software Foundation; we sometimes make exceptions for this. Our decision will be guided by the two goals of preserving the free status of all

derivatives of our free software and of promoting the sharing and reuse of software generally.

NO WARRANTY

11. BECAUSE THE PROGRAM IS LICENSED FREE OF CHARGE, THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

12. IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MAY MODIFY AND/OR REDISTRIBUTE THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES,INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively convey the exclusion of warranty; and each file should have at least the "copyright" line and a pointer to where the full notice is found.

<one line to give the program's name and a brief idea of what it does.>

Copyright (C) <year> <name of author>

This program is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version.

This program is distributed in the hope that it will be useful,but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details.

You should have received a copy of the GNU General Public License along with this program; if not, write to the Free Software Foundation, Inc., 51 Franklin St, Fifth Floor, Boston, MA 02110-1301

Also add information on how to contact you by electronic and paper mail.

If the program is interactive, make it output a short notice like this when it starts in an interactive mode:

Gnomovision version 69, Copyright (C) year name of author

Gnomovision comes with ABSOLUTELY NO WARRANTY; for details type `show w'.

This is free software, and you are welcome to redistribute it under certain conditions; type `show c' for details.

The hypothetical commands `show w' and `show c' should show the appropriate parts of the General Public License. Of course, the commands you use may be called something other than `show w' and `show c'; they could even be mouse-clicks or menu items--whatever suits your program.

You should also get your employer (if you work as a programmer) or your school, if any, to sign a "copyright disclaimer" for the program, if necessary. Here is a sample; alter the names:

Yoyodyne, Inc., hereby disclaims all copyright interest in the program `Gnomovision' (which makes passes at compilers) written by James Hacker.

<signature of Ty Coon>, 1 April 1989 Ty Coon, President of Vice

This General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Library General Public License instead of this License.

Software:Geos

Copyright notice:

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2013 Sandro Santilli <strk@keybit.net>

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Copyright (C) 2005-2011 Refractions Research Inc.

Copyright (C) 2009 Ragi Y. Burhum <ragi@burhum.com>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2005 2006 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006-2011 Refractions Research Inc.

Copyright (C) 2011 Sandro Santilli <strk@keybit.net

Copyright (C) 2009-2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2016 Daniel Baston

Copyright (C) 2008 Sean Gillies

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Refractions Research Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Sandro Santilli <strk@keybit.net>

Copyright (C) 2008-2010 Safe Software Inc.

Copyright (C) 2006-2007 Refractions Research Inc.

Copyright (C) 2005-2007 Refractions Research Inc.

Copyright (C) 2007 Refractions Research Inc.

Copyright (C) 2014 Mika Heiskanen <mika.heiskanen@fmi.fi>

Copyright (C) 2009-2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 2011 Sandro Santilli <strk@keybit.net>

Copyright (C) 2010 Sandro Santilli <strk@keybit.net>

Copyright (C) 2009 Mateusz Loskot

Copyright (C) 2005-2009 Refractions Research Inc.

Copyright (C) 2001-2009 Vivid Solutions Inc.

Copyright (C) 2012 Sandro Santilli <strk@keybit.net>

Copyright (C) 2006 Wu Yongwei

Copyright (C) 2012 Excensus LLC.

Copyright (C) 1996-2015 Free Software Foundation, Inc.

Copyright (c) 1995 Olivier Devillers <Olivier.Devillers@sophia.inria.fr>

Copyright (C) 2007-2010 Safe Software Inc.

Copyright (C) 2010 Safe Software Inc.

Copyright (C) 2006 Refractions Research

Copyright 2004 Sean Gillies, sgillies@frii.com

Copyright (C) 2011 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2015 Nyall Dawson <nyall dot dawson at gmail dot com>

Original code (2.0 and earlier)copyright (c) 2000-2006 Lee Thomason (www.grinninglizard.com)

Original code (2.0 and earlier)copyright (c) 2000-2002 Lee Thomason (www.grinninglizard.com)

License: LGPL V2.1

GNU LESSER GENERAL PUBLIC LICENSE

Version 2.1, February 1999

Copyright (C) 1991, 1999 Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

[This is the first released version of the Lesser GPL. It also counts as the successor of the GNU Library Public License, version 2, hence the version number 2.1.]

Preamble

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the GNU General Public

Licenses are intended to guarantee your freedom to share and change free software--to make sure the software is free for all its users.

This license, the Lesser General Public License, applies to some specially designated software packages--typically libraries--of the Free Software Foundation and other authors who decide to use it. You can use it too, but we suggest you first think carefully about whether this license or the ordinary General Public License is the better strategy to use in any particular case, based on the explanations below.

When we speak of free software, we are referring to freedom of use, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish); that you receive source code or can get it if you want it; that you can change the software and use pieces of it in new free programs; and that you are informed that you can do these things.

To protect your rights, we need to make restrictions that forbid distributors to deny you these rights or to ask you to surrender these rights. These restrictions translate to certain responsibilities for you if you distribute copies of the library or if you modify it.

For example, if you distribute copies of the library, whether gratis or for a fee, you must give the recipients all the rights that we gave you. You must make sure that they, too, receive or can get the source code. If you link other code with the library, you must provide complete object files to the recipients, so that they can relink them with the library after making changes to the library and recompiling it. And you must show them these terms so they know their rights.

We protect your rights with a two-step method: (1) we copyright the library, and (2) we offer you this license, which gives you legal permission to copy, distribute and/or modify the library.

To protect each distributor, we want to make it very clear that there is no warranty for the free library. Also, if the library is modified by someone else and passed on,

the recipients should know that what they have is not the original version, so that the original author's reputation will not be affected by problems that might be introduced by others.

Finally, software patents pose a constant threat to the existence of any free program. We wish to make sure that a company cannot effectively restrict the users of a free program by obtaining a restrictive license from a patent holder. Therefore, we insist that any patent license obtained for a version of the library must be consistent with the full freedom of use specified in this license.

Most GNU software, including some libraries, is covered by the ordinary GNU General Public License. This license, the GNU Lesser General Public License, applies to certain designated libraries, and

is quite different from the ordinary General Public License. We use this license for certain libraries in order to permit linking those libraries into non-free programs.

When a program is linked with a library, whether statically or using a shared library, the combination of the two is legally speaking a combined work, a derivative of the original library. The ordinary General Public License therefore permits such linking only if the entire combination fits its criteria of freedom. The Lesser General Public License permits more lax criteria for linking other code with the library.

We call this license the "Lesser" General Public License because it does Less to protect the user's freedom than the ordinary General Public License. It also provides other free software developers Less of an advantage over competing non-free programs. These disadvantages are the reason we use the ordinary General Public License for many libraries. However, the Lesser license provides advantages in certain special circumstances.

For example, on rare occasions, there may be a special need to encourage the widest possible use of a certain library, so that it becomes a de-facto standard. To achieve this, non-free programs must be allowed to use the library. A more frequent case is that a free library does the same job as widely used non-free libraries. In this case, there is little to gain by limiting the free library to free software only, so we use the Lesser General Public License.

In other cases, permission to use a particular library in non-free programs enables a greater number of people to use a large body of free software. For example, permission to use the GNU C Library in

non-free programs enables many more people to use the whole GNU operating system, as well as its variant, the GNU/Linux operating system.

Although the Lesser General Public License is Less protective of the users' freedom, it does ensure that the user of a program that is linked with the Library has the freedom and the wherewithal to run that program using a modified version of the Library.

The precise terms and conditions for copying, distribution and modification follow. Pay close attention to the difference between a "work based on the library" and a "work that uses the library". The

former contains code derived from the library, whereas the latter must be combined with the library in order to run.

GNU LESSER GENERAL PUBLIC LICENSE

TERMS AND CONDITIONS FOR COPYING, DISTRIBUTION AND MODIFICATION

0. This License Agreement applies to any software library or other program which contains a notice placed by the copyright holder or other authorized party saying it may be distributed under the terms of this Lesser General Public License (also called "this License"). Each licensee is addressed as "you".

A "library" means a collection of software functions and/or data prepared so as to be conveniently linked with application programs (which use some of those functions and data) to form executables.

The "Library", below, refers to any such software library or work which has been distributed under these terms. A "work based on the Library" means either the Library or any derivative work under

copyright law: that is to say, a work containing the Library or a portion of it, either verbatim or with modifications and/or translated straightforwardly into another language. (Hereinafter, translation is included without limitation in the term "modification".)

"Source code" for a work means the preferred form of the work for making modifications to it. For a library, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the library.

Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running a program using the Library is not restricted, and output from such a program is covered only if its contents constitute a work based on the Library (independent of the use of the Library in a tool for writing it). Whether that is true depends on what the Library does and what the program that uses the Library does.

1. You may copy and distribute verbatim copies of the Library's complete source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an

appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and distribute a copy of this License along with the

Library.

You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Library or any portion of it, thus forming a work based on the Library, and copy and distribute such modifications or work under the terms of Section 1

above, provided that you also meet all of these conditions:

a) The modified work must itself be a software library.

b) You must cause the files modified to carry prominent notices stating that you changed the files and the date of any change.

c) You must cause the whole of the work to be licensed at no charge to all third parties under the terms of this License.

d) If a facility in the modified Library refers to a function or a table of data to be supplied by an application program that uses the facility, other than as an argument passed when the facility is invoked, then you must make a good faith effort to ensure that, in the event an application does not supply such function or table, the facility still operates, and performs whatever part of

its purpose remains meaningful.

(For example, a function in a library to compute square roots has a purpose that is entirely well-defined independent of the application. Therefore, Subsection 2d requires that any application-supplied function or table used by this function must be optional: if the application does not supply it, the square root function must still compute square roots.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Library, and can be reasonably considered independent and separate works in

themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Library, the distribution of the whole must be on the terms of this License, whose permissions for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it.

Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or

collective works based on the Library.

In addition, mere aggregation of another work not based on the Library with the Library (or with a work based on the Library) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

3. You may opt to apply the terms of the ordinary GNU General Public License instead of this License to a given copy of the Library. To do this, you must alter all the notices that refer to this License, so that they refer to the ordinary GNU General Public License, version 2, instead of to this License. (If a newer version than version 2 of the ordinary GNU General Public License has appeared, then you

can specify that version instead if you wish.) Do not make any other change in these notices.

Once this change is made in a given copy, it is irreversible for that copy, so the ordinary GNU General Public License applies to all subsequent copies and derivative works made from that copy.

This option is useful when you wish to copy part of the code of the Library into a program that is not a library.

4. You may copy and distribute the Library (or a portion or derivative of it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you accompany

it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange.

If distribution of object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place satisfies the requirement to

distribute the source code, even though third parties are not compelled to copy the source along with the object code.

5. A program that contains no derivative of any portion of the Library, but is designed to work with the Library by being compiled or linked with it, is called a "work that uses the Library". Such a

work, in isolation, is not a derivative work of the Library, and therefore falls outside the scope of this License.

However, linking a "work that uses the Library" with the Library creates an executable that is a derivative of the Library (because it contains portions of the Library), rather than a "work that uses the library". The executable is therefore covered by this License.

Section 6 states terms for distribution of such executables.

When a "work that uses the Library" uses material from a header file that is part of the Library, the object code for the work may be a derivative work of the Library even though the source code is not. Whether this is true is especially significant if the work can be linked without the Library, or if the work is itself a library. The threshold for this to be true is not precisely defined by law.

If such an object file uses only numerical parameters, data structure layouts and accessors, and small macros and small inline functions (ten lines or less in length), then the use of the object

file is unrestricted, regardless of whether it is legally a derivative work. (Executables containing this object code plus portions of the Library will still fall under Section 6.)

Otherwise, if the work is a derivative of the Library, you may distribute the object code for the work under the terms of Section 6. Any executables containing that work also fall under Section 6,

whether or not they are linked directly with the Library itself.

6. As an exception to the Sections above, you may also combine or link a "work that uses the Library" with the Library to produce a work containing portions of the Library, and distribute that work

under terms of your choice, provided that the terms permit modification of the work for the customer's own use and reverse engineering for debugging such modifications.

You must give prominent notice with each copy of the work that the Library is used in it and that the Library and its use are covered by this License. You must supply a copy of this License. If the work during execution displays copyright notices, you must include the copyright notice for the Library among them, as well as a reference directing the user to the copy of this License. Also, you must do one of these things:

a) Accompany the work with the complete corresponding machine-readable source code for the Library including whatever changes were used in the work (which must be distributed under Sections 1 and 2 above); and, if the work is an executable linked with the Library, with the complete machine-readable "work that uses the Library", as object code and/or source code, so that the user can modify the Library and then relink to produce a modified executable containing the modified Library. (It is understood that the user who changes the contents of definitions files in the Library will not necessarily be able to recompile the application to use the modified definitions.)

b) Use a suitable shared library mechanism for linking with the Library. A suitable mechanism is one that (1) uses at run time a copy of the library already present on the user's computer system,

rather than copying library functions into the executable, and (2) will operate properly with a modified version of the library, if the user installs one, as long as the modified version is interface-compatible with the version that the work was made with.

c) Accompany the work with a written offer, valid for at least three years, to give the same user the materials specified in Subsection 6a, above, for a charge no more than the cost of performing this distribution.

d) If distribution of the work is made by offering access to copy from a designated place, offer equivalent access to copy the above specified materials from the same place.

e) Verify that the user has already received a copy of these materials or that you have already sent this user a copy.

For an executable, the required form of the "work that uses the Library" must include any data and utility programs needed for reproducing the executable from it. However, as a special exception,

the materials to be distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on

which the executable runs, unless that component itself accompanies the executable.

It may happen that this requirement contradicts the license restrictions of other proprietary libraries that do not normally accompany the operating system. Such a contradiction means you cannot

use both them and the Library together in an executable that you distribute.

7. You may place library facilities that are a work based on the Library side-by-side in a single library together with other library facilities not covered by this License, and distribute such a combined library, provided that the separate distribution of the work based on the Library and of the other library facilities is otherwise permitted, and provided that you do these two things:

a) Accompany the combined library with a copy of the same work based on the Library, uncombined with any other library facilities. This must be distributed under the terms of the Sections above.

b) Give prominent notice with the combined library of the fact that part of it is a work based on the Library, and explaining where to find the accompanying uncombined form of the same work.

8. You may not copy, modify, sublicense, link with, or distribute the Library except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, link with, or distribute the Library is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

9. You are not required to accept this License, since you have not signed it. However, nothing else grants you permission to modify or distribute the Library or its derivative works. These actions are prohibited by law if you do not accept this License. Therefore, by modifying or distributing the Library (or any work based on the Library), you indicate your acceptance of this License to do so, and all its terms and conditions for copying, distributing or modifying the Library or works based on it.

10. Each time you redistribute the Library (or any work based on the Library), the recipient automatically receives a license from the original licensor to copy, distribute, link with or modify the Library subject to these terms and conditions. You may not impose any further restrictions on the recipients' exercise of the rights granted herein.

You are not responsible for enforcing compliance by third parties with this License.

11. If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Library at all. For example, if a patent license would not permit royalty-free redistribution of the Library by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Library.

If any portion of this section is held invalid or unenforceable under any particular circumstance, the balance of the section is intended to apply, and the section as a whole is intended to apply in other circumstances.

It is not the purpose of this section to induce you to infringe any patents or other property right claims or to contest validity of any such claims; this section has the sole purpose of protecting the

integrity of the free software distribution system which is implemented by public license practices. Many people have made generous contributions to the wide range of software distributed through that system in reliance on consistent application of that system; it is up to the author/donor to decide if he or she is willing to distribute software through any other system and a licensee cannot

impose that choice.

This section is intended to make thoroughly clear what is believed to be a consequence of the rest of this License.

12. If the distribution and/or use of the Library is restricted in certain countries either by patents or by copyrighted interfaces, the original copyright holder who places the Library under this License may add an explicit geographical distribution limitation excluding those countries, so that distribution is permitted only in or among countries not thus excluded. In such case, this License incorporates the limitation as if written in the body of this License.

13. The Free Software Foundation may publish revised and/or new versions of the Lesser General Public License from time to time.

Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Library specifies a version number of this License which applies to it and "any later version", you have the option of following the terms and conditions either of that version or of any later version published by the Free Software Foundation. If the Library does not specify a license version number, you may choose any version ever published by the Free Software Foundation.

14. If you wish to incorporate parts of the Library into other free programs whose distribution conditions are incompatible with these, write to the author to ask for permission. For software which is

copyrighted by the Free Software Foundation, write to the Free Software Foundation; we sometimes make exceptions for this. Our decision will be guided by the two goals of preserving the free status

of all derivatives of our free software and of promoting the sharing and reuse of software generally.

NO WARRANTY

15. BECAUSE THE LIBRARY IS LICENSED FREE OF CHARGE, THERE IS NO WARRANTY FOR THE LIBRARY, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE LIBRARY "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE LIBRARY IS WITH YOU. SHOULD THE LIBRARY PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

16. IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MAY MODIFY AND/OR REDISTRIBUTE THE LIBRARY AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE LIBRARY (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING

RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE LIBRARY TO OPERATE WITH ANY OTHER SOFTWARE), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Libraries

If you develop a new library, and you want it to be of the greatest possible use to the public, we recommend making it free software that everyone can redistribute and change. You can do so by permitting redistribution under these terms (or, alternatively, under the terms of the ordinary General Public License).

To apply these terms, attach the following notices to the library. It is safest to attach them to the start of each source file to most effectively convey the exclusion of warranty; and each file should have at least the "copyright" line and a pointer to where the full notice is found.

<one line to give the library's name and a brief idea of what it does.>

Copyright (C) <year> <name of author>

This library is free software; you can redistribute it and/or modify it under the terms of the GNU Lesser General Public License as published by the Free Software Foundation; either version 2.1 of the License, or (at your option) any later version.

This library is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU

Lesser General Public License for more details.

You should have received a copy of the GNU Lesser General Public License along with this library; if not, write to the Free Software Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301

Also add information on how to contact you by electronic and paper mail.

You should also get your employer (if you work as a programmer) or your school, if any, to sign a "copyright disclaimer" for the library, if necessary. Here is a sample; alter the names:

Yoyodyne, Inc., hereby disclaims all copyright interest in the library `Frob' (a library for tweaking knobs) written by James Random Hacker.

<signature of Ty Coon>, 1 April 1990

Ty Coon, President of Vice

That's all there is to it!

Software: JSON-C

Copyright notice:

Copyright (c) 2004, 2005 Metaparadigm Pte. Ltd.

Copyright (c) 2009-2012 Eric Haszlakiewicz

Copyright (c) 2004, 2005 Metaparadigm Pte Ltd

Copyright (c) 2009 Hewlett-Packard Development Company, L.P.

Copyright 2011, John Resig

Copyright 2011, The Dojo Foundation

Copyright (c) 2012 Eric Haszlakiewicz

Copyright (c) 2009-2012 Hewlett-Packard Development Company, L.P.

Copyright (c) 2008-2009 Yahoo! Inc. All rights reserved.

Copyright (C) 1996, 1997, 1998, 1999, 2000, 2001, 2003, 2004, 2005, 2006,

2007, 2008, 2009, 2010, 2011 Free Software Foundation, Inc.

Copyright (c) 2013 Metaparadigm Pte. Ltd.

License: MIT License

Copyright (c) 2009-2012 Eric Haszlakiewicz

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

Copyright (c) 2004, 2005 Metaparadigm Pte Ltd

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

Software: proj

Copyright notice:

"Copyright (C) 2010 Mateusz Loskot <mateusz@loskot.net>

Copyright (C) 2007 Douglas Gregor <doug.gregor@gmail.com>

Copyright (C) 2007 Troy Straszheim

CMake, Copyright (C) 2009-2010 Mateusz Loskot <mateusz@loskot.net>)

Copyright (C) 2011 Nicolas David <nicolas.david@ign.fr>

Copyright (c) 2000, Frank Warmerdam

Copyright (c) 2011, Open Geospatial Consortium, Inc.

Copyright (C) 1996, 1997, 1998, 1999, 2000, 2001, 2003, 2004, 2005, 2006,

2007, 2008, 2009, 2010, 2011 Free Software Foundation, Inc.

Copyright (c) Charles Karney (2012-2015) <charles@karney.com> and licensed

Copyright (c) 2005, Antonello Andrea

Copyright (c) 2010, Frank Warmerdam

Copyright (c) 1995, Gerald Evenden

Copyright (c) 2000, Frank Warmerdam <warmerdam@pobox.com>

Copyright (c) 2010, Frank Warmerdam <warmerdam@pobox.com>

Copyright (c) 2013, Frank Warmerdam

Copyright (c) 2003 Gerald I. Evenden

Copyright (c) 2012, Frank Warmerdam <warmerdam@pobox.com>

Copyright (c) 2002, Frank Warmerdam

Copyright (c) 2004 Gerald I. Evenden

Copyright (c) 2012 Martin Raspaud

Copyright (c) 2001, Thomas Flemming, tf@ttqv.com

Copyright (c) 2002, Frank Warmerdam <warmerdam@pobox.com>

Copyright (c) 2009, Frank Warmerdam

Copyright (c) 2003, 2006 Gerald I. Evenden

Copyright (c) 2011, 2012 Martin Lambers <marlam@marlam.de>

Copyright (c) 2006, Andrey Kiselev

Copyright (c) 2008-2012, Even Rouault <even dot rouault at mines-paris dot org>

Copyright (c) 2001, Frank Warmerdam

Copyright (c) 2001, Frank Warmerdam <warmerdam@pobox.com>

Copyright (c) 2008 Gerald I. Evenden

"

License: MIT License

Please see above

Software: libxml2

Copyright notice:

"See Copyright for the status of this software.

Copyright (C) 1998-2003 Daniel Veillard. All Rights Reserved.

Copyright (C) 2003 Daniel Veillard.

copy: see Copyright for the status of this software.

copy: see Copyright for the status of this software

copy: see Copyright for the status of this software.

Copyright (C) 2000 Bjorn Reese and Daniel Veillard.

Copy: See Copyright for the status of this software.

See COPYRIGHT for the status of this software

Copyright (C) 2000 Gary Pennington and Daniel Veillard.

Copyright (C) 1996, 1997, 1998, 1999, 2000, 2001, 2003, 2004, 2005, 2006, 2007 Free Software Foundation, Inc.

Copyright (C) 1998 Bjorn Reese and Daniel Stenberg.

Copyright (C) 2001 Bjorn Reese <breese@users.sourceforge.net>

Copyright (C) 2000 Bjorn Reese and Daniel Stenberg.

Copyright (C) 2001 Bjorn Reese and Daniel Stenberg.

See Copyright for the status of this software

"

License: MIT License

Please see above

14 Resource Monitoring

GaussDB(DWS) provides multiple dimensional resource monitoring views to show the real-time and historical resource usage of tasks.

14.1 User Resource Monitoring

In the multi-tenant management framework, you can query the real-time usage of all user resources (including the memory, number of CPU cores, storage space, temporary space, operator spilling space, and I/Os) in real time through the system views **PG_TOTAL_USER_RESOURCE_INFO** and **PGXC_TOTAL_USER_RESOURCE_INFO** and the function **GS_WLM_USER_RESOURCE_INFO**. You can also query the system catalog **GS_WLM_USER_RESOURCE_HISTORY** and system view **PGXC_WLM_USER_RESOURCE_HISTORY** for the historical usage of user resources.

Precautions

- The CPU, I/O, and memory usage of all jobs on fast and slow lanes (simple jobs on fast lanes and complex jobs on slow lanes) can be monitored.
- Currently, the memory and CPU usage of fast track jobs are not controlled. When the fast lane jobs occupy a large number of resources, the used resources may exceed the resource limit.
- In the DN monitoring view, I/O, memory, and CPU display the resource usage and limits of resource pools.

- In the CN monitoring view, I/O, memory, and CPU display the total resource usage and limit of all DN resource pools in the cluster.
- The DN monitoring information is updated every 5 seconds. CNs collect monitoring information from DNs every 5 seconds. Because each instance updates or collects user monitoring information independently, the monitoring information update time on each instance may be different.
- The auxiliary thread automatically invokes the persistence function every 30 seconds to make user monitoring data persistent. So, normally, you don't have to do this.
- When there are a large number of users and a large cluster, querying such real-time views will cause network latency due to the real-time communication overhead between CNs and DNs.
- Resources are not monitored for an initial administrator.

Procedure

- Query all users' resource quotas and real-time resource usage.

```
SELECT * FROM PG_TOTAL_USER_RESOURCE_INFO;
```

  The result view is as follows:

```
username       | used_memory | total_memory | used_cpu | total_cpu | used_space | total_space |
used_temp_space | total_temp_space | used_spill_space | total_spill_space | read_kbytes | write_kbytes |
read_counts | write_counts | read_speed | write_speed | send_speed | recv_speed
----------------------+-------------+--------------+----------+-----------+------------+-------------
+-----------------+------------------+------------------+-------------------+-------------+--------------
+-------------+--------------+------------+-------------+------------+------------
perfadm            |          0 |          0 |       0 |        0 |        0 |         -1 |             0 |             -1
|              0 |             -1 |          0 |          0 |          0 |          0 |         0 |         0 |         0
|          0
usern              |          0 |      17250 |       0 |       48 |        0 |         -1 |             0 |             -1
|              0 |             -1 |          0 |          0 |          0 |          0 |         0 |         0 |         0
|          0
(2 rows)
```

  The I/O resource monitoring fields (**read_kbytes**, **write_kbytes**, **read_counts**, **write_counts**, **read_speed**, and **write_speed**) can be available only when the GUC parameter described in **enable_user_metric_persistent** is enabled.

  For details about each column, see **PG_TOTAL_USER_RESOURCE_INFO**.

- Query a user's resource quota and real-time resource usage.

```
SELECT * FROM GS_WLM_USER_RESOURCE_INFO('username');
```

  The query result is as follows:

```
userid | used_memory | total_memory | used_cpu | total_cpu | used_space | total_space |
used_temp_space | total_temp_space | used_spill_space | total_spill_space | read_kbytes | write_kbytes |
read_counts | write_counts | read_speed | write_speed | send_speed | recv_speed
--------+-------------+--------------+----------+-----------+------------+-------------+-----------------
+-----------------+------------------+------------------+-------------------+-------------+--------------
+-------------+--------------+------------+-------------+------------+------------
16407 |          18 |       1655 |       6 |         19 |         13787176 |         -1 |             0 |             -1
|              0 |             -1 |          0 |          0 |          0 |          0 |         0 |         0 |         0
|          0
(1 row)
```

- Query all users' resource quotas and historical resource usage.

```
SELECT * FROM GS_WLM_USER_RESOURCE_HISTORY;
```

  The query result is as follows:

```
username       |          timestamp          | used_memory | total_memory | used_cpu | total_cpu |
used_space | total_space | used_temp_space | total_temp_space | used_spill_space | total_spill_space |
read_kbytes | write_kbytes | read_counts | write_counts | read_speed  | write_speed | send_speed |
recv_speed
```



```
----------------------+------------------------------+-------------+--------------+----------+-----------
+------------+-------------+----------------+-----------------+-----------------+------------------
+------------+-------------+------------+-------------+------------+-------------+-----------+-----------
usern              | 2020-01-08 22:56:06.456855+08 |         0 |       17250 |        0 |       48 |        0
|         -1 |           0 |             -1 |        88349078 |             -1 |       45680 |        34 |       5710
|          8 |         320 |          0 |          0 |          0
userg              | 2020-01-08 22:56:06.458659+08 |         0 |       15525 |    33.48 |       48 |        0
|         -1 |           0 |             -1 |       110169581 |             -1 |       17648 |        23 |
2206 |          5 |         123 |          0 |          0 |          0
user1              | 2020-01-08 22:56:06.460252+08 |         0 |       13972 |    33.48 |       48 |        0
|         -1 |           0 |             -1 |       136106277 |             -1 |       17648 |        23 |
2206 |          5 |         123 |          0 |          0 |          0
```

For the system catalog **GS_WLM_USER_RESOURCE_HISTORY**, data in the **PG_TOTAL_USER_RESOURCE_INFO** view is periodically saved to historical tables only when the GUC parameter **enable_user_metric_persistent** is enabled.

For details about each column, see **GS_WLM_USER_RESOURCE_HISTORY**.

14.2 Resource Pool Monitoring

Overview

In the multi-tenant management framework, if queries are associated with resource pools, the resources occupied by the queries are summarized to the associated resource pools. You can query the real-time resource usage of all resource pools in the resource pool monitoring view and query the historical resource usage of resource pools in the resource pool monitoring history table.

The resource pool monitoring data is updated every 5s. However, due to the time difference between CNs and DNs, the actual monitoring data update time may be longer than 5s. Generally, the time does not exceed 10s. The resource pool monitoring data is persisted every 30 seconds. The resource pool monitoring logic is basically the same as that of the user resource monitoring. Therefore, the **enable_user_metric_persistent** and **user_metric_retention_time** parameters are used to control the persistence and aging of resource pool monitoring data, respectively.

Resources monitored by a resource pool include the running and queuing information of fast and slow lane jobs, and CPU, memory, and logical I/O resource monitoring information. The monitoring views and history tables are as follows:

- Real-time monitoring view of resource pools (single CN): **GS_RESPOOL_RUNTIME_INFO**
- Real-time monitoring view of resource pools (all CNs): **PGXC_RESPOOL_RUNTIME_INFO**
- Real-time monitoring view of resource pool resources (single CN): **GS_RESPOOL_RESOURCE_INFO**
- Real-time monitoring view of resource pool resources (all CNs): **PGXC_RESPOOL_RESOURCE_INFO**
- Historical resource monitoring table of the resource pool (single CN): **GS_RESPOOL_RESOURCE_HISTORY**
- Monitoring view of historical resource pool resources (all CNs): **PGXC_RESPOOL_RESOURCE_HISTORY**

NOTE

- Resource pool monitoring monitors the CPU, I/O, and memory usage of all jobs on the fast and slow lanes.
- Currently, the memory and CPU usage of fast track jobs are not controlled. When the fast lane jobs occupy a large number of resources, the used resources may exceed the resource limit.
- In the monitoring view of DN resource pools, I/O, memory, and CPU display the resource usage and limits of resource pools.
- In the monitoring view of CN resource pools, I/O, memory, and CPU display the total resource usage and limit of all DN resource pools in the cluster.
- Resource pool monitoring information on DNs is updated every 5 seconds. CNs collect resource pool monitoring information from DNs every 5 seconds. Because each instance updates or collects resource pool monitoring information independently, the monitoring information update time on each instance may be different.
- The auxiliary thread automatically invokes the persistence function every 30 seconds to make the resource pool monitoring data persistent. So, normally, you don't need to do this.

Procedure

- Querying the real-time running status of jobs in a resource pool.

```
SELECT * FROM GS_RESPOOL_RUNTIME_INFO;
```

The result view is as follows:

```
 nodegroup |     rpname     | ref_count | fast_run | fast_wait | slow_run | slow_wait
-----------+----------------+-----------+----------+-----------+----------+-----------
 vc1       | p2             |        10 |        0 |         0 |        0 |         0
 vc2       | p3             |        10 |        5 |         5 |        0 |         0
 vc2       | p4             |         0 |        0 |         0 |        0 |         0
 vc1       | default_pool |         0 |        0 |         0 |        0 |         0
 vc2       | default_pool |         0 |        0 |         0 |        0 |         0
 vc1       | p1             |        20 |        5 |         5 |        3 |         7
(6 rows)
```

Where,

a. **ref_count** indicates the number of jobs that reference the current resource pool information. Its value will be retained until the management ends.

b. **fast_run** and **slow_run** are load management accounting information. Their values are valid only when **fast_limit** and **slow_limit** are larger than **0**.

c. This view is valid only on CNs. The persistence information is stored in **GS_RESPOOL_RESOURCE_HISTORY**.

d. For details about each field, see **GS_RESPOOL_RUNTIME_INFO**.

- Querying the resource quota and real-time resource usage of a resource pool.

```
SELECT * FROM GS_RESPOOL_RESOURCE_INFO;
```

The result view is as follows:

```
nodegroup |     rpname     |       cgroup        | ref_count | fast_run | fast_wait | fast_limit | slow_run |
slow_wait | slow_limit | used_cpu | cpu_limit | used_mem | estimate_mem | mem_limit |read_kbytes |
write_kbytes | read_counts | write_counts | read_speed | write_speed | send_speed | recv_speed
-----------+----------------+---------------------+-----------+----------+-----------+------------+----------+
+-----------+------------+----------+-----------+----------+--------------+-----------+-------------+--------------
+-------------+--------------+------------+-------------+------------+------------
 vc1       | p2             | DefaultClass:Rush   |        10 |        0 |         0 |         -1 |        0 |         0 |         10
|      9.97 |         48 |       20 |           0 |     11555 |         8 |        2880 |           1 |         360 |         1
|         589 |          0 |          0
 vc2       | p3             | DefaultClass:Rush   |        10 |        5 |         5 |          5 |        0 |         0 |         10
```



```
|    4.98 |       48 |       11 |          0 |     11555 |         0 |         848 |          0 |         106 |         0
|         173 |         0 |         0
 vc2       | p4          | DefaultClass:Rush   |        0 |       0 |        0 |        -1 |       0 |       0 |        10
|        0 |       48 |       0 |          0 |     11555 |         0 |          0 |          0 |          0 |         0
|          0 |         0 |         0
 vc1       | default_pool | DefaultClass:Medium |        0 |       0 |        0 |        -1 |       0 |       0
|        -1 |       0 |       48 |       0 |          0 |     11555 |         0 |          0 |          0 |          0
|         0 |         0 |         0 |         0
 vc2       | default_pool | DefaultClass:Medium |        0 |       0 |        0 |        -1 |       0 |       0
|        -1 |       0 |       48 |       0 |          0 |     11555 |         0 |          0 |          0 |          0
|         0 |         0 |         0 |         0
 vc1       | p1          | DefaultClass:Rush   |       20 |       5 |        5 |         5 |       3 |       7 |         3
|    7.98 |       48 |       16 |         768 |     11555 |         8 |        2656 |          1 |         332 |         1
|         543 |         0 |         0
(6 rows)
```

a. This view is valid on both CNs and DNs. The CPU, memory, and I/O usage on a DN indicates the resource consumption of the DN. The CPU, memory, and I/O usage on a CN is the total resource consumption of all DNs in the cluster.

b. **estimate_mem** is valid only on CNs under dynamic load management. It displays the estimated memory accounting of the resource pool.

c. I/O monitoring information is recorded only when **enable_logical_io_statistics** is enabled.

d. For details about each field, see **GS_RESPOOL_RESOURCE_INFO**.

- Querying the resource quota and historical resource usage of a resource pool.

```
SELECT * FROM GS_RESPOOL_RESOURCE_HISTORY ORDER BY timestamp DESC;
```

The result view is as follows:

```
timestamp           | nodegroup   |     rpname    |      cgroup        | ref_count | fast_run | fast_wait |
fast_limit | slow_run | slow_wait | slow_limit | used_cpu | cpu_limit | used_mem | estimate_mem |
mem_limit | read_kbytes | write_kbytes | read_counts | write_counts | read_speed | write_speed |
send_speed | recv_speed
-------------------------------+-------------+-------------+--------------------+-----------+----------
+-----------+------------+----------+-----------+------------+----------+-----------+----------+--------------
+-----------+-------------+--------------+-------------+--------------+------------+-------------+------------
+------------
 2022-03-04 09:41:57.53739+08  | vc1         | p2          | DefaultClass:Rush  |        10 |        0 |         0
|        -1 |        0 |         0 |         10 |     9.97 |       48 |   20 |           0 |     11555 |          0 |
2320 |          0 |         290 |          0 |        474 |          0 |         0
 2022-03-04 09:41:57.53739+08  | vc1         | p1          | DefaultClass:Rush  |        20 |        5 |         5
|         5 |        3 |         7 |         3 |     7.98 |       48 |   16 |         768 |     11555 |          0 |
1896 |          0 |         237 |          0 |        387 |          0 |         0
 2022-03-04 09:41:57.53739+08  | vc2         | default_pool | DefaultClass:Medium |        0 |        0
|         0 |        -1 |        0 |         0 |        -1 |        0 |       48 |    0 |           0 |     11555 |          0
|           0 |          0 |           0 |          0 |          0 |          0 |          0
 2022-03-04 09:41:57.53739+08  | vc1         | default_pool | DefaultClass:Medium |        0 |        0
|         0 |        -1 |        0 |         0 |        -1 |        0 |       48 |    0 |           0 |     11555 |          0
|           0 |          0 |           0 |          0 |          0 |          0 |          0
 2022-03-04 09:41:57.53739+08  | vc2         | p4          | DefaultClass:Rush  |        0 |        0 |         0
|        -1 |        0 |         0 |         10 |        0 |       48 |    0 |           0 |     11555 |          0 |          0
|           0 |          0 |           0 |          0 |          0 |          0
 2022-03-04 09:41:57.53739+08  | vc2         | p3          | DefaultClass:Rush  |        10 |        5 |         5
|         5 |        0 |         0 |         10 |     4.99 |       48 |   11 |           0 |     11555 |          0 |        880
|           0 |          110 |          0 |         180 |          0 |          0
 2022-03-04 09:41:27.335234+08 | vc2         | p3          | DefaultClass:Rush  |        10 |        5 |         5
|         5 |        0 |         0 |         10 |     4.98 |       48 |   11 |           0 |     11555 |          0 |        856
|           0 |          107 |          0 |         175 |          0 |          0
```

a. The monitoring information comes from the resource pool monitoring history table. When **enable_user_metric_persistent** is enabled, the monitoring information is recorded every 30 seconds.

b. The storage duration of the table data is specified by the **user_metric_retention_time** parameter.

c. For details about each field, see **GS_RESPOOL_RESOURCE_HISTORY**.

14.3 Monitoring Memory Resources

Monitoring the Memory

GaussDB(DWS) provides a view for monitoring the memory usage of the entire cluster.

Query the pgxc_total_memory_detail view as a user with sysadmin permissions.

```
SELECT * FROM pgxc_total_memory_detail;
```

If the following error message is returned during the query, enable the memory management function.

```
SELECT * FROM pgxc_total_memory_detail;
ERROR:  unsupported view for memory protection feature is disabled.
CONTEXT:  PL/pgSQL function pgxc_total_memory_detail() line 12 at FOR over EXECUTE statement
```

You can set **enable_memory_limit** and **max_process_memory** on the GaussDB(DWS) console to enable memory management. The procedure is as follows:

1. Log in to the GaussDB(DWS) management console.
2. In the navigation pane on the left, click **Clusters**.
3. In the cluster list, find the target cluster and click its name. The **Basic Information** page is displayed.
4. Click the **Parameter Modification** tab, change the value of **enable_memory_limit** to **on**, and click **Save** to save the file.
5. Change the value of **max_process_memory** to a proper one. For details about the modification suggestions, see **max_process_memory**. After it is done, click **Save**.
6. In the **Modification Preview** dialog box, confirm the modifications and click **Save**. After the modification, restart the cluster for the modification to take effect.

Monitoring the Shared Memory

You can query the context information about the shared memory on the pg_shared_memory_detail view.

```
SELECT * FROM pg_shared_memory_detail;
          contextname          | level |             parent              | totalsize | freesize | usedsize
-------------------------------+-------+---------------------------------+-----------+----------+----------
 ProcessMemory                 |     0 |                                 |     24576 |     9840 |    14736
 Workload manager memory context |     1 | ProcessMemory                   |   2105400 |     7304 |  2098096
 wlm collector hash table      |     2 | Workload manager memory context |      8192 |     3736 |     4456
 Resource pool hash table      |     2 | Workload manager memory context |     24576 |    15968 |     8608
 wlm cgroup hash table         |     2 | Workload manager memory context |     24576 |    15968 |     8608
(5 rows)
```

This view lists the context name of the memory, level, the upper-layer memory context, and the total size of the shared memory.

In the database, GUC parameter **memory_tracking_mode** is used to configure the memory statistics collecting mode, including the following options:

- **none:** The memory statistics collecting function is not enabled.
- **normal:** Only memory statistics is collected in real time and no file is generated.
- **executor:** The statistics file is generated, containing the context information about all allocated memory used on the execution layer.

  When the parameter is set to **executor**, cvs files are generated under the **pg_log** directory of the DN process. The file names are in the format of **memory_track**_*<DN name>*_**query**_*<queryid>***.csv**. The information about the operators executed by the postgres thread of the executor and all stream threads are input in this file during task execution.

  The instance is built with a file content similar to the following:

  ```
  0, 0, ExecutorState, 0, PortalHeapMemory, 0, 40K, 602K, 23
  1, 3, CStoreScan_29360131_25, 0, ExecutorState, 1, 265K, 554K, 23
  2, 128, cstore scan per scan memory context, 1, CStoreScan_29360131_25, 2, 24K, 24K, 23
  3, 127, cstore scan memory context, 1, CStoreScan_29360131_25, 2, 264K, 264K, 23
  4, 7, InitPartitionMapTmpMemoryContext, 1, CStoreScan_29360131_25, 2, 31K, 31K, 23
  5, 2, VecPartIterator_29360131_24, 0, ExecutorState, 1, 16K, 16K, 23
  0, 0, ExecutorState, 0, PortalHeapMemory, 0, 24K, 1163K, 20
  1, 3, CStoreScan_29360131_22, 0, ExecutorState, 1, 390K, 1122K, 20
  2, 20, cstore scan per scan memory context, 1, CStoreScan_29360131_22, 2, 476K, 476K, 20
  3, 19, cstore scan memory context, 1, CStoreScan_29360131_22, 2, 264K, 264K, 20
  4, 7, InitPartitionMapTmpMemoryContext, 1, CStoreScan_29360131_22, 2, 23K, 23K, 20
  5, 2, VecPartIterator_29360131_21, 0, ExecutorState, 1, 16K, 16K, 20
  ```

  The fields include the output SN, SN of the memory allocation context within the thread, name of the current memory context, output SN of the parent memory context, name of the parent memory context, tree layer No. of the memory context, peak memory used by the current memory context, peak memory used by the current memory context and all its child memory contexts, and plan node ID of the query where the thread is executed.

  In this example, the record "1, 3, CStoreScan_29360131_22, 0, ExecutorState, 1, 390K, 1122K, 20" represents the following information about Explain Analyze:

  - **CstoreScan_29360131_22** indicates the CstoreScan operator.
  - **1122K** indicates the peak memory used by the CstoreScan operator.
- **fullexec:** The generated file includes the information about all memory contexts requested by the execution layer.

  If the parameter is set to **fullexec**, the output information will be similar to that for **executor**, except that some memory context allocation information may be returned because the information about all memory applications (no matter succeeded or not) is printed. As only the memory application information is recorded, the peak memory used by the memory context is recorded as **0**.

14.4 Instance Resource Monitoring

GaussDB(DWS) provides system catalogs for monitoring the resource usage of CNs and DNs (including memory, CPU usage, disk I/O, process physical I/O, and process logical I/O), and system catalogs for monitoring the resource usage of the entire cluster.

For details about the system catalog **GS_WLM_INSTANCE_HISTORY**, see **GS_WLM_INSTANCE_HISTORY**.

NOTE

Data in the system catalog**GS_WLM_INSTANCE_HISTORY** is distributed in corresponding instances. CN monitoring data is stored in the CN instance, and DN monitoring data is stored in the DN instance. The DN has a standby node. When the primary DN is abnormal, the monitoring data of the DN can be restored from the standby node. However, a CN has no standby node. When a CN is abnormal and then restored, the monitoring data of the CN will be lost.

Procedure

- Query the latest resource usage of the current instance.

```
SELECT * FROM GS_WLM_INSTANCE_HISTORY ORDER BY TIMESTAMP DESC;
```

The query result is as follows:

```
instancename |           timestamp           | used_cpu | free_mem | used_mem | io_await | io_util  |
disk_read | disk_write | process_read | process_write | logical_read | logical_write | read_counts |
write_counts
-------------+-------------------------------+----------+----------+----------+----------+----------+-----------
+------------+--------------+---------------+--------------+---------------+-------------+--------------
dn_6015_6016 | 2022-01-10 17:29:17.329495+08 |        0 |    14570 |     8982 |  662.923 |  99.9601 |
697666 |    93655.5 |       183104 |         30082 |       285659 |         30079 |      357717 |        37667
dn_6015_6016 | 2022-01-10 17:29:07.312049+08 |        0 |    14578 |     8974 |  883.102 |  99.9801 |
756228 |    81417.4 |       189722 |         30786 |       285681 |         30780 |      358103 |        38584
dn_6015_6016 | 2022-01-10 17:28:57.284472+08 |        0 |    14583 |     8969 |  727.135 |  99.9801 |
648581 |    88799.6 |       177120 |         31176 |       252161 |         31175 |      316085 |        39079
dn_6015_6016 | 2022-01-10 17:28:47.256613+08 |        0 |    14591 |     8961 |  679.534 |   100.08 |
655360 |     169962 |       179404 |         30424 |       242002 |         30422 |      303351 |        38136
```

- Query the resource usage of the current instance during a specified period.

```
SELECT * FROM GS_WLM_INSTANCE_HISTORY WHERE TIMESTAMP > '2022-01-10' AND TIMESTAMP
< '2020-01-11' ORDER BY TIMESTAMP DESC;
```

The query result is as follows:

```
instancename |           timestamp           | used_cpu | free_mem | used_mem | io_await | io_util  |
disk_read | disk_write | process_read | process_write | logical_read | logical_write | read_counts |
write_counts
-------------+-------------------------------+----------+----------+----------+----------+----------+-----------
+------------+--------------+---------------+--------------+---------------+-------------+--------------
dn_6015_6016 | 2022-01-10 17:29:17.329495+08 |        0 |    14570 |     8982 |  662.923 |  99.9601 |
697666 |    93655.5 |       183104 |         30082 |       285659 |         30079 |      357717 |        37667
dn_6015_6016 | 2022-01-10 17:29:07.312049+08 |        0 |    14578 |     8974 |  883.102 |  99.9801 |
756228 |    81417.4 |       189722 |         30786 |       285681 |         30780 |      358103 |        38584
dn_6015_6016 | 2022-01-10 17:28:57.284472+08 |        0 |    14583 |     8969 |  727.135 |  99.9801 |
648581 |    88799.6 |       177120 |         31176 |       252161 |         31175 |      316085 |        39079
dn_6015_6016 | 2022-01-10 17:28:47.256613+08 |        0 |    14591 |     8961 |  679.534 |   100.08 |
655360 |     169962 |       179404 |         30424 |       242002 |         30422 |      303351 |        38136
```

- To query the latest resource usage of a cluster, you can invoke the **pgxc_get_wlm_current_instance_info** stored procedure on the CN.

```
SELECT * FROM pgxc_get_wlm_current_instance_info('ALL');
```

The query result is as follows:

```
instancename |           timestamp           | used_cpu | free_mem | used_mem | io_await | io_util |
disk_read | disk_write | process_read | process_write | logical_read | logical_write | read_counts |
write_counts
-------------+-------------------------------+----------+----------+----------+----------+---------+-----------
+------------+--------------+---------------+--------------+---------------+-------------+--------------
coordinator2 | 2020-01-14 21:58:29.290894+08 |        0 |    12010 |      278 |  16.0445 | 7.19561 |
184.431 |    27959.3 |           0 |           10 |           0 |           0 |           0 |           0
coordinator3 | 2020-01-14 21:58:27.567655+08 |        0 |    12000 |      288 |  .964557 | 3.40659 |
332.468 |    3375.02 |          26 |           13 |           0 |           0 |           0 |           0
datanode1    | 2020-01-14 21:58:23.900321+08 |        0 |    11899 |      389 |  1.17296 |    3.25 |
329.6 |    2870.4 |          28 |            8 |          13 |           3 |          18 |           6
datanode2    | 2020-01-14 21:58:32.832989+08 |        0 |    11904 |      384 |   17.948 | 8.52148 |
214.186 |    25894.1 |          28 |           10 |          13 |           3 |          18 |           6
datanode3    | 2020-01-14 21:58:24.826694+08 |        0 |    11894 |      394 |  1.16088 |    3.15 |      328
```



```
|    2868.8 |          25 |          10 |          13 |           3 |          18 |           6
coordinator1 | 2020-01-14 21:58:33.367649+08 |       0 |    11988 |      300 |  9.53286 |   10.05 |
43.2 |      55232 |           0 |           0 |           0 |           0 |          0 |           0
coordinator1 | 2020-01-14 21:58:23.216645+08 |       0 |    11988 |      300 |  1.17085 | 3.21182 |
324.729 |    2831.13 |           8 |          13 |           0 |           0 |          0 |           0
(7 rows)
```

- To query historical resource usage of a cluster, you can invoke the **pgxc_get_wlm_current_instance_info** stored procedure on the CN.

  ```
  SELECT * FROM pgxc_get_wlm_history_instance_info('ALL', '2020-01-14 21:00:00', '2020-01-14
  22:00:00', 3);
  ```

  The query result is as follows:

  ```
  instancename |           timestamp           | used_cpu | free_mem | used_mem | io_await |  io_util  |
  disk_read | disk_write | process_read | process_write | logical_read | logical_write | read_counts |
  write_counts
  -------------+-------------------------------+----------+----------+----------+----------+-----------+-----------
  +------------+-------------+--------------+---------------+--------------+---------------+-------------+--------------
  coordinator2 | 2020-01-14 21:50:49.778902+08 |        0 |    12020 |      268 |  .127371 |   .789211 |
  15.984 |    3994.41 |           0 |           0 |           0 |           0 |          0 |           0
  coordinator2 | 2020-01-14 21:53:49.043646+08 |        0 |    12018 |      270 |  30.2902 |   8.65404 |
  276.77 |    16741.8 |           3 |           1 |           0 |           0 |          0 |           0
  coordinator2 | 2020-01-14 21:57:09.202654+08 |        0 |    12018 |      270 |   .16051 |   .979021 |
  59.9401 |       5596 |           0 |           0 |           0 |           0 |          0 |           0
  coordinator3 | 2020-01-14 21:38:48.948646+08 |        0 |    12012 |      276 | .0769231 | .00999001
  |         0 |    35.1648 |           0 |           1 |           0 |           0 |          0 |           0
  coordinator3 | 2020-01-14 21:40:29.061178+08 |        0 |    12012 |      276 |  .118421 |   .0199601
  |         0 |    970.858 |           0 |           0 |           0 |           0 |          0 |           0
  coordinator3 | 2020-01-14 21:50:19.612777+08 |        0 |    12010 |      278 |   24.411 |   11.7665 |
  8.78244 |    44641.1 |           0 |           0 |           0 |           0 |          0 |           0
  datanode1    | 2020-01-14 21:49:42.758649+08 |        0 |    11909 |      379 |  .798776 |      8.02 |
  51.2 |    20924.8 |           0 |           0 |           0 |           0 |          0 |           0
  datanode1    | 2020-01-14 21:49:52.760188+08 |        0 |    11909 |      379 |  23.8972 |      14.1 |
  0 |      74760 |           0 |           0 |           0 |           0 |          0 |           0
  datanode1    | 2020-01-14 21:50:22.769226+08 |        0 |    11909 |      379 |  39.5868 |       7.4 |        0
  |    19760.8 |           0 |           0 |           0 |           0 |          0 |           0
  datanode2    | 2020-01-14 21:58:02.826185+08 |        0 |    11905 |      383 |  .351648 |       .32 |
  20.8 |      504.8 |           0 |           0 |           0 |           0 |          0 |           0
  datanode2    | 2020-01-14 21:56:42.80793+08  |        0 |    11906 |      382 |  .559748 |       .04 |        0
  |      326.4 |           0 |           0 |           0 |           0 |          0 |           0
  datanode2    | 2020-01-14 21:45:21.632407+08 |        0 |    11901 |      387 |  12.1313 |   4.55544 |
  3.1968 |    45177.2 |           0 |           0 |           0 |           0 |          0 |           0
  datanode3    | 2020-01-14 21:58:14.823317+08 |        0 |    11898 |      390 |  .378205 |       .99 |
  48 |    23353.6 |           0 |           0 |           0 |           0 |          0 |           0
  datanode3    | 2020-01-14 21:47:50.665028+08 |        0 |    11901 |      387 |  1.07494 |       1.19 |
  0 |    15506.4 |           0 |           0 |           0 |           0 |          0 |           0
  datanode3    | 2020-01-14 21:51:21.720117+08 |        0 |    11903 |      385 |  10.2795 |       3.11 |
  0 |    11031.2 |           0 |           0 |           0 |           0 |          0 |           0
  coordinator1 | 2020-01-14 21:42:59.121945+08 |        0 |    12020 |      268 | .0857143 | .0699301
  |         0 |    6579.02 |           0 |           0 |           0 |           0 |          0 |           0
  coordinator1 | 2020-01-14 21:41:49.042646+08 |        0 |    12020 |      268 |  20.9039 |   11.3786 |
  6042.76 |    57903.7 |           0 |           0 |           0 |           0 |          0 |           0
  coordinator1 | 2020-01-14 21:41:09.007652+08 |        0 |    12020 |      268 | .0446429 |    .03996 |
  0 |    1109.29 |           0 |           0 |           0 |           0 |          0 |           0
  (18 rows)
  ```

14.5 Real-time Top SQL

You can query real-time Top SQL in real-time resource monitoring views at different levels. The real-time resource monitoring view records the resource usage (including memory, data spilled to disks, and CPU time) and performance alarm information during job running.

The following table describes the external interfaces of the real-time views.

Table 14-1 Real-time resource monitoring views

Level	Monitored Node	View
Query level/perf level	Current CN	GS_WLM_SESSION_STATISTICS
	All CNs	PGXC_WLM_SESSION_STATISTICS
operator level	Current CN	GS_WLM_OPERATOR_STATISTICS
	All CNs	PGXC_WLM_OPERATOR_STATISTICS

NOTE

- The view level is determined by the resource monitoring level, that is, the **resource_track_level** configuration.
- The perf and operator levels affect the values of the **query_plan** and **warning** columns in **GS_WLM_SESSION_STATISTICS**/**PGXC_WLM_SESSION_INFO**. For details, see **SQL Self-Diagnosis**.
- Prefixes **gs** and **pgxc** indicate views showing single CN information and those showing cluster information, respectively. Common users can log in to a CN in the cluster to query only views with the **gs** prefix.
- When you query this type of views, there will be network latency, because the views obtain resource usage in real time.
- If an instance fault occurs, some Top SQL statement information may fail to be recorded in real-time resource monitoring views.
- Top SQL statements are recorded in real-time resource monitoring views as follows:
  - Special DDL statements, such as **SET**, **RESET**, **SHOW**, **ALTER SESSION SET**, and **SET CONSTRAINTS**, are not recorded.
  - DDL statements, such as **CREATE**, **ALTER**, **DROP**, **GRANT**, **REVOKE**, and **VACUUM**, are recorded.
  - DML statements are recorded, including:
    - the execution of **SELECT**, **INSERT**, **UPDATE**, and **DELETE**
    - the execution of **EXPLAIN ANALYZE** and **EXPLAIN PERFORMANCE**
    - the use of the query-level or perf-level views
  - The entry statements for invoking functions and stored procedures are recorded. When the GUC parameter **enable_track_record_subsql** is enabled, some internal statements (except the **DECLARE** definition statement) of a stored procedure can be recorded. Only the internal statements delivered to DNs for execution are recorded, and the remaining internal statements are filtered out.
  - The anonymous block statement is recorded. When the GUC parameter **enable_track_record_subsql** is enabled, some internal statements of an anonymous block can be recorded. Only the internal statements delivered to DNs for execution are recorded, and the remaining internal statements are filtered out.
  - The cursor statements are recorded. If a cursor does not read data from the cache but triggers the condition for delivering the statement to a DN for execution, the cursor statement is recorded and the statement and execution plan are enhanced. However, if the cursor reads data from the cache, the cursor statement is not recorded. When a cursor statement is used in an anonymous block or function and the cursor reads a large amount of data from a DN but is not fully used, the monitoring information about the cursor on the DN cannot be recorded due to the current architecture limitation. The **With Hold** cursor syntax has a special execution logic. It executes queries during transaction committing. If a statement execution error is reported during this period of time, the **aborted** status of the job cannot be recorded in the TopSQL history table.
  - Jobs in a redistribution process are not monitored.
  - The parameters of a statement with placeholders executed by JDBC are generally specified. However, if the length of the parameter and the original statement exceeds 64 KB, the parameter is not recorded. If the statement is a lightweight statement, it is directly delivered to the DN for execution and the parameter is not recorded.
  - In cluster 8.1.3 and later versions, the TopSQL monitoring at the query and perf levels does not affect the query performance. The default value of the GUC parameter **resource_track_cost** for resource monitoring of statements has been changed to **0**. When you query the TopSQL real-time monitoring view, by default, all statements that are being executed are displayed.
  - In 8.1.3 and later versions, if the GUC parameter **enable_track_record_subsql** for querying the TopSQL monitoring view is enabled, regardless of whether the

substatement monitoring function is enabled in the service statements, you can view the substatement running information in the TopSQL monitoring view.

- You are advised not to fully enable substatement monitoring in stored procedures, that is, **enable_track_record_subsql**, in the 8.1.3 cluster version. Because the substatements cannot be filtered by time, fully enabling substatement monitoring may record too many substatements. As a result, archived monitoring tables occupy a large amount of disk space. In the 8.1.3 cluster version, you are advised to enable only the parameters in the corresponding session when querying real-time monitoring information or locating and analyzing some stored procedures. In 8.2.1, the GUC parameter **resource_track_subsql_duration** is added. The default value is 180 seconds. You can use this parameter to filter substatements to be archived by execution time. The parameter can be adjusted.
- Due to specification restrictions, the records of the main statements that are not written to disks in the TopSQL history table are delayed. The records are displayed in the TopSQL history table only when the job is delivered next time.
- The **spill_size** field at the query level (job monitoring) and operator level (operator monitoring) varies due to the statistical dimension. The spill size at the query level is the statement files spilled to disks, and the spill size at the operator level is the read and write I/O volume of a specific operator at the logical layer.
- When the GUC parameter **enable_stream_operator** is set to off, the displayed operator execution information may be inaccurate.

Prerequisites

- The GUC parameter **enable_resource_track** is set to **on**. The default value is **on**.
- The GUC parameter **resource_track_level** is set to **query**, **perf** or **operator**. The default value is **query**.
- Job monitoring rules are as follows:
  - Jobs whose execution cost estimated by the optimizer is greater than or equal to **resource_track_cost**.
- If the Cgroups function is properly loaded, you can run the **gs_cgroup -P** command to view information about Cgroups.
- The GUC parameter **enable_track_record_subsql** specifies whether to record internal statements of a stored procedure or anonymous block.

In the preceding prerequisites, **enable_resource_track** is a system-level parameter that specifies whether to enable resource monitoring. **resource_track_level** is a session-level parameter. You can set the resource monitoring level of a session as needed. The following table describes the values of the two parameters.

Table 14-2 Setting the resource monitoring level to collect statistics

enable_resource_track	resource_track_level	Query-Level Information	Operator-Level Information
on(default)	none	Not collected	Not collected
	query(default)	Collected	Not collected
	perf	Collected	Not collected
	operator	Collected	Collected

enable_resource_track	resource_track_level	Query-Level Information	Operator-Level Information
off	none/query/ operator	Not collected	Not collected

Procedure

Step 1 Query for the real-time CPU information in the **gs_session_cpu_statistics** view.

```
SELECT * FROM gs_session_cpu_statistics;
```

Step 2 Query for the real-time memory information in the **gs_session_memory_statistics** view.

```
SELECT * FROM gs_session_memory_statistics;
```

Step 3 Query for the real-time resource information about the current CN in the **gs_wlm_session_statistics** view.

```
SELECT * FROM gs_wlm_session_statistics;
```

Step 4 Query for the real-time resource information about all CNs in the **pgxc_wlm_session_statistics** view.

```
SELECT * FROM pgxc_wlm_session_statistics;
```

Step 5 Query for the real-time resource information about job operators on the current CN in the **gs_wlm_operator_statistics** view.

```
SELECT * FROM gs_wlm_operator_statistics;
```

Step 6 Query for the real-time resource information about job operators on all CNs in the **pgxc_wlm_operator_statistics** view.

```
SELECT * FROM pgxc_wlm_operator_statistics;
```

Step 7 Query for the load management information about the jobs executed by the current user in the **PG_SESSION_WLMSTAT** view.

```
SELECT * FROM pg_session_wlmstat;
```

Step 8 Query the job execution status of the current user on each CN in the **pgxc_wlm_workload_records** view (this view is available when the dynamic load function is enabled, that is, **enable_dynamic_workload** is set to **on**).

```
SELECT * FROM pgxc_wlm_workload_records;
```

----End

14.6 Historical Top SQL

You can query historical Top SQL in historical resource monitoring views. The historical resource monitoring view records the resource usage (including memory, data spilled to disks, and CPU time), running status (including errors, termination, and exceptions), and performance alarm information when a job is complete. For queries that abnormally terminate due to FATAL or PANIC errors, their status is displayed as **aborted** and no detailed information is recorded. Status information about query parsing in the optimization phase cannot be monitored.

The following table describes the external interfaces of the historical views.

Level	Monitored Node	View	
Query/perf (recommended)	Current CN	History (Internal dump interface. Only statements that have ended in the last three minutes are displayed.)	GS_WLM_SESSION_HISTORY
		History (all statements)	GS_WLM_SESSION_INFO
	All CNs	History (Internal dump interface. Only statements that have ended in the last three minutes are displayed.)	PGXC_WLM_SESSION_HISTORY
		History (all statements)	PGXC_WLM_SESSION_INFO
Operator level	Current CN	History (Only statements that have ended in the last three minutes are displayed.)	GS_WLM_OPERATOR_HISTORY
		History (internal dump interface, all statements)	GS_WLM_OPERARROR_INFO
	All CNs	History (Only statements that have ended in the last three minutes are displayed.)	PGXC_WLM_OPERATOR_HISTORY
		History (internal dump interface, all statements)	PGXC_WLM_OPERATOR_INFO

NOTE

- The view level is determined by the resource monitoring level, that is, the **resource_track_level** configuration.
- The perf and operator levels affect the values of the **query_plan** and **warning** columns in **GS_WLM_SESSION_STATISTICS**/**PGXC_WLM_SESSION_INFO**. For details, see **SQL Self-Diagnosis**.
- Prefixes **gs** and **pgxc** indicate views showing single CN information and those showing cluster information, respectively. Common users can log in to a CN in the cluster to query only views with the **gs** prefix.
- If instance fault occurs, some SQL statement information may fail to be recorded in historical resource monitoring views.
- In some abnormal cases, the status information column in the historical Top SQL may be displayed as **unknown**. The recorded monitoring information may be inaccurate.
- The SQL statements that can be recorded in historical resource monitoring views are the same as those recorded in real-time resource monitoring views. For details, see **SQL statements recorded in real-time resource monitoring views**.
- Historical Top SQL records data only when the GUC parameter **enable_resource_record** is enabled.
- You can query historical Top SQL queries and operator-level data only through the PostgreSQL database.
- Historical Top SQL focuses on locating and demarcating query performance problems. It is not used for auditing or recording syntax analysis error statements.
- In 8.2.1 and later cluster versions, the **resource_track_subsql_duration** parameter (default value: 180s) is added to filter out substatements in the stored procedure whose execution time is less than the value of this parameter and archive only substatements whose execution time is greater than the value of this parameter. In 8.2.1 and later versions, the default value of **enable_track_record_subsql** is changed from **off** to **on**, which means substatements in stored procedures are recorded by default. If a substatement is recorded, it must meet the following conditions:
  - In the session where the statement is, the **enable_track_record_subsql** parameter is enabled.
  - The substatement must be pushed down to DNs for execution. (To prevent TopSQL from recording too many substatements, substatements that are not pushed down to DNs will be filtered out.)
  - The execution time of the substatement exceeds the value of **resource_track_subsql_duration** in the session.
- By default, the History view queries statements that end in the last 3 minutes. It does this by querying tables. It is actually a temporary view for performance considerations. Since the 8.1.3 cluster version, the real-time monitoring and archiving functions of the TopSQL monitoring have been greatly improved are no performance considerations are needed. Therefore, you are not advised to use the History view.
- In 8.1.3 and later versions, the TopSQL real-time monitoring has no impact on statement performance. You can set the GUC **parameter resource_track_cost** to **0** to monitor the running information of all statements. The statement archiving in the TopSQL history monitoring also has no impact on statement performance. However, when the TPS is high, the following factors need to be considered:
  - Record the disk overhead of all statements. You can estimate the disk space required for archiving a statement as 8 KB, calculate the space usage based on the peak TPS, and adjust the values of **resource_track_duration** and **resource_track_subsql_duration**.
  - For memory overhead for caching all statements, you can estimate the memory size required for archiving a statement as 16 KB, and the interval for archiving statements in batches as 5 seconds, then calculate the required peak memory size based on the peak service TPS. The calculation method is as follows: 5 seconds x TPS x 16 KB. The value of **session_history_memory GUC** (default value: 100 MB)

must be greater than the calculation result to ensure that all statements can be recorded.

Prerequisites

- The GUC parameter **enable_resource_track** is set to **on**. The default value is **on**.
- The GUC parameter **resource_track_level** is set to **query**, **perf**, or **operator**. The default value is **query**. For details, see **Table 14-2**.
- The GUC parameter **enable_resource_record** is set to **on**. The default value is **on**.
- The value of the **resource_track_duration** parameter (**60s** by default) is less than the job execution time.
- The GUC parameter **enable_track_record_subsql** specifies whether to record internal statements of a stored procedure or anonymous block. The default value is **on**.
- The value of **resource_track_subsql_duration** is less than the execution time of the internal statement in the stored procedure (180s by default).
- Jobs whose execution time recorded in the real-time resource monitoring view (see **Table 14-1**) is greater than or equal to **resource_track_duration** are monitored.
- If the Cgroups function is properly loaded, you can run the **gs_cgroup -P** command to view information about Cgroups.

Procedure

Step 1 Query the load records of the current CN after its latest job is complete in the **gs_wlm_session_history** view.

```
SELECT * FROM gs_wlm_session_history;
```

Step 2 Query the load records of all the CNs after their latest job are complete in the **pgxc_wlm_session_history** view.

```
SELECT * FROM pgxc_wlm_session_history;
```

Step 3 Query the load records of the current CN through the **gs_wlm_session_info** table after the task is complete. To query the historical records successfully, set **enable_resource_record** to **on**.

```
SELECT * FROM gs_wlm_session_info;
```

- Top 10 queries that consume the most memory (You can specify a query period.)

```
SELECT * FROM gs_wlm_session_info order by max_peak_memory desc limit 10;
SELECT * FROM gs_wlm_session_info WHERE start_time >= '2022-05-15 21:00:00' and finish_time <='2022-05-15 23:30:00' order by max_peak_memory desc limit 10;
```

- Showing the 10 queries consuming the most CPU resources:

```
SELECT * FROM gs_wlm_session_info order by total_cpu_time desc limit 10;
SELECT * FROM gs_wlm_session_info WHERE start_time >= '2022-05-15 21:00:00' and finish_time <='2022-05-15 23:30:00' order by total_cpu_time desc limit 10;
```

Step 4 Query for the load records of all the CNs after their jobs are complete in the **pgxc_wlm_session_info** view. To query the historical records successfully, set **enable_resource_record** to **on**.

```
SELECT * FROM pgxc_wlm_session_info;
```


- Showing the 10 queries on which the CN spends the most time:

```
SELECT * FROM pgxc_wlm_session_info order by duration desc limit 10;
```

- Query the execution information about a query statement that has been executed. For example, query the execution information about the statement whose **queryid** is **76561193695026478**.

```
SELECT * FROM pgxc_wlm_session_info where queryid = '76561193695026478';
```

Step 5 Use the **pgxc_get_wlm_session_info_bytime** function to filter and query the **pgxc_wlm_session_info** view. To query the historical records successfully, set **enable_resource_record** to **on**. You are advised to use this function if the view contains a large number of records.

NOTE

A GaussDB(DWS) cluster uses the UTC time by default, which has an 8-hour time difference with the system time. Before queries, ensure that the database time is the same as the system time.

- Return the queries started between **2019-09-10 15:30:00** and **2019-09-10 15:35:00** on all CNs. For each CN, a maximum of 10 queries will be returned.

```
SELECT * FROM pgxc_get_wlm_session_info_bytime('start_time', '2019-09-10 15:30:00', '2019-09-10 15:35:00', 10);
```

- Return the queries ended between **2019-09-10 15:30:00** and **2019-09-10 15:35:00** on all CNs. For each CN, a maximum of 10 queries will be returned.

```
SELECT * FROM pgxc_get_wlm_session_info_bytime('finish_time', '2019-09-10 15:30:00', '2019-09-10 15:35:00', 10);
```

Step 6 Query the recent resource information of the job operators on the current CN in the **gs_wlm_operator_history** view. Ensure that **resource_track_level** is set to **operator**.

```
SELECT * FROM gs_wlm_operator_history;
```

Step 7 Query the recent resource information of the job operators on all the CNs in the **pgxc_wlm_operator_history** view. Ensure that **resource_track_level** is set to **operator**.

```
SELECT * FROM pgxc_wlm_operator_history;
```

Step 8 Query the recent resource information of the job operators on the current CN in the **gs_wlm_operator_info** view. Ensure that **resource_track_level** is set to **operator** and **enable_resource_record** to **on**.

```
SELECT * FROM gs_wlm_operator_info;
```

Step 9 Query for the historical resource information of job operators on all the CNs in the **pgxc_wlm_operator_info** view. Ensure that **resource_track_level** is set to **operator** and **enable_resource_record** to **on**.

```
SELECT * FROM pgxc_wlm_operator_info;
```

----End

NOTE

- The number of data records that can be retained in the memory is limited due to the preset memory limit. After the real-time query is complete, the data records are imported to historical views. For a query-level view, when the number of queries to be recorded exceeds the upper limit allowed by the memory, the current query cannot be recorded and the next query is performed based on a new rule. On each CN, the memory usage of the query-level historical view is recorded (100 MB by default). You can query the data in the **PG_TOTAL_MEMORY_DETAIL** view.
- For operator-level views, whether a record can be stored depends on the upper limit allowed by the memory at that time point. If the number of plan nodes plus the number of records in the memory exceeds the upper limit, the record cannot be stored. On each CN, the maximum numbers of real-time and historical operator-level records that can be stored in the memory are **max_oper_realt_num** (set to **56987** by default) and **max_oper_hist_num** (set to **113975** by default), respectively. The average number of plan nodes of a query is **num_plan_node**. Maximum number of concurrent tasks allowed by real-time views on each CN is: **num_realt_active** = **max_oper_realt_num**/**num_plan_node**. Maximum number of concurrent tasks allowed by historical views on each CN is: **num_hist_active** = **max_oper_hist_num**/(**180**/**run_time**)/**num_plan_node**.
- In high concurrency, ensure that the number of queries to be recorded does not exceed the maximum values set for query- and operator-level views. You can modify the memory of the historical query view by configuring the **session_history_memory** parameter. The memory size increases in direct proportion to the maximum number of queries that can be recorded.

14.7 TopSQL Query Example

In this section, TPC-DS sample data is used as an example to describe how to query **Real-time Top SQL** and **Historical Top SQL**.

Configuring Cluster Parameters

To query for historical or archived resource monitoring information about jobs of top SQLs, you need to set related GUC parameters first. The procedure is as follows:

1. Log in to the GaussDB(DWS) management console.
2. On the **Cluster Management** page, locate the required cluster and click the cluster name. The cluster details page is displayed.
3. Click the **Parameter Modifications** tab to view the values of cluster parameters.
4. Set an appropriate value for parameter **resource_track_duration** and click **Save**.

   NOTE

   If **enable_resource_record** is set to **on**, storage space expansion may occur and thereby slightly affects the performance. Therefore, set is to **off** if record archiving is unnecessary.
5. Go back to the **Cluster Management** page, click the refresh button in the upper right corner, and wait until the cluster parameter settings are applied.

Example for Querying for Top SQLs

The TPC-DS sample data is used as an example.

Step 1 Open the SQL client tool and connect to your database.

Step 2 Run the **EXPLAIN** statement to query for the estimated cost of the SQL statement to be executed to determine whether resources of the SQL statement will be monitored.

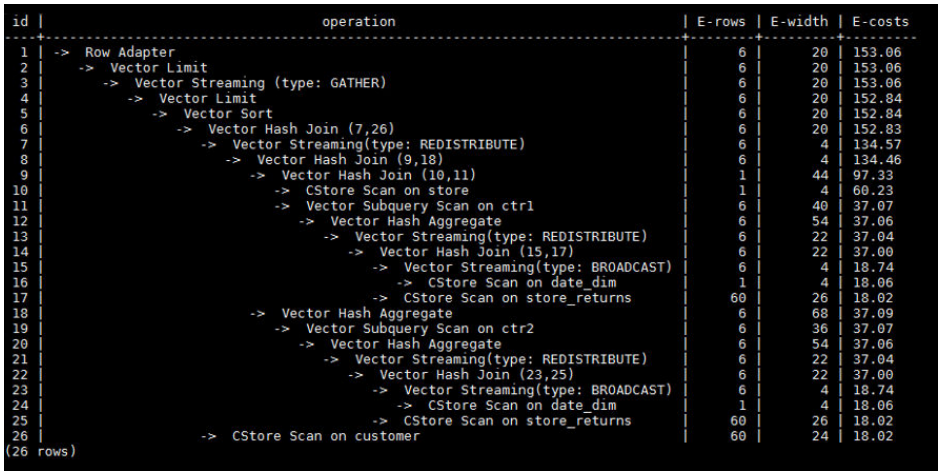
By default, only resources of a query whose execution cost is greater than the value of **resource_track_cost** are monitored and can be queried by users.

For example, run the following statements to query for the estimated execution cost of the SQL statement:

```
SET CURRENT_SCHEMA = tpcds;
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 = 'TN'
AND ctr1.ctr_customer_sk = c_customer_sk
ORDER BY c_customer_id
limit 100;
```

In the following query result, the value in the first row of the **E-costs** column is the estimated cost of the SQL statement.

Figure 14-1 EXPLAIN result



```
id |                                operation                                | E-rows | E-width | E-costs
---+-------------------------------------------------------------------------+--------+---------+---------
 1 | ->  Row Adapter                                                         |      6 |      20 | 153.06
 2 |    ->  Vector Limit                                                     |      6 |      20 | 153.06
 3 |       ->  Vector Streaming (type: GATHER)                               |      6 |      20 | 153.06
 4 |          ->  Vector Limit                                               |      6 |      20 | 152.84
 5 |             ->  Vector Sort                                             |      6 |      20 | 152.84
 6 |                ->  Vector Hash Join (7,26)                              |      6 |      20 | 152.83
 7 |                   ->  Vector Streaming(type: REDISTRIBUTE)              |      6 |       4 | 134.57
 8 |                      ->  Vector Hash Join (9,18)                        |      6 |       4 | 134.46
 9 |                         ->  Vector Hash Join (10,11)                    |      1 |      44 | 97.33
10 |                            ->  CStore Scan on store                     |      1 |       4 | 60.23
11 |                            ->  Vector Subquery Scan on ctr1             |      6 |      40 | 37.07
12 |                               ->  Vector Hash Aggregate                 |      6 |      54 | 37.06
13 |                                  ->  Vector Streaming(type: REDISTRIBUTE)|      6 |      22 | 37.04
14 |                                     ->  Vector Hash Join (15,17)        |      6 |      22 | 37.00
15 |                                        ->  Vector Streaming(type: BROADCAST)|      6 |       4 | 18.74
16 |                                           ->  CStore Scan on date_dim   |      1 |       4 | 18.06
17 |                                        ->  CStore Scan on store_returns |     60 |      26 | 18.02
18 |                         ->  Vector Hash Aggregate                       |      6 |      68 | 37.09
19 |                            ->  Vector Subquery Scan on ctr2             |      6 |      36 | 37.07
20 |                               ->  Vector Hash Aggregate                 |      6 |      54 | 37.06
21 |                                  ->  Vector Streaming(type: REDISTRIBUTE)|      6 |      22 | 37.04
22 |                                     ->  Vector Hash Join (23,25)        |      6 |      22 | 37.00
23 |                                        ->  Vector Streaming(type: BROADCAST)|      6 |       4 | 18.74
24 |                                           ->  CStore Scan on date_dim   |      1 |       4 | 18.06
25 |                                        ->  CStore Scan on store_returns |     60 |      26 | 18.02
26 |                   ->  CStore Scan on customer                           |     60 |      24 | 18.02
(26 rows)
```

In this example, to demonstrate the resource monitoring function of top SQLs, you need to set **resource_track_cost** to a value smaller than the estimated cost in the **EXPLAIN** result, for example, **100**. For details about the parameter setting, see **resource_track_cost**.

NOTE

After completing this example, you still need to reset **resource_track_cost** to its default value **100000** or a proper value. An overly small parameter value will compromise the database performance.

Step 3 Run SQL statements.

```
SET CURRENT_SCHEMA = tpcds;
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 = 'TN'
AND ctr1.ctr_customer_sk = c_customer_sk
ORDER BY c_customer_id
limit 100;
```

Step 4 During statement execution, query for the real-time memory peak information about the SQL statement on the current CN.

```
SELECT query,max_peak_memory,average_peak_memory,memory_skew_percent FROM
gs_wlm_session_statistics ORDER BY start_time DESC;
```

The preceding command queries for the real-time peak information at the query-level. The peak information includes the maximum memory peak among all DNs per second, average memory peak among all DNs per second, and memory usage skew across DNs.

For more examples of querying for the real-time resource monitoring information of top SQLs, see **Real-time Top SQL**.

Step 5 Wait until the SQL statement execution in **Step 3** is complete, and then query for the historical resource monitoring information of the statement.

```
SELECT query,start_time,finish_time,duration,status FROM gs_wlm_session_history ORDER BY start_time
desc;
```

The preceding command queries for the historical information at the query-level. The peak information includes the execution start time, execution duration (unit: ms), and execution status. The time unit is ms.

For more examples of querying for the historical resource monitoring information of top SQLs, see **Historical Top SQL**.

Step 6 Wait for 3 minutes after the execution of the SQL statement in **Step 3** is complete, query for the historical resource monitoring information of the statement in the **info** view.

If **enable_resource_record** is set to **on** and the execution time of the SQL statement in **Step 3** is no less than the value of **resource_track_duration**, historical information about the SQL statement will be archived to the **gs_wlm_session_info** view 3 minutes after the execution of the SQL statement is complete.

The **info** view can be queried only when the **postgres** database is connected. Therefore, switch to the **postgres** database before running the following statement:


```
SELECT query,start_time,finish_time,duration,status FROM gs_wlm_session_info ORDER BY start_time desc;
```

----End

15 System Catalogs and System Views

15.1 Overview of System Catalogs and System Views

System catalogs are used by GaussDB(DWS) to store structure metadata. They are a core component the GaussDB(DWS) database system and provide control information for the database system. These system catalogs contain cluster installation information and information about various queries and processes in GaussDB(DWS). You can collect information about the database by querying the system catalog.

System views provide ways to query system catalogs and internal database status. 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 basic table. It is only a virtual object rather than a physical one. A database only stores the definition of a view and does not store its data. The data is still stored in the original 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.

In separation of duty, non-administrators have no permission to view system catalogs and views. In other scenarios, system catalogs and views are either visible only to administrators or visible to all users. Some of the following system catalogs and views have marked the need of administrator permissions. They are accessible only to administrators.

NOTICE

- Do not add, delete, or modify system catalogs or system views. Manual modification or damage to system catalogs or system views may cause system information inconsistency, system control exceptions, or even cluster unavailability.
- System catalogs do not support toast and cannot be stored across pages. If the size of a page in a system catalog is 8 KB, the length of each field must be less than 8 KB.

15.2 System Catalogs

15.2.1 GS_BLOCKLIST_QUERY

GS_BLOCKLIST_QUERY records job blocklist and exception information. This table uses **unique_sql_id** as the unique index to collect statistics on job exception information and record blocklist information. You can associate **GS_BLOCKLIST_QUERY** with **GS_WLM_SESSION_INFO** to obtain the **query** column and execution information of a job.

GaussDB(DWS) also provides the **GS_BLOCKLIST_QUERY** view for querying job blocklist and exception information. This view can directly display the **query** column. This view depends on **GS_WLM_SESSION_INFO**. If the **GS_WLM_SESSION_INFO** table is large, the query may take a long time.

Table 15-1 GS_BLOCKLIST_QUERY columns

Name	Type	Reference	Description
unique_sql_id	bigint	-	Unique query ID generated based on the query parsing tree.
block_list	boolean	-	Check whether a job is in the blocklist.
except_num	integer	-	Query the number of job exceptions.
except_time	timestamp	-	Query the time when the last job exception occurred.

NOTE

- The schema of this system catalog is **dbms_om**.
- This system catalog contains unique indexes, which are distributed on DNs in hash mode. The distributed column is **unique_sql_id**.
- This system catalog can be queried only in the **gaussdb** database. If it is queried in other databases, an error will be reported.
- The **GS_BLOCKLIST_QUERY** view is stored in **pg_catalog**.
- Generally, constant values are ignored during unique SQL ID calculation in DML statements. However, constant values cannot be ignored in DDL, DCL, and parameter setting statements. A **unique_sql_id** may correspond to one or more queries.

15.2.2 GS_OBSSCANINFO

GS_OBSSCANINFO defines the OBS runtime information scanned in cluster acceleration scenarios. Each record corresponds to a piece of runtime information of a foreign table on OBS in a query.

Table 15-2 GS_OBSSCANINFO columns

Name	Type	Reference	Description
query_id	bigint	-	Specifies a query ID.
user_id	text	-	Specifies a database user who performs queries.
table_name	text	-	Specifies the name of a foreign table on OBS.
file_type	text	-	Specifies the format of files storing the underlying data.
time_stamp	time_stam	-	Specifies the scanning start time.
actual_time	double	-	Specifies the scanning execution time in seconds.
file_scanned	bigint	-	Specifies the number of files scanned.
data_size	double	-	Specifies the size of data scanned in bytes.
billing_info	text	-	Specifies the reserved fields.

15.2.3 GS_RESPOOL_RESOURCE_HISTORY

The **GS_RESPOOL_RESOURCE_HISTORY** table records the historical monitoring information about a resource pool on both CNs and DNs.

Table 15-3 GS_RESPOOL_RESOURCE_HISTORY columns

Name	Type	Description
timestamp	timestamp	Time when resource pool monitoring information is persistently stored
nodegroup	name	Name of the logical cluster of the resource pool. The default value is **installation**.
rpname	name	Resource pool name
cgroup	name	Name of the Cgroup associated with the resource pool
ref_count	int	Number of jobs referenced by the resource pool. The number is counted regardless of whether the jobs are controlled by the resource pool. This parameter is valid only on CNs.
fast_run	int	Number of running jobs in the fast lane of the resource pool. This parameter is valid only on CNs.
fast_wait	int	Number of jobs queued in the fast lane of the resource pool. This parameter is valid only on CNs.
fast_limit	int	Limit on the number of concurrent jobs in the fast lane in a resource pool. This parameter is valid only on CNs.
slow_run	int	Number of running jobs in the slow lane of the resource pool. This parameter is valid only on CNs.
slow_wait	int	Number of jobs queued in the slow lane of the resource pool. This parameter is valid only on CNs.
slow_limit	int	Limit on the number of concurrent jobs in the slow lane in a resource pool. This parameter is valid only on CNs.
used_cpu	double	Average number of CPUs used by the resource pool in a 5s monitoring period. The value is accurate to two decimal places. • On a DN, it indicates the number of CPUs used by the resource pool on the current DN. • On a CN, it indicates the total CPU usage of resource pools on all DNs.

Name	Type	Description
cpu_limit	int	It indicates the upper limit of available CPUs for resource pools. If the CPU share is limited, this parameter indicates the available CPUs for GaussDB(DWS). If the CPU limit is specified, this parameter indicates the available CPUs for associated Cgroups. • On a DN, it indicates the upper limit of available CPUs for the resource pool on the current DN. • On a CN, it indicates the total upper limit of available CPUs for resource pools on all DNs.
used_mem	int	Memory used by the resource pool, in MB. • On a DN, it indicates the memory usage of the resource pool on the current DN. • On a CN, it indicates the total memory usage of resource pools on all DNs.
estimate_mem	int	Estimated memory used by the jobs running in the resource pools on the current CN. This parameter is valid only on CNs.
mem_limit	int	Upper limit of available memory for the resource pool (unit: MB). • On a DN, it indicates the upper limit of available memory for the resource pool on the current DN. • On a CN, it indicates the total upper limit of available memory for resource pools on all DNs.
read_kbytes	bigint	Number of logical read bytes in the resource pool within a 5s monitoring period (unit: KB). • On a DN, it indicates the number of logical read bytes in the resource pool on the current DN. • On a CN, it indicates the total logical read bytes of resource pools on all DNs.
write_kbytes	bigint	Number of logical write bytes in the resource pool within a 5s monitoring period (unit: KB). • On a DN, it indicates the number of logical write bytes in the resource pool on the current DN. • On a CN, it indicates the total logical write bytes of resource pools on all DNs.

Name	Type	Description
read_counts	bigint	Number of logical reads in the resource pool within a 5s monitoring period. ● On a DN, it indicates the number of logical reads in the resource pool on the current DN. ● On a CN, it indicates the total number of logical reads in resource pools on all DNs.
write_counts	bigint	Number of logical writes in the resource pool within a 5s monitoring period. ● On a DN, it indicates the number of logical writes in the resource pool on the current DN. ● On a CN, it indicates the total number of logical writes in resource pools on all DNs.
read_speed	double	Average rate of logical reads of the resource pool in a 5s monitoring period, in KB/s. ● On a DN, it indicates the logical read rate of the resource pool on the current DN. ● On a CN, it indicates the overall logical read rate of resource pools on all DNs.
write_speed	double	Average rate of logical writes of resource pools in a 5s monitoring period, in KB/s. ● On a DN, it indicates the logical write rate of the resource pool on the current DN. ● On a CN, it indicates the overall logical write rate of resource pools on all DNs.
send_speed	double	Average network sending rate of the resource pool in a 5-second monitoring period, in KB/s. ● On a DN, it indicates the network sending rate of the resource pool on the current DN. ● On a CN, it indicates that the cumulative sum of the network sending rates of the resource pool on all DNs.
recv_speed	double	Average network receiving rate of the resource pool in a 5-second monitoring period, in KB/s. ● On a DN, it indicates the network receiving rate of the resource pool on the current DN. ● On a CN, it indicates that the cumulative sum of the network receiving rates of the resource pool on all DNs.

15.2.4 GS_WLM_INSTANCE_HISTORY

The **GS_WLM_INSTANCE_HISTORY** system catalog stores information about resource usage related to CN or DN instances. Each record in the system table indicates the 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.

Table 15-4 GS_WLM_INSTANCE_HISTORY column

Name	Type	Description
instancename	text	Instance name
timestamp	timestamp with time zone	Timestamp
used_cpu	int	CPU usage of an instance
free_mem	int	Unused memory of an instance (unit: MB)
used_mem	int	Used memory of an instance (unit: MB)
io_await	real	Specifies the **io_wait** value (average value within 10 seconds) of the disk used by an instance.
io_util	real	Specifies the **io_util** value (average value within 10 seconds) of the disk used by an instance.
disk_read	real	Specifies the disk read rate (average value within 10 seconds) of an instance (unit: KB/s).
disk_write	real	The disk write rate (average value within 10 seconds) of an instance (unit: KB/s).
process_read	bigint	Specifies the read rate (excluding the number of bytes read from the disk pagecache) of the corresponding instance process that reads data from a disk. (Unit: KB/s)
process_write	bigint	Specifies the 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. (Unit: KB/s)
logical_read	bigint	CN instance: N/A DN instance: Specifies the logical read byte rate of the instance in the statistical interval (10 seconds). (Unit: KB/s)

Name	Type	Description
logical_write	bigint	CN instance: N/A DN instance: Specifies the logical write byte rate of the instance within the statistical interval (10 seconds). (Unit: KB/s)
read_counts	bigint	CN instance: N/A DN instance: Specifies the total number of logical read operations of the instance in the statistical interval (10 seconds).
write_counts	bigint	CN instance: N/A DN instance: Specifies the total number of logical write operations of the instance in the statistical interval (10 seconds).

15.2.5 GS_WLM_OPERATOR_INFO

GS_WLM_OPERATOR_INFO records operators of completed jobs. The data is dumped from the kernel to a system catalog. If the GUC parameter **enable_resource_record** is set to **on**, the system imports records from **GS_WLM_OPERATOR_HISTORY** to this system catalog every three minutes. You are not advised to enable this function because it occupies storage space and affects performance.

NOTE

- This system catalog's schema is **dbms_om**.
- The **pg_catalog** has the **GS_WLM_OPERATOR_INFO** view.

Table 15-5 GS_WLM_OPERATOR_INFO columns

Name	Type	Description
nodename	text	Name of the CN where the statement is executed
queryid	bigint	Internal query_id used for statement execution
pid	bigint	Thread ID of the backend
plan_node_id	integer	plan_node_id of the execution plan of a query
plan_node_name	text	Name of the operator corresponding to plan_node_id
start_time	timestamp with time zone	Time when an operator starts to process the first data record

Name	Type	Description
duration	bigint	Total execution time of an operator. The unit is ms.
query_dop	integer	Degree of parallelism (DOP) of the current operator
estimated_rows	bigint	Number of rows estimated by the optimizer
tuple_processed	bigint	Number of elements returned by the current operator
min_peak_memory	integer	Minimum peak memory used by the current operator on all DNs. The unit is MB.
max_peak_memory	integer	Maximum peak memory used by the current operator on all DNs. The unit is MB.
average_peak_memory	integer	Average peak memory used by the current operator on all DNs. The unit is MB.
memory_skew_percent	integer	Memory usage skew of the current operator among DNs
min_spill_size	integer	Minimum spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
max_spill_size	integer	Maximum spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
average_spill_size	integer	Average spilled data among all DNs when a spill occurs. The unit is MB. The default value is **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. The unit is ms.
max_cpu_time	bigint	Maximum execution time of the operator on all DNs. The unit is ms.
total_cpu_time	bigint	Total execution time of the operator on all DNs. The unit is ms.
cpu_skew_percent	integer	Skew of the execution time among DNs.

Name	Type	Description
warning	text	Warning. The following warnings are displayed: 1. Sort/SetOp/HashAgg/HashJoin spill 2. Spill file size large than 256MB 3. Broadcast size large than 100MB 4. Early spill 5. Spill times is greater than 3 6. Spill on memory adaptive 7. Hash table conflict

15.2.6 GS_WLM_SESSION_INFO

GS_WLM_SESSION_INFO records load management information about a completed job executed on all CNs. The data is dumped from the kernel to a system catalog. If the GUC parameter **enable_resource_record** is set to **on**, the system imports records from **GS_WLM_SESSION_HISTORY** to this system catalog every three minutes. You are not advised to enable this function because it occupies storage space and affects performance. For details about the columns, see **Table 15-145**.

NOTE

- This system catalog's schema is **dbms_om**.
- This system catalog has a distribution column, the gaussdb column, in PostgreSQL databases only, not other databases.
- The **pg_catalog** has the **GS_WLM_SESSION_INFO** view.

15.2.7 GS_WLM_USER_RESOURCE_HISTORY

The **GS_WLM_USER_RESOURCE_HISTORY** system catalog stores information about resources used by users. The data of this table is stored on both CNs and DNs. Each record in the system table indicates the resource usage of a user at a time point, including the memory, number of CPU cores, storage space, temporary space, operator spill space, logical I/O traffic, number of logical I/O times, and logical I/O rate. The memory, CPU, and I/O monitoring items record only the resource usage of complex jobs.

Data in the **GS_WLM_USER_RESOURCE_HISTORY** system table comes from the **PG_TOTAL_USER_RESOURCE_INFO** view.

Table 15-6 GS_WLM_USER_RESOURCE_HISTORY column

Name	Type	Description
username	text	Username

Name	Type	Description
timestamp	timestamp with time zone	Timestamp
used_memory	int	Memory size used by a user, in MB. • DN: The memory used by users on the current DN is displayed. • CN: The total memory usage of users on all DNs is displayed.
total_memory	int	Memory used by the resource pool, in MB. **0** indicates that the available memory is not limited and depends on the maximum memory available in the database (**max_dynamic_memory**). A calculation formula is as follows: total_memory = max_dynamic_memory * parent_percent * user_percent CN: The sum of maximum available memory on all DNs is displayed.
used_cpu	real	Number of CPU cores in use
total_cpu	int	Total number of CPU cores of the Cgroup associated with a user on the node
used_space	bigint	Used storage space (unit: KB)
total_space	bigint	Available storage space (unit: KB). **-1** indicates that the storage space is not limited.
used_temp_space	bigint	Used temporary storage space (unit: KB)
total_temp_space	bigint	Available temporary storage space (unit: KB). **-1** indicates that the maximum temporary storage space is not limited.
used_spill_space	bigint	Space occupied by operators spilled to disk (unit: KB)
total_spill_space	bigint	Available storage space for operator spill to disk (unit: KB). The value **-1** indicates that the space is not limited.
read_kbytes	bigint	Byte traffic of read operations in a monitoring period (unit: KB)
write_kbytes	bigint	Byte traffic of write operations in a monitoring period (unit: KB)
read_counts	bigint	Number of read operations in a monitoring period.

Name	Type	Description
write_counts	bigint	Number of write operations in a monitoring period.
read_speed	real	Byte rate of read operations in a monitoring period (unit: KB)
write_speed	real	Byte rate of write operations in a monitoring period (unit: KB)
send_speed	double	Network sending rate in a monitoring period, in KB/s.
recv_speed	double	Network receiving rate in a monitoring period, in KB/s.

15.2.8 PG_AGGREGATE

pg_aggregate records information about aggregation 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 15-7 PG_AGGREGATE columns

Name	Type	Reference	Description
aggfnoid	regproc	PG_PROC.oid	PG_PROC OID of the aggregate function
aggtransfn	regproc	PG_PROC.oid	Transition function
aggcollectfn	regproc	PG_PROC.oid	Aggregate function
aggfinalfn	regproc	PG_PROC.oid	Final function (zero if none)
aggsortop	oid	PG_OPERATOR.oid	Associated sort operator (zero if none)
aggtranstype	oid	PG_TYPE.oid	Data type of the aggregate function's internal transition (state) data
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 out null.

Name	Type	Reference	Description
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 out null.

15.2.9 PG_AM

PG_AM records information about index access methods. There is one row for each index access method supported by the system.

Table 15-8 PG_AM columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
amname	name	-	Name of the access method
amstrategies	smallint	-	Number of operator strategies for this access method, or zero if access method does not have a fixed set of operator strategies
amsupport	smallint	-	Number of support routines for this access method
amcanorder	boolean	-	Whether the access method supports ordered scans sorted by the indexed column's value
amcanorderbyop	boolean	-	Whether the access method supports ordered scans sorted by the result of an operator on the indexed column
amcanbackward	boolean	-	Whether the access method supports backward scanning
amcanunique	boolean	-	Whether the access method supports unique indexes
amcanmulticol	boolean	-	Whether the access method supports multi-column indexes

Name	Type	Reference	Description
amoptionalkey	boolean	-	Whether the access method supports a scan without any constraint for the first index column
amsearcharray	boolean	-	Whether the access method supports **ScalarArrayOpExpr** searches
amsearchnulls	boolean	-	Whether the access method supports **IS NULL/NOT NULL** searches
amstorage	boolean	-	Whether an index storage data type can differ from a column data type
amclusterable	boolean	-	Whether an index of this type can be clustered on
ampredlocks	boolean	-	Whether an index of this type manages fine-grained predicate locks
amkeytype	oid	**PG_TYPE**.oid	Type of data stored in index, or zero if not a fixed type
aminsert	regproc	**PG_PROC**.oid	"Insert this tuple" function
ambeginscan	regproc	**PG_PROC**.oid	"Prepare for index scan" function
amgettuple	regproc	**PG_PROC**.oid	"Next valid tuple" function, or zero if none
amgetbitmap	regproc	**PG_PROC**.oid	"Fetch all valid tuples" function, or zero if none
amrescan	regproc	**PG_PROC**.oid	"(Re)start index scan" function
amendscan	regproc	**PG_PROC**.oid	"Clean up after index scan" function
ammarkpos	regproc	**PG_PROC**.oid	"Mark current scan position" function
amrestrpos	regproc	**PG_PROC**.oid	"Restore marked scan position" function
ammerge	regproc	**PG_PROC**.oid	"Merge multiple indexes" function
ambuild	regproc	**PG_PROC**.oid	"Build new index" function
ambuildempty	regproc	**PG_PROC**.oid	"Build empty index" function
ambulkdelete	regproc	**PG_PROC**.oid	Bulk-delete function

Name	Type	Reference	Description
amvacuumcleanup	regproc	PG_PROC.oid	Post-**VACUUM** cleanup function
amcanreturn	regproc	PG_PROC.oid	Function to check whether index supports index-only scans, or zero if none
amcostestimate	regproc	PG_PROC.oid	Function to estimate cost of an index scan
amoptions	regproc	PG_PROC.oid	Function to parse and validate **reloptions** for an index

15.2.10 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 15-9 PG_AMOP columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
amopfamily	oid	PG_OPFAMILY.oid	Operator family this entry is for
amoplefttype	oid	PG_TYPE.oid	Left-hand input data type of operator
amoprighttype	oid	PG_TYPE.oid	Right-hand input data type of operator
amopstrategy	smallint	-	Number of operator strategies
amoppurpose	"char"	-	Operator purpose, either **s** for search or **o** for ordering
amopopr	oid	PG_OPERATOR.oid	OID of the operator
amopmethod	oid	PG_AM.oid	Index access method the operator family is for

Name	Type	Reference	Description
amopsortfamily	oid	PG_OPFAMILY.oid	The btree operator family this entry sorts according to, if an ordering operator; zero if 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 the **ORDER BY** are specified by the **amopsortfamily** column, which must reference a btree operator family for the operator's result type.

15.2.11 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 belonging to an operator family.

Table 15-10 PG_AMPROC columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
amprocfamily	oid	PG_OPFAMILY.oid	Operator family this entry is for
amproclefttype	oid	PG_TYPE.oid	Left-hand input data type of associated operator
amprocrighttype	oid	PG_TYPE.oid	Right-hand input data type of associated operator
amprocnum	smallint	-	Support procedure number
amproc	regproc	PG_PROC.oid	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**.

15.2.12 PG_ATTRDEF

PG_ATTRDEF stores default values of columns.

Table 15-11 PG_ATTRDEF columns

Name	Type	Description
adrelid	oid	Table to which the column belongs
adnum	smallint	Number of the column
adbin	pg_node_tree	Internal representation of the default value of the column
adsrc	text	Internal representation of the readable default value
adbin_on_update	pg_node_tree	Internal representation of the value of **on_update_expr**
adsrc_on_update	text	Internal representation of the human-readable value of **on_update_expr**

15.2.13 PG_ATTRIBUTE

PG_ATTRIBUTE records information about table columns.

Table 15-12 PG_ATTRIBUTE columns

Name	Type	Description
attrelid	oid	Table to which the column belongs
attname	name	Column name
atttypid	oid	Column type

Name	Type	Description
attstattarget	integer	Controls the level of details of statistics collected for this column by **ANALYZE**. • A zero value indicates that no statistics should be collected. • A negative value says to use the system default statistics target. • The exact meaning of positive values is data type-dependent. 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 **pg_type.typlen** of the column's type
attnum	smallint	Number of a column.
attndims	integer	Number of dimensions if the column is an array; otherwise, the value is 0.
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 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 **pg_type.typbyval** of the column's type
attstorage	"char"	Copy of **pg_type.typstorage** of this column's type
attalign	"char"	Copy of **pg_type.typalign** of the column's type
attnotnull	boolean	A not-null constraint. It is possible to change this column to enable or disable the constraint.
atthasdef	boolean	Indicates that 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.

Name	Type	Description
attisdropped	boolean	Whether the column has been dropped and is no longer valid. A dropped column is still physically present in the table but is ignored by the analyzer, so it cannot be accessed through SQL.
attislocal	boolean	Whether the column is defined locally in the relation. Note that a column can be locally defined and inherited simultaneously.
attcmprmode	tinyint	Compressed modes for a specific column The compressed mode includes: • ATT_CMPR_NOCOMPRESS • ATT_CMPR_DELTA • ATT_CMPR_DICTIONARY • ATT_CMPR_PREFIX • ATT_CMPR_NUMSTR
attinhcount	integer	Number of direct ancestors 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[]	Property-level options
attfdwoptions	text[]	Property-level external data options
attinitdefval	bytea	**attinitdefval** stores the default value expression. **ADD COLUMN** in a row-store table must use this column.
attkvtype	tinyint	**kv_type** attribute of a column. Values: • **0** indicates the default value, which is used for non-time series tables. • **1** indicates TSTAG, a dimension attribute, which is used only for time series tables. • **2** indicates TSFIELD, a metric attribute, which is used only for the time sequence table. • **3** indicates TSTIME, a time attribute, which is used only for time series tables.

Example

Query the field names and field IDs of a specified table. Replace **t1** and **public** with the actual table name and schema name, respectively.


```
SELECT attname,attnum FROM pg_attribute WHERE attrelid=(SELECT pg_class.oid FROM pg_class JOIN
pg_namespace ON relnamespace=pg_namespace.oid WHERE relname='t1' and nspname='public') and
attnum>0;
    attname      | attnum
-----------------+--------
 product_id      |      1
 product_name    |      2
 product_quantity |      3
(3 rows)
```

15.2.14 PG_AUTHID

PG_AUTHID records information about the 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 the rolcanlogin is set or not, can use other roles as members.

For a cluster, only one **pg_authid** exists which is not available for every database. It is accessible only to users with system administrator rights.

Table 15-13 PG_AUTHID columns

Column	Type	Description
oid	oid	Row identifier (hidden attribute; must be explicitly selected)
rolname	name	Role name
rolsuper	boolean	Whether the role is the initial system administrator with the highest permission
rolinherit	boolean	Whether the role automatically inherits permissions of roles it is a member of
rolcreaterole	boolean	Whether the role can create more roles
rolcreatedb	boolean	Whether the role can create databases
rolcatupdate	boolean	Whether the role can directly update system catalogs. Only the initial system administrator whose usesysid is 10 has this permission. It is not available for other users.
rolcanlogin	boolean	Whether a role can log in, that is, whether a role can be given as the initial session authorization identifier.
rolreplication	boolean	Indicates that the role is a replicated one (an adaptation syntax and no actual meaning).
rolauditadmin	boolean	Indicates that the role is an audit user.
rolsystemadmin	boolean	Indicates that the role is an administrator.
rolconnlimit	integer	For roles that can log in, this sets maximum number of concurrent connections this role can make. -1 means no limit.

Column	Type	Description
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
rolparentid	oid	OID of a group user to which the user belongs
roltabspace	Text	Storage space of the user permanent table
rolkind	char	Special type of user, including private users, logical cluster administrators, and common users.
rolnodegroup	oid	OID of a node group associated with a user. The node group must be a logical cluster.
roltempspace	Text	Storage space of the user temporary table
rolspillspace	Text	Operator disk spill space of the user
rolexcpdata	text	Reserved column
rolauthinfo	text	Additional information when LDAP authentication is used. If other authentication modes are used, the value is **NULL**.
rolpwdexpire	integer	Password expiration time. Users can change their password before it expires. After the password expires, only the administrator can change the password. The value **-1** indicates that the password never expires.
rolpwdtime	timestamp with time zone	Time when a password is created

15.2.15 PG_AUTH_HISTORY

PG_AUTH_HISTORY records the authentication history of the role. It is accessible only to users with system administrator rights.

Table 15-14 PG_AUTH_HISTORY columns

Name	Type	Description
roloid	oid	ID of the role
passwordtime	timestamp with time zone	Time of password creation and change
rolpassword	text	Role password that is encrypted using MD5 or SHA256, or that is not encrypted

15.2.16 PG_AUTH_MEMBERS

PG_AUTH_MEMBERS records the membership relations between roles.

Table 15-15 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

15.2.17 PG_CAST

PG_CAST records conversion relationships between data types.

Table 15-16 PG_CAST columns

Name	Type	Description
castsource	oid	OID of the source data type
casttarget	oid	OID of the target data type
castfunc	oid	OID of the conversion function. If the value is **0**, no conversion function is required.

Name	Type	Description
castcontext	"char"	Conversion mode between the source and target data types • **e** indicates that only explicit conversion can be performed (using the CAST or :: syntax). • **i** indicates that only implicit conversion can be performed. • **a** indicates that both explicit and implicit conversion can be performed between data types.
castmethod	"char"	Conversion method • **f** indicates that conversion is performed using the specified function in the **castfunc** column. • **b** indicates that binary forcible conversion rather than the specified function in the **castfunc** column is performed between data types.

15.2.18 PG_CLASS

PG_CLASS records database objects and their relations.

Table 15-17 PG_CLASS columns

Name	Type	Description
oid	oid	Row identifier (hidden attribute; must be explicitly selected)
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 this table's row type (the index is 0 because the index does not have **pg_type** record)
reloftype	oid	OID is of composite type. **0** indicates other types.
relowner	oid	Owner of the relationship
relam	oid	Specifies the 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. If such file does not exist, the value is **0**.

Name	Type	Description
reltablespace	oid	Tablespace in which this relationship is stored. If its 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 this 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 this table. The OID is 0 if no TOAST table exists. The TOAST table stores large columns "offline" in a secondary table.
reltoastidxid	oid	OID of the index for a TOAST table. The OID is 0 for a table other than a TOAST table.
reldeltarelid	oid	OID of a Delta table Delta tables belong to column-store tables. They store long tail data generated during data import.
reldeltaidx	oid	OID of the index for a Delta table
relcudescrelid	oid	OID of a CU description table 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. 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 cluster. Only certain system catalogs (such as **pg_database**) are shared.

Name	Type	Description
relpersistence	"char"	• **p** indicates a permanent table. • **u** indicates a non-log table. • **t** indicates a temporary table.
relkind	"char"	• **r** indicates an ordinary table. • **i** indicates an index. • **S** indicates a sequence. • **v** indicates a view. • **c** indicates the composite type. • **t** indicates a TOAST table. • **f** indicates a foreign table. • **m** indicates a materialized view.
relnatts	smallint	Number of user columns in the relationship (excluding system columns) **pg_attribute** has the same number of rows corresponding to the user columns.
relchecks	smallint	Number of constraints on a table. For details, see **PG_CONSTRAINT**.
relhasoids	boolean	Its value is **true** if an OID is generated for each row of the relationship.
relhaspkey	boolean	Its value is **true** if the table has (or once had) a primary key.
relhasrules	boolean	Its value is **true** if the table has rules. See table **PG_REWRITE** to check whether it has rules.
relhastriggers	boolean	Its value is **true** if the table has (or once had) triggers. For details, see **PG_TRIGGER**.
relhassubclass	boolean	Its value is **true** if the table has (or once had) any inheritance child table.
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. • **0** indicates other tables that do not support compression (primarily system tables, on which the compression attribute cannot be modified). • **1** indicates that the compression feature of the table data is NOCOMPRESS or has no specified keyword. • **2** indicates that the compression feature of the table data is COMPRESS.
relhasclusterkey	boolean	Whether the local cluster storage is used

Name	Type	Description
relrowmovement	boolean	Whether the row migration is allowed when the partitioned table is updated • **true** indicates that the row migration is allowed. • **false** indicates that the row migration is not allowed.
parttype	"char"	Whether the table or index has the property of a partitioned table • **p** indicates that the table or index has the property of a partitioned table. • **n** indicates that the table or index does not have the property of a partitioned table. • **v** indicates that the table is the value partitioned table in the HDFS.
relfrozenxid	xid32	All transaction IDs before this one have been replaced with a permanent ("frozen") transaction ID in this table. This column is used to track whether the table needs to be vacuumed in order 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. To ensure forward compatibility, this column is reserved. The **relfrozenxid64** column is added to record the information.

relacl	aclitem[]	Access permissions
		The command output of the query is as follows:
		`rolename=xxxx/yyyy --Assigning privileges to a role`
		`=xxxx/yyyy --Assigning the permission to public`
		xxxx indicates the assigned privileges, and *yyyy* indicates the roles that are assigned to the privileges. For details about permission descriptions, see **Table 15-18**.

reloptions	text[]	Access-method-specific options, as "keyword=value" strings
relfrozenxid64	xid	All transaction IDs before this one have been replaced with a permanent ("frozen") transaction ID in this table. This column is used to track whether the table needs to be vacuumed in order 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.

Table 15-18 Description of privileges

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	ANALYZE|ANALYSE
L	ALTER
P	DROP
v	VACUUM
arwdDxtA, vLP	ALL PRIVILEGES (used for tables)
*	Authorization options for preceding permissions

Examples

View the OID and relfilenode of a table.

```
SELECT oid,relname,relfilenode FROM pg_class WHERE relname = 'table_name';
```

Count row-store tables.

```
SELECT 'row count:'||count(1) as point FROM pg_class WHERE relkind = 'r' and oid > 16384 and
reloptions::text not like '%column%' and reloptions::text not like '%internal_mask%';
```

Count column-store tables.

```
SELECT 'column count:'||count(1) as point FROM pg_class WHERE relkind = 'r' and oid > 16384 and
reloptions::text like '%column%';
```

Query the comments of all tables in the database:

```
SELECT relname as tabname,obj_description(relfilenode,'pg_class') as comment FROM pg_class;
```


15.2.19 PG_COLLATION

PG_COLLATION records the available collations, which are essentially mappings from an SQL name to operating system locale categories.

Table 15-19 PG_COLLATION columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
collname	name	-	Collation name (unique per namespace and encoding)
collnamespace	oid	PG_NAMESPACE.oid	OID of the namespace that contains this collation
collowner	oid	PG_AUTHID.oid	Owner of the collation
collencoding	integer	-	Encoding in which the collation is applicable, or **-1** if it works for any encoding
collcollate	name	-	**LC_COLLATE** for this collation object
collctype	name	-	**LC_CTYPE** for this collation object

15.2.20 PG_CONSTRAINT

PG_CONSTRAINT records check, primary key, unique, and foreign key constraints on the tables.

Table 15-20 PG_CONSTRAINT columns

Name	Type	Description
conname	name	Constraint name (not necessarily unique)
connamespace	oid	OID of the namespace that contains the constraint
contype	"char"	• **c** indicates check constraints. • **f** indicates foreign key constraints. • **p** indicates primary key constraints. • **u** indicates unique constraints. • **t** indicates trigger constraints.
condeferrable	boolean	Whether the constraint can be deferrable

Name	Type	Description
condeferred	boolean	Whether the constraint can be deferrable by default
convalidated	boolean	Whether the constraint is valid Currently, only foreign key and check constraints can be set to false.
conrelid	oid	Table containing this constraint. The value is **0** if it is not a table constraint.
contypid	oid	Domain containing this constraint. The value is **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 • **a** indicates no action. • **r** indicates restriction. • **c** indicates cascading. • **n** indicates that the parameter is set to null. • **d** indicates that the default value is used.
confdeltype	"char"	Foreign key deletion action code • **a** indicates no action. • **r** indicates restriction. • **c** indicates cascading. • **n** indicates that the parameter is set to null. • **d** indicates that the default value is used.
confmatchtype	"char"	Foreign key match type • **f** indicates full match. • **p** indicates partial match. • **u** indicates simple match (not specified).
conislocal	boolean	Whether the local constraint is defined for the relationship
coninhcount	integer	Number of direct inheritance parent tables this constraint has. When the number is not **0**, the constraint cannot be deleted or renamed.
connoinherit	boolean	Whether the constraint can be inherited

Name	Type	Description
consoft	boolean	Whether the column indicates an informational constraint.
conopt	boolean	Whether you can use Informational Constraint to optimize the execution plan.
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
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

NOTICE

- **consrc** is not updated when referenced objects change; for example, it will not track renaming of columns. Rather than relying on this field, it's best to use **pg_get_constraintdef()** to extract the definition of a check constraint.
- **pg_class.relchecks** must be consistent with the number of check-constraint entries in this table for each relationship.

Example

Query whether a specified table has a primary key.

```
CREATE TABLE t1
(
    C_CUSTKEY    BIGINT       ,
    C_NAME       VARCHAR(25)  ,
    C_ADDRESS    VARCHAR(40)  ,
    C_NATIONKEY  INT          ,
    C_PHONE      CHAR(15)     ,
    C_ACCTBAL    DECIMAL(15,2),
    CONSTRAINT C_CUSTKEY_KEY PRIMARY KEY(C_CUSTKEY,C_NAME)
)
```



```
DISTRIBUTE BY HASH(C_CUSTKEY,C_NAME);

SELECT conname FROM pg_constraint WHERE conrelid = 't1'::regclass AND contype = 'p';
    conname
---------------
 c_custkey_key
(1 row)
```

15.2.21 PG_CONVERSION

PG_CONVERSION records encoding conversion information.

Table 15-21 PG_CONVERSION columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
conname	name	-	Conversion name (unique in a namespace)
connamespace	oid	PG_NAMESPACE.oid	OID of the namespace that contains this conversion
conowner	oid	PG_AUTHID.oid	Owner of the conversion
conforencoding	integer	-	Source encoding ID
contoencoding	integer	-	Destination encoding ID
conproc	regproc	PG_PROC.oid	Conversion procedure
condefault	boolean	-	Its value is **true** if this is the default conversion.

15.2.22 PG_DATABASE

PG_DATABASE records information about the available databases.

Table 15-22 PG_DATABASE columns

Name	Type	Description
datname	name	Database name
datdba	oid	Owner of the database, usually the user who created it
encoding	integer	Character encoding for this database You can use pg_encoding_to_char() to convert this number to the encoding name.
datcollate	name	Sequence used by the database

Name	Type	Description
datctype	name	Character type used by the database
datistemplate	boolean	Whether this column can serve as a template database
datallowconn	boolean	If false then 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. **-1** indicates no limit.
datlastsysoid	oid	Last system OID in the database
datfrozenxid	xid32	Tracks whether the database needs to be vacuumed in order to prevent transaction ID wraparound. 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
datacl	aclitem[]	Access permissions
datfrozenxid64	xid	Tracks whether the database needs to be vacuumed in order to prevent transaction ID wraparound.

15.2.23 PG_DB_ROLE_SETTING

PG_DB_ROLE_SETTING records the default values of configuration items bonded to each role and database when the database is running.

Table 15-23 PG_DB_ROLE_SETTING columns

Name	Type	Description
setdatabase	oid	Database corresponding to the configuration items; the value is **0** if the database is not specified
setrole	oid	Role corresponding to the configuration items; the value is **0** if the role is not specified
setconfig	text[]	Default value of configuration items when the database is running

15.2.24 PG_DEFAULT_ACL

PG_DEFAULT_ACL records the initial privileges assigned to the newly created objects.

Table 15-24 PG_DEFAULT_ACL columns

Name	Type	Description
defaclrole	oid	ID of the role associated with the permission
defaclnamespace	oid	Namespace associated with the permission; the value is **0** if no ID
defaclobjtype	"char"	Object type of the permission: • **r** indicates a table or view. • **S** indicates a sequence. • **f** indicates a function. • **T** indicates a type.
defaclacl	aclitem[]	Access permissions that this type of object should have on creation

Examples

Run the following command to view the initial permissions of the new user **role1**:

```
select * from PG_DEFAULT_ACL;
 defaclrole | defaclnamespace | defaclobjtype |    defaclacl
------------+-----------------+---------------+-----------------
      16820 |           16822 | r             | {role1=r/user1}
```

You can also run the following statement to convert the format:

```
SELECT pg_catalog.pg_get_userbyid(d.defaclrole) AS "Granter",  n.nspname AS "Schema",  CASE d.defaclobjtype WHEN 'r' THEN 'table' WHEN 'S' THEN 'sequence' WHEN 'f' THEN 'function' WHEN 'T' THEN 'type' END AS "Type",  pg_catalog.array_to_string(d.defaclacl, E', ') AS "Access privileges" FROM pg_catalog.pg_default_acl d LEFT JOIN pg_catalog.pg_namespace n ON n.oid = d.defaclnamespace ORDER BY 1, 2, 3;
```

If the following information is displayed, **user1** grants **role1** the read permission on schema **user1**.

```
 Granter | Schema | Type  | Access privileges
---------+--------+-------+-------------------
 user1   | user1  | table | role1=r/user1
(1 row)
```

15.2.25 PG_DEPEND

PG_DEPEND records the dependency relationships 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 **PG_SHDEPEND**, which provides similar functionality for recording dependencies between objects that are shared between database clusters.

Table 15-25 PG_DEPEND columns

Name	Type	Reference	Description
classid	oid	PG_CLASS.oid	OID of the system catalog the dependent object is in
objid	oid	Any OID column	OID of the specific dependent object
objsubid	integer	-	For a table column, this is the column number (the objid and classid refer to the table itself). For all other object types, this column is **0**.
refclassid	oid	PG_CLASS.oid	OID of the system catalog the referenced object is in
refobjid	oid	Any OID column	OID of the specific referenced object
refobjsubid	integer	-	For a table column, this is the column number (the refobjid and refclassid refer to the table itself). For all other object types, this column is **0**.
deptype	"char"	-	A code defining the specific semantics of this dependency relationship

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 defined 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. For example, a trigger used to enforce a foreign key constraint is set to an item internally dependent on its constraint in **PG_CONSTRAINT**.
- DEPENDENCY_EXTENSION (e): The dependent object is a member of the extension that is the referenced object. (For details, see **PG_EXTENSION**). The

dependent object can be dropped 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 with dependent object are all zeroes.

Examples

Query the table that depends on the database object sequence **serial1**:

1. Query the OID of the sequence **serial1** in the system catalog **PG_CLASS**.

```
SELECT oid FROM pg_class WHERE relname ='serial1';
 oid
-------
 17815
(1 row)
```

2. Use the system catalog **PG_DEPEND** and the OID of **serial1** to obtain the objects that depend on **serial1**.

```
SELECT * FROM pg_depend WHERE objid ='17815';
 classid | objid | objsubid | refclassid | refobjid | refobjsubid | deptype
---------+-------+----------+------------+----------+-------------+---------
    1259 | 17815 |        0 |       2615 |     2200 |           0 | n
    1259 | 17815 |        0 |       1259 |    17812 |           1 | a
(2 rows)
```

3. Obtain the OID of the table that depends on the serial1 sequence based on the refobjid field and query the table name. The result indicates that the table **customer_address** depends on **serial1**.

```
SELECT relname FROM pg_class where oid='17812';
     relname
------------------
 customer_address
(1 row)
```

15.2.26 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**.

See also **PG_SHDESCRIPTION**, which performs a similar function for descriptions involving objects that are shared across a database cluster.

Table 15-26 PG_DESCRIPTION columns

Name	Type	Reference	Description
objoid	oid	Any OID column	OID of the object this description pertains to
classoid	oid	**PG_CLASS**.oid	OID of the system catalog this object appears in

Name	Type	Reference	Description
objsubid	integer	-	For a comment on a table column, this is the column number (the **objoid** and **classoid** refer to the table itself). For all other object types, this column is **0**.
description	text	-	Arbitrary text that serves as the description of this object

15.2.27 PG_ENUM

PG_ENUM records entries showing the values and labels for each enum type. The internal representation of a given enum value is actually the OID of its associated row in **pg_enum**.

Table 15-27 PG_ENUM columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
enumtypid	oid	PG_TYPE.oid	OID of the **pg_type** entry that contains this enum value
enumsortorder	real	-	Sort position of this enum value within its enum type
enumlabel	name	-	Textual label for this enum 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 enum type. That is, if two even OIDs belong to the same enum 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 enum comparison routines to avoid catalog lookups in many common cases. The routines that create and alter enum types attempt to assign even OIDs to enum values whenever possible.

When an enum type is created, its members are assigned sort-order positions from 1 to *n*. But 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 enum type.

15.2.28 PG_EXCEPT_RULE

The **PG_EXCEPT_RULE** system catalog stores information about exception rules. An exception rule set consists of multiple exception rules with the same name.

Table 15-28 PG_EXCEPT_RULE

Name	Type	Description
name	name	Name of an exception rule set.
rule	name	Type of a rule in the exception rule set, or action taken when the current exception rule set is triggered. (For example, it can be **blocktime**, **elapsedtime**, **spillsize**, or an action taken after an exception rule is triggered.)
value	name	Rule threshold corresponding to the exception rule. If it specifies the action taken after an exception rule is triggered, its value is **abort**.

15.2.29 PG_EXTENSION

PG_EXTENSION records information about the installed extensions. By default, GaussDB(DWS) has 12 extensions, that is, PLPGSQL, DIST_FDW, FILE_FDW, HDFS_FDW, HSTORE, PLDBGAPI, DIMSEARCH, PACKAGES, GC_FDW, UUID-OSSP, LOG_FDW, and ROACH_API.

Table 15-29 PG_EXTENSION

Name	Type	Description
extname	name	Extension name
extowner	oid	Owner of the extension
extnamespace	oid	Namespace containing the extension's exported objects
extrelocatable	boolean	Its value is **true** if the extension can be relocated to another schema.
extversion	text	Version number of the extension
extconfig	oid[]	Configuration information about the extension
extcondition	text[]	Filter conditions for the extension's configuration information

15.2.30 PG_EXTENSION_DATA_SOURCE

PG_EXTENSION_DATA_SOURCE records information about external data source. An external data source contains information about an external database, such as its password encoding. It is mainly used with Extension Connector.

Table 15-30 PG_EXTENSION_DATA_SOURCE columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
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	-	Type of an external data source. It is NULL by default.
srcacl	aclitem[]	-	Access permissions
srcoptions	text[]	-	Option used for foreign data sources. It is a keyword=value string.

15.2.31 PG_FINE_DR_INFO

The **PG_FINE_DR_INFO** system catalog records the replay status of the fine-grained DR standby table. This system catalog is supported only by clusters of version 8.2.0.100 or later.

Table 15-31 PG_FINE_DR_INFO columns

Name	Type	Description
oid	oid	Row identifier (hidden attribute; displayed only when explicitly selected)
relid	oid	OID of the standby fine-grained DR table
lastcsn	xid	CSN of the last successful playback
lastxmin	xid	xmin of the last successful playback
lastxmax	xid	xmax of the last successful playback
laststarttime	timestamp with time zone	Start time of the last successful playback
lastendtime	timestamp with time zone	End time of the last successful playback

Examples

Check the playback status of the standby table in the DR cluster.


```
SELECT * FROM pg_fine_dr_info;
 relid | lastcsn | lastxmin | lastxmax |         laststarttime         |          lastendtime
-------+---------+----------+----------+-------------------------------+-------------------------------
 21132 | 1251610 |  1251609 |  1251611 | 2023-01-04 20:51:58.375136+08 | 2023-01-04 20:51:58.393986+08
(1 row)
```

15.2.32 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.

Table 15-32 PG_FOREIGN_DATA_WRAPPER columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
fdwname	name	-	Name of the foreign-data wrapper
fdwowner	oid	PG_AUTHID.oid	Owner of the foreign-data wrapper
fdwhandler	oid	PG_PROC.oid	References a handler function that is responsible for supplying execution routines for the foreign-data wrapper. Its value is **0** if no handler is provided.
fdwvalidator	oid	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. Its value is **0** if no validator is provided.
fdwacl	aclitem[]	-	Access permissions
fdwoptions	text[]	-	Option used for foreign data wrappers. It is a keyword=value string.

15.2.33 PG_FOREIGN_SERVER

PG_FOREIGN_SERVER records the 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 15-33 PG_FOREIGN_SERVER columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
srvname	name	-	Name of the foreign server
srvowner	oid	**PG_AUTHID**.oid	Owner of the foreign server
srvfdw	oid	**PG_FOREIGN_DATA_WRAPPER**.oid	OID of the foreign-data wrapper of 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. It is a keyword=value string.

15.2.34 PG_FOREIGN_TABLE

PG_FOREIGN_TABLE records auxiliary information about foreign tables.

Table 15-34 PG_FOREIGN_TABLE columns

Name	Type	Description
ftrelid	oid	OID of the foreign table
ftserver	oid	OID of the server where the foreign table is located
ftwriteonly	boolean	Whether data can be written in the foreign table
ftoptions	text[]	Foreign table options

15.2.35 PG_INDEX

PG_INDEX records part of the information about indexes. The rest is mostly in **PG_CLASS**.

Table 15-35 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 this index is for
indnatts	smallint	Number of columns in an index
indisunique	boolean	This index is a unique index if the value is **true**.
indisprimary	boolean	This index represents the primary key of the table if the value is **true**. If this value is **true**, the value of **indisunique** is true.
indisexclusion	boolean	This index supports exclusion constraints if the value is **true**.
indimmediate	boolean	A uniqueness check is performed upon data insertion if the value is **true**.
indisclustered	boolean	The table was last clustered on this index if the value is **true**.
indisusable	boolean	This index supports insert/select if the value is **true**.
indisvalid	boolean	This index is valid for queries if the value is **true**. If this column is **false**, this 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.
indcheckxmin	boolean	If the value is **true**, queries must not use the index until the xmin of this row in **pg_index** is below their **TransactionXmin** event horizon, because the table may contain broken HOT chains with incompatible rows that they can see.
indisready	boolean	If the value is **true**, this index is ready for inserts. If the value is **false**, this index is ignored when data is inserted or modified.
indkey	int2vector	This is an array of **indnatts** values that indicate which table columns this index creates. For example, a value of **1 3** means that the first and the third columns make up the index key. **0** in this array indicates that the corresponding index attribute is an expression over the table columns, rather than a simple column reference.

Name	Type	Description
indcollation	oidvector	ID of each column used by the index
indclass	oidvector	For each column in the index key, this column contains the OID of the operator class to use. For details, see **PG_OPCLASS**.
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_tree	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**. NULL if all index attributes are simple references.
indpred	pg_node_tree	Expression tree (in **nodeToString()** representation) for partial index predicate. If the index is not a partial index, the value is null.
indnullstreatment	tinyint	Processing mode of the **NULL** value in the unique index. This field is valid only if **indisunique** is set to **true**. Options: • **0**: **NULLS DISTINCT**. **NULL** values are not equivalent and can be inserted repeatedly. • **1**: **NULLS NOT DISTINCT**. **NULL** values are equivalent and cannot be inserted repeatedly. • **2**: **NULLS IGNORE**. **NULL** columns are ignored during equivalent comparison. If all index columns are **NULL**, **NULL** values can be inserted repeatedly. If part of the index columns are **NULL**, data can be inserted only if non-null values are different. Default value: **0** **NOTE** • If the current cluster was upgraded from an earlier version to 8.2.0.100, the value of this field is **NULL** for existing indexes. For newly created indexes, the value of this field is determined by the **[NULLS [NOT] DISTINCT | NULLS IGNORE]** field. The default value is **0**. • If the current cluster is newly installed and its version is 8.2.0.100, for newly created indexes, the value of this field is determined by the **[NULLS [NOT] DISTINCT | NULLS IGNORE]** field. The default value is **0**.

15.2.36 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 15-36 PG_INHERITS columns

Name	Type	Reference	Description
inhrelid	oid	PG_CLASS.oid	OID of the child table
inhparent	oid	PG_CLASS.oid	OID of the 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.

15.2.37 PG_JOBS

PG_JOBS records detailed information about jobs created by users. Dedicated threads poll the **pg_jobs** table and trigger jobs based on scheduled job execution time. This table belongs to the Shared Relation category. All job records are visible to all databases.

Table 15-37 PG_JOBS columns

Name	Type	Description
job_id	integer	Job ID, primary key, unique (with a unique index)
what	text	Job content
log_user	oid	Username of the job creator
priv_user	oid	User ID of the job executor
job_db	oid	OID of the database where the job is executed
job_nsp	oid	OID of the namespace where a job is running
job_node	oid	CN node on which the job will be created and executed

Name	Type	Description
is_broken	boolean	Indicates whether the current job is invalid.
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 consecutive failures.
interval	text	Job execution interval
last_start_date	timestamp without time zone	Start time of the last job execution, accurate to millisecond
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

15.2.38 PG_LANGUAGE

PG_LANGUAGE records programming languages. You can use them and interfaces to write functions or stored procedures.

Table 15-38 PG_LANGUAGE columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
lanname	name	-	Name of the language
lanowner	oid	PG_AUTHID.oid	Owner of the language

Name	Type	Reference	Description
lanispl	boolean	-	The value is **false** for internal languages (such as SQL) and **true** for user-defined languages. Currently, **gs_dump** still uses this to determine which languages need to be dumped, but this might be replaced by a different mechanism in the future.
lanpltrusted	boolean	-	Its 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.
lanplcallfoid	oid	PG_PROC.oid	For external languages, this references the language handler, which is a special function that is responsible for executing all functions that are written in the particular language.
laninline	oid	PG_PROC.oid	This references a function that is responsible for executing "inline" anonymous code blocks (DO blocks). The value is **0** if inline blocks are not supported.
lanvalidator	oid	PG_PROC.oid	This references a language validator function that is 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 permissions

15.2.39 PG_LARGEOBJECT

PG_LARGEOBJECT records the 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 to be LOBLKSIZE (which is currently BLCKSZ/4, or typically 2 kB).

It is accessible only to users with system administrator rights.

Table 15-39 PG_LARGEOBJECT columns

Name	Type	Reference	Description
loid	oid	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	-	Actual 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 are read as zeroes.

15.2.40 PG_LARGEOBJECT_METADATA

PG_LARGEOBJECT_METADATA records metadata associated with large objects. The actual large object data is stored in **PG_LARGEOBJECT**.

Table 15-40 PG_LARGEOBJECT_METADATA columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
lomowner	oid	PG_AUTHID.oid	Owner of the large object
lomacl	aclitem[]	-	Access permissions

15.2.41 PG_MATVIEW

PG_MATVIEW provides the materialized view information of the current node. This view is supported only by clusters of 8.3.0 and later versions.

Table 15-41 PG_MATVIEW columns

Column	Type	Description
mvid	oid	OID of the materialized view.

build_mode	char	Build mode of the materialized view. • **'d'**: indicates "deferred", which means that data is contained in the materialized view only when the view is refreshed for the first time. • **'i'**: indicates "immediate", which means that the latest data is included when the materialized view is created.
refresh_method	char	**'c'** indicates that the data is completely refreshed.
refresh_mode	char	Refresh mode of the materialized view. **'d'**: indicates manual refresh. '**a**': indicates that the materialized view is always active and is automatically refreshed in the background.
rewrite_enable	boolean	Indicates whether query rewriting of the materialized view is supported.
active	boolean	Indicates whether the materialized view needs to be refreshed.
relnum	Int	Number of materialized view base tables.
start_time	timestamptz	Time when the materialized view is refreshed for the first time. If this parameter is left blank, the first refresh time is the current time plus the interval.
interval	interval	Interval for refreshing the materialized view.
refresh_time	timestamptz	Last refresh time of the materialized view.

15.2.42 PG_NAMESPACE

PG_NAMESPACE records the namespaces, that is, schema-related information.

Table 15-42 PG_NAMESPACE columns

Name	Type	Description
nspname	name	Name of the 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 permissions For details, see GRANT and REVOKE.

Name	Type	Description
permspace	bigint	Quota of a schema's permanent tablespace
usedspace	bigint	Used size of a schema's permanent tablespace

15.2.43 PG_OBJECT

PG_OBJECT records the user creation, creation time, last modification time, and last analyzing time of objects of specified types (types existing in **object_type**).

Table 15-43 PG_OBJECT columns

Name	Type	Description
object_oid	oid	Object identifier.
object_type	"char"	Object type: • **r** indicates a table, which can be an ordinary table or a temporary table. • **i** indicates an index. • **s** indicates a sequence. • **v** indicates a view. • **p** indicates a stored procedure and function. • **f** indicates a foreign table.
creator	oid	ID of the creator.
ctime	timestamp with time zone	Object creation time.
mtime	timestamp with time zone	Time when the object was last modified. By default, the **ALTER**, **COMMENT**, **GRANT/REVOKE**, and **TRUNCATE** operations are recorded. **object_mtime_record_mode** can be used to control whether **ALTER**, **COMMENT**, **GRANT**/**REVOKE**, and **TRUNCATE** operations are recorded.
last_analyze_time	timestamp with time zone	Time when an object is analyzed for the last time.

NOTICE

- Only normal user operations are recorded. Operations before the object upgrade and during the **initdb** process cannot be recorded.
- **ctime** and **mtime** are the start time of the transaction.
- The time of object modification due to capacity expansion is also recorded.

15.2.44 PG_OBSSCANINFO

PG_OBSSCANINFO defines the OBS runtime information scanned in cluster acceleration scenarios. Each record corresponds to a piece of runtime information of a foreign table on OBS in a query.

Table 15-44 PG_OBSSCANINFO columns

Name	Type	Reference	Description
query_id	bigint	-	Query ID
user_id	text	-	Database user who performs queries
table_name	text	-	Name of a foreign table on OBS
file_type	text	-	Format of files storing the underlying data
time_stamp	time_stam	-	Scanning start time
actual_time	double	-	Scanning execution time, in seconds
file_scanned	bigint	-	Number of files scanned
data_size	double	-	Size of data scanned, in bytes
billing_info	text	-	Reserved columns

15.2.45 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 lefthand input.

Table 15-45 PG_OPCLASS columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
opcmethod	oid	**PG_AM**.oid	Index access method the operator class is for
opcname	name	-	Name of the operator class
opcnamespace	oid	**PG_NAMESPACE**.oid	Namespace to which the operator class belongs
opcowner	oid	**PG_AUTHID**.oid	Owner of the operator class
opcfamily	oid	**PG_OPFAMILY**.oid	Operator family containing the operator class
opcintype	oid	**PG_TYPE**.oid	Data type that the operator class indexes
opcdefault	boolean	-	Whether the operator class is the default for **opcintype**. If it is, its value is **true**.
opckeytype	oid	**PG_TYPE**.oid	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. Also, there must be no more than one **pg_opclass** row having **opcdefault** true for any given combination of **opcmethod** and **opcintype**.

15.2.46 PG_OPERATOR

PG_OPERATOR records information about operators.

Table 15-46 PG_OPERATOR columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
oprname	name	-	Name of the operator
oprnamespace	oid	**PG_NAMESPACE**.oid	OID of the namespace that contains this operator
oprowner	oid	**PG_AUTHID**.oid	Owner of the operator

Name	Type	Reference	Description
oprkind	"char"	-	• **b**: infix ("both") • **l**: prefix ("left") • **r**: postfix ("right")
oprcanmerge	boolean	-	Whether the operator supports merge joins
oprcanhash	boolean	-	Whether the operator supports hash joins
oprleft	oid	**PG_TYPE**.oid	Type of the left operand
oprright	oid	**PG_TYPE**.oid	Type of the right operand
oprresult	oid	**PG_TYPE**.oid	Type of the result
oprcom	oid	**PG_OPERATOR**.oid	Commutator of this operator, if any
oprnegate	oid	**PG_OPERATOR**.oid	Negator of this operator, if any
oprcode	regproc	**PG_PROC**.oid	Function that implements this operator
oprrest	regproc	**PG_PROC**.oid	Restriction selectivity estimation function for this operator
oprjoin	regproc	**PG_PROC**.oid	Join selectivity estimation function for this operator

15.2.47 PG_OPFAMILY

PG_OPFAMILY defines operator families.

Each operator family is a collection of operators and associated support routines that implement the 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 concept allows cross-data-type operators to be used with indexes and to be reasoned about using knowledge of access method semantics.

Table 15-47 PG_OPFAMILY columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)

Name	Type	Reference	Description
opfmethod	oid	PG_AM.oid	Index access method the operator family is for
opfname	name	-	Name of the operator family
opfnamespace	oid	PG_NAMESPACE.oid	Namespace of the operator family
opfowner	oid	PG_AUTHID.oid	Owner of the operator family

The majority of the information defining an operator family is not in **PG_OPFAMILY**, but in the associated **PG_AMOP**, **PG_AMPROC**, and **PG_OPCLASS**.

15.2.48 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 **PG_PARTITION** system catalog.

Table 15-48 PG_PARTITION columns

Name	Type	Description
relname	name	Names of the partitioned tables, table partitions, TOAST tables on table partitions, and index partitions
parttype	"char"	Object type • **r** indicates a partitioned table. • **p** indicates a table partition. • **x** indicates an index partition. • **t** indicates a TOAST table.
parentid	oid	OID of the partitioned table in **PG_CLASS** when the object is a partitioned table or table partition OID of the partitioned index when the object is an index partition
rangenum	integer	Reserved field.
intervalnum	integer	Reserved field.
partstrategy	"char"	Partition policy of the partitioned table. The following policies are supported: **r** indicates the range partition. **v** indicates the numeric partition. **l**: indicates the list partition.

Name	Type	Description
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, 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
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 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
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

Name	Type	Description
reloptions	text[]	Storage property of a partition used for collecting online scale-out information. Same as **pg_class.reloptions**, it is a keyword=value string.
relfrozenxid64	xid	Frozen transaction ID
boundexprs	pg_node_tree	Partition boundary expression. ● For range partitioning, it is the upper boundary expression of a partition. ● For list partitioning, it is a collection of partition boundary enumeration values. The **pg_node_tree** data is not readable. You can use the expression **pg_get_expr** to translate the current column into readable information. SELECT pg_get_expr(boundexprs, 0) FROM pg_partition WHERE relname = 'country_202201'; pg_get_expr --- ROW(202201, 'city1'::text), ROW(202201, 'city2'::text) (1 row)

Example

Query the partition information of the partitioned table **web_returns_p2**.

```
CREATE TABLE web_returns_p2
(
    wr_returned_date_sk       integer,
    wr_returned_time_sk       integer,
    wr_item_sk                integer NOT NULL,
    wr_refunded_customer_sk   integer
)
WITH (orientation = column)
DISTRIBUTE BY HASH (wr_item_sk)
PARTITION BY RANGE(wr_returned_date_sk)
(
    PARTITION p2016 START(20161231) END(20191231) EVERY(10000),
    PARTITION p0 END(maxvalue)
);

SELECT oid FROM pg_class WHERE relname ='web_returns_p2';
  oid
-------
 97628

SELECT relname,parttype,parentid,boundaries FROM pg_partition WHERE parentid = '97628';
    relname     | parttype | parentid | boundaries
----------------+----------+----------+------------
 web_returns_p2 | r        |    97628 |
 p2016_0        | p        |    97628 | {20161231}
 p2016_1        | p        |    97628 | {20171231}
 p2016_2        | p        |    97628 | {20181231}
 p2016_3        | p        |    97628 | {20191231}
 p0             | p        |    97628 | {NULL}
(6 rows)
```


15.2.49 PG_PLTEMPLATE

PG_PLTEMPLATE records template information for procedural languages.

Table 15-49 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.
tmpldbacreate	boolean	The value is **true** if the language is created by the owner of the database.
tmplhandler	text	Name of the call handler function
tmplinline	text	Name of the anonymous block handler. If no name of the block handler exists, the value is null.
tmplvalidator	text	Name of the verification function. If no verification function is available, the value is null.
tmpllibrary	text	Path of the shared library that implements languages
tmplacl	aclitem[]	Access permissions for template (not yet used)

15.2.50 PG_PROC

PG_PROC records information about functions or procedures.

Table 15-50 PG_PROC columns

Name	Type	Description
proname	name	Name of the function
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	Estimate number of result rows

Name	Type	Description
provariadic	oid	Data type of parameter element
protransform	regproc	Simplified call method for this function
proisagg	boolean	Whether this function is an aggregate function
proiswindow	boolean	Whether this function is a window function
prosecdef	boolean	Whether this function is a security definer (such as a "setuid" function)
proleakproof	boolean	Whether this function has side effects. If no leakproof treatment is provided for parameters, the function throws errors.
proisstrict	boolean	The function returns null if any call parameter is null. In that case the function does not actually be called at all. Functions that are not "strict" must be prepared to process null inputs.
proretset	boolean	The function returns a set, that is, multiple values of the specified data type.
provolatile	"char"	Whether the function's result depends only on its input parameters, or is affected by outside factors ● It is **i** for "immutable" functions, which always deliver the same result for the same inputs. ● It is **s** for "stable" functions, whose results (for fixed inputs) do not change within a scan. ● It is **v** for "volatile" functions, whose results may change at any time.
pronargs	smallint	Number of parameters
pronargdefaults	smallint	Number of parameters that have default values
prorettype	oid	OID of the returned parameter type
proargtypes	oidvector	Array with the data types of the function parameters. This array includes only input parameters (including **INOUT** parameters) and thus represents the call signature of the function.

Name	Type	Description
proallargtypes	oid[]	Array with the data types of the 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, and **proargtypes** is subscripted from 0.
proargmodes	"char"[]	Array with the modes of the function parameters. ● **i** indicates **IN** parameters. ● **o** indicates **OUT** parameters. ● **b** indicates **INOUT** parameters. If all the parameters are **IN** parameters, this column is null. Note that subscripts of this array correspond to positions of **proallargtypes** not **proargtypes**.
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 calling 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 permissions For details, see GRANT and REVOKE.
prodefaultargpos	int2vector	Locations of the function default values. Not only the last few parameters have default values.

Name	Type	Description
fencedmode	boolean	Execution mode of a function, indicating whether a 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. The default value is **fence**.
proshippable	boolean	Whether a function can be pushed down to DNs. The default value is **false**. • Functions of the IMMUTABLE type can always be pushed down to the DNs. • Functions of the STABLE or VOLATILE type can be pushed down to DNs only if their attribute is **SHIPPABLE**.
propackage	boolean	Indicates whether the function supports overloading, which is mainly used for the Oracle style function. The default value is **false**.

Examples

Query the OID of a specified function. For example, obtain the OID **1295** of the **justify_days** function.

```
SELECT oid FROM pg_proc where proname ='justify_days';
 oid
------
 1295
(1 row)
```

Query whether a function is an aggregate function. For example, the **justify_days** function is a non-aggregate function.

```
SELECT proisagg FROM pg_proc where proname ='justify_days';
 proisagg
----------
 f
(1 row)
```

15.2.51 PG_PUBLICATION

PG_PUBLICATION records all the publications created in the current database. This system catalog is supported only by clusters of version 8.2.0.100 or later.

Table 15-51 PG_PUBLICATION columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; displayed only when explicitly selected)
pubname	name	-	Publication name

Name	Type	Reference	Description
pubowner	oid	PG_AUTHID.oid	Publication owner
puballtables	boolean	-	If its value is **true**, the publication includes all the tables in the database, including any tables that will be created in the future.
pubinsert	boolean	-	If its value is **true**, the INSERT operation is copied for the tables in the publication.
pubupdate	boolean	-	If its value is **true**, the UPDATE operation is copied for the tables in the publication.
pubdelete	boolean	-	If its value is **true**, the DELETE operation is copied for the tables in the publication.
pubtruncate	boolean	-	If its value is **true**, the TRUNCATE operation is copied for the tables in the publication.

Examples

View all releases.

```
SELECT * FROM pg_publication;
 pubname | pubowner | puballtables | pubinsert | pubupdate | pubdelete | pubtruncate
---------+----------+--------------+-----------+-----------+-----------+-------------
 mypub   |       10 | t            | t         | t         | t         | t
(1 row)
```

15.2.52 PG_PUBLICATION_NAMESPACE

PG_PUBLICATION_NAMESPACE records the mapping between publications and schemas in the current database, which is a many-to-many mapping. This system catalog is supported only by clusters of version 8.2.0.100 or later.

Table 15-52 PG_PUBLICATION_NAMESPACE columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; displayed only when explicitly selected)
prpubid	oid	PG_PUBLICATION.oid	Publication OID in the mapping
pnnspid	oid	PG_NAMESPACE.oid	Schema OID in the mapping

Examples

View all mappings between publications and schemas.

```
SELECT * FROM pg_publication_namespace;
 pnpubid | pnnspid
---------+---------
   16797 |   16796
(1 row)
```

15.2.53 PG_PUBLICATION_REL

PG_PUBLICATION_REL records the mapping between publications and tables in the current database, which is a many-to-many mapping. This system catalog is supported only by clusters of version 8.2.0.100 or later.

NOTE

To check detailed information, you are advised to use the **PG_PUBLICATION_TABLES** view.

Table 15-53 PG_PUBLICATION_REL columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; displayed only when explicitly selected)
prpubid	oid	**PG_PUBLICATION**.oid	Publication OID in the mapping
prrelid	oid	**PG_CLASS**.oid	OID of the mapped table

Examples

View all mappings between publications and tables.

```
postgres=# SELECT * FROM pg_publication_rel;
 prpubid | prrelid
---------+---------
   16797 |   16757
   16797 |   16776
(2 rows)
```

15.2.54 PG_RANGE

PG_RANGE records information about range types.

This is in addition to the types' entries in **PG_TYPE**.

Table 15-54 PG_RANGE columns

Name	Type	Reference	Description
rngtypid	oid	**PG_TYPE**.oid	OID of the range type

Name	Type	Reference	Description
rngsubtype	oid	PG_TYPE.oid	OID of the element type (subtype) of this range type
rngcollation	oid	PG_COLLATION.oid	OID of the collation used for range comparisons, or 0 if none
rngsubopc	oid	PG_OPCLASS.oid	OID of the subtype's operator class used for range comparisons
rngcanonical	regproc	PG_PROC.oid	OID of the function to convert a range value into canonical form, or 0 if none
rngsubdiff	regproc	PG_PROC.oid	OID of the function to return the difference between two element values as **double precision**, or 0 if none

rngsubopc (plus **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.

15.2.55 PG_REDACTION_COLUMN

PG_REDACTION_COLUMN records the information about the redacted columns.

Table 15-55 PG_REDACTION_COLUMN columns

Name	Type	Description
object_oid	oid	OID of the object to be redacted.
column_attrno	smallint	**attrno** of the redacted column.
function_type	integer	Redaction type. **NOTE** This column is reserved. It is used only for forward compatibility of redacted column information in earlier versions. The value can be **0** (NONE) or **1** (FULL).
function_parameters	text	Parameters used when the redaction type is **partial** (reserved).

Name	Type	Description
regexp_pattern	text	Pattern string when the redaction type is **regexp** (reserved).
regexp_replace_string	text	Replacement string when the redaction type is **regexp** (reserved).
regexp_position	integer	Start and end replacement positions when the redaction type is **regexp** (reserved).
regexp_occurrence	integer	Replacement times when the redaction type is **regexp** (reserved).
regexp_match_parameter	text	Regular control parameter used when the redaction type is **regexp** (reserved).
column_description	text	Description of the redacted column.
function_expr	pg_node_tree	Internal representation of the redaction function.
inherited	bool	Whether a redacted column is inherited from another redacted column.
policy_oid	oid	OID of the masking policy. Supported by clusters of 8.2.1.100 and later versions. It is used to search for masked column information from the metadata in the system catalog.

15.2.56 PG_REDACTION_POLICY

PG_REDACTION_POLICY records information about the object to be redacted.

Table 15-56 PG_REDACTION_POLICY columns

Name	Type	Description
object_oid	oid	OID of the object to be redacted.
policy_name	name	Name of the redaction policy.
enable	boolean	Policy status (enabled or disabled). **NOTE** The value can be: • **true**: enabled • **false**: disabled
expression	pg_node_tree	Policy effective expression (for users).
policy_description	text	Description of a policy.
inherited	bool	Whether a redaction policy is inherited from another redaction policy.
policy_order	float4	Masking policy sequence. This field is supported by 8.2.1.100 and later cluster versions.

15.2.57 PG_RELFILENODE_SIZE

The **PG_RELFILENODE_SIZE** system catalog provides file-level space statistics. Each record in the table corresponds to a physical file on the disk and the size of the file.

Table 15-57 PG_RELFILENODE_SIZE columns

Name	Type	Description
databaseid	oid	OID of the database that the physical file belongs to If a system catalog is shared across databases, its value is **0**.
tablespaceid	oid	Tablespace OID of the physical file
relfilenode	oid	Serial number of the physical file
backendid	integer	ID of the background thread that creates the physical file. Generally, the value is **-1**.

Name	Type	Description
type	integer	Type of the physical file. • The value **0** indicates a data file. • The value **1** indicates an FSM file. • The value **2** indicates a VM file. • The value **3** indicates a BCM file. • If the value greater than 4 indicates the total size of the data file and BCM file of the column in a column-store table.
filesize	bigint	Size of the physical file, in bytes.

15.2.58 PG_RLSPOLICY

PG_RLSPOLICY displays the information about row-level access control policies.

Table 15-58 PG_RLSPOLICY columns

Name	Type	Description
polname	name	Name of a row-level access control policy
polrelid	oid	Table OID of a row-level access control policy
polcmd	char	SQL operations affected by a row-level access control policy. The options are ***(ALL)**, **r(SELECT)**, **w(UPDATE)**, and **d(DELETE)**.
polpermissive	boolean	Type of a row-level access control policy **NOTE** Values of **polpermissive**: • **true**: The row-level access control policy is a permissive policy. • **false**: The row-level access control policy is a restrictive policy.
polroles	oid[]	OID of database user affected by a row-level access control policy
polqual	pg_node_tree	SQL condition expression of a row-level access control policy

15.2.59 PG_RESOURCE_POOL

PG_RESOURCE_POOL records the information about database resource pool.

Table 15-59 PG_RESOURCE_POOL columns

Name	Type	Description
respool_name	name	Name of the resource pool
mem_percent	integer	Configured memory percentage. **0** indicates that the memory of the resource pool is not controlled.
cpu_affinity	bigint	Reserved column without an actual meaning
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 number of concurrent simple jobs allowed by the resource pool. **-1** and **0** indicate that there are no limitations.
memory_limit	name	Estimated memory upper limit for a query.
parentid	oid	OID of the parent resource pool
io_limits	integer	Reserved column without an actual meaning
io_priority	text	Reserved column without an actual meaning
nodegroup	name	Name of the logical cluster associated with the resource pool. The value is **installation** for a non-logical cluster.
is_foreign	boolean	Whether the resource pool can be used for users outside the logical cluster. If it is set to **true**, the resource pool controls the resources of common users who do not belong to the current resource pool.
short_acc	boolean	Whether to enable short query acceleration for a resource pool. This function is enabled by default. • If short query acceleration is enabled, simple queries are controlled on the fast lane. • If short query acceleration is disabled, and simple queries are controlled on the slow lane.

Name	Type	Description
except_rule	text	Exception rule associated with a resource pool. There can be multiple associated rules, which are separated by commas (,).
weight	integer	Resource scheduling weight. Currently, this parameter is used only for network scheduling.

15.2.60 PG_REWRITE

PG_REWRITE records rewrite rules defined for tables and views.

Table 15-60 PG_REWRITE columns

Name	Type	Description
rulename	name	Rule name
ev_class	oid	Name of the table that uses the rule
ev_attr	smallint	Column this rule is for (always **0** to indicate the entire table)
ev_type	"char"	Event type for this rule: • 1 = SELECT • 2 = UPDATE • 3 = INSERT • 4 = DELETE
ev_enabled	"char"	Controls in which mode the rule fires • **O**: The rule fires in "origin" and "local" modes. • **D**: The rule is disabled. • **R**: The rule fires in "replica" mode. • **A**: The rule always fires.
is_instead	boolean	Its value is **true** if the rule is an **INSTEAD** rule.
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

15.2.61 PG_SECLABEL

PG_SECLABEL records security labels on database objects.

See also **PG_SHSECLABEL**, which performs a similar function for security labels of database objects that are shared across a database cluster.

Table 15-61 PG_SECLABEL columns

Name	Type	Reference	Description
objoid	oid	Any OID column	OID of the object this security label pertains to
classoid	oid	PG_CLASS.oid	OID of the system catalog that contains the object
objsubid	integer	-	For a security label on a table column, this is the column number.
provider	text	-	Label provider associated with this label
label	text	-	Security label applied to this object

15.2.62 PG_SHDEPEND

PG_SHDEPEND records the dependency relationships between database objects and shared objects, such as roles. This information allows GaussDB(DWS) to ensure that those objects are unreferenced before attempting to delete them.

See also **PG_DEPEND**, which performs a similar function for dependencies involving objects within a single database.

Unlike most system catalogs, **PG_SHDEPEND** is shared across all databases of a cluster: there is only one copy of **PG_SHDEPEND** per cluster, not one per database.

Table 15-62 PG_SHDEPEND columns

Name	Type	Reference	Description
dbid	oid	PG_DATABASE.oid	OID of the database the dependent object is in. The value is **0** for a shared object.
classid	oid	PG_CLASS.oid	OID of the system catalog the dependent object is in.
objid	oid	Any OID column	OID of the specific dependent object

Name	Type	Reference	Description
objsubid	integer	-	For a table column, this is the column number (the **objid** and **classid** refer to the table itself). For all other object types, this column is **0**.
refclassid	oid	PG_CLASS.oid	OID of the system catalog the referenced object is in (must be a shared catalog)
refobjid	oid	Any OID column	OID of the specific referenced object
deptype	"char"	-	Code segment defining the specific semantics of this dependency relationship. See the following text for details.
objfile	text	-	Path of the 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 defined 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 ACL (access control list, i.e., privileges list) 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 must never be deleted. Entries of this type are created only by **initdb**. The columns for the dependent object contain zeroes.

15.2.63 PG_SHDESCRIPTION

PG_SHDESCRIPTION records optional comments for shared database objects. Descriptions can be manipulated with the **COMMENT** command and viewed with gsql's **\d** commands.

See also **PG_DESCRIPTION**, which performs 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 15-63 PG_SHDESCRIPTION columns

Name	Type	Reference	Description
objoid	oid	Any OID column	OID of the object this description pertains to
classoid	oid	PG_CLASS.oid	OID of the system catalog where the object resides
description	text	-	Arbitrary text that serves as the description of this object

15.2.64 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 **PG_SECLABELS**.

See also **PG_SECLABEL**, which performs 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 15-64 PG_SHSECLABEL columns

Name	Type	Reference	Description
objoid	oid	Any OID column	OID of the object this security label pertains to
classoid	oid	PG_CLASS.oid	OID of the system catalog where the object resides
provider	text	-	Label provider associated with this label
label	text	-	Security label applied to this object

15.2.65 PG_STATISTIC

PG_STATISTIC records statistics about tables and index columns in a database. It is accessible only to users with system administrator rights.

Table 15-65 PG_STATISTIC columns

Name	Type	Description
starelid	oid	Table or index which 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 for 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, not-null data values in the column for all DNs • A value greater than zero is the actual number of distinct values. • A value less than zero 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.) • **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. 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. Value range: 1 to 5
stanumbersN	real[]	Numerical statistics of the appropriate type for Slot N. The value is null if the slot kind does not involve numerical values. 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. Value range: 1 to 5

Name	Type	Description
stadndistinct	real	Number of unique non-null data values in the **dn1** column • A value greater than zero is the actual number of distinct values. • A value less than zero 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.) • **0** indicates that the number of distinct values is unknown.
staextinfo	text	Information about extension statistics (reserved)

15.2.66 PG_STATISTIC_EXT

PG_STATISTIC_EXT records extended statistics about tables in a database. The range of extended statistics to be collected is specified by users. Only system administrators can access this system catalog.

Table 15-66 PG_STATISTIC_EXT columns

Parameter	Type	Description
starelid	oid	Table or index which the described column belongs to
starelkind	"char"	Type of an object
stainherit	boolean	Whether to collect statistics for 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, not-null data values in the column for all DNs • A value greater than zero is the actual number of distinct values. • A value less than zero 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.) • **0** indicates that the number of distinct values is unknown.

Parameter	Type	Description
stadndistinct	real	Number of unique non-null data values in the **dn1** column • A value greater than zero is the actual number of distinct values. • A value less than zero 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.) • **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. 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. Value range: 1 to 5
stakey	int2vector	Array of a column ID
stanumbersN	real[]	Numerical statistics of the appropriate type for Slot N. The value is null if the slot kind does not involve numerical values. 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. Value range: 1 to 5
staexprs	pg_node_tree	Expression corresponding to the extended statistics information.

15.2.67 PG_STAT_OBJECT

Records table statistics and autovacuum efficiency information of the current DB instance, and creates indexes for the **databaseid**, **relid**, and **partid** columns. Update of this system catalog is controlled by the **enable_pg_stat_object** parameter. This system catalog is supported only by clusters of version 8.2.1 or later.

Table 15-67 PG_STAT_OBJECT columns

Column	Type	Reference	Description
databaseid	oid	PG_DATABASE.oid	OID of the database.
relid	oid	PG_CLASS.oid	OID of the table. It is the OID of the primary table for a partitioned table.
partid	oid	PG_PARTITION.oid	Partition OID. For an ordinary table, the value of this column is **0**.
numscans	bigint	-	Number of times that sequential scans are started.
tuples_returned	bigint	-	Number of visible tuples fetched by sequential scans.
tuples_fetched	bigint	-	Number of visible tuples fetched.
tuples_inserted	bigint	-	Number of inserted records.
tuples_updated	bigint	-	Number of updated records.
tuples_deleted	bigint	-	Number of deleted records.
tuples_hot_updated	bigint	-	Number of HOT updates.
n_live_tuples	bigint	-	Number of visible tuples.
last_autovacuum_begin_n_dead_tuple	bigint	-	Number of tuples deleted before Autovacuum is executed.
n_dead_tuples	bigint	-	Number of tuples deleted after Autovacuum is successful.
changes_since_analyze	bigint	-	Last data modification time after Analyze.
blocks_fetched	bigint	-	Number of selected pages.
blocks_hit	bigint	-	Number of scanned pages.
cu_mem_hit	bigint	-	Number of CU memory hits.

Column	Type	Reference	Description
cu_hdd_sync	bigint	-	Times that CUs are synchronously read from disks.
cu_hdd_asyn	bigint	-	Times that CUs are asynchronously read from disks.
data_changed_timestamp	timestamp with time zone	-	Last data modification time.
data_access_timestamp	timestamp with time zone	-	Last access time of a table.
analyze_timestamp	timestamp with time zone	-	Last Analyze time.
analyze_count	bigint	-	Total number of Analyze times.
autovac_analyze_timestamp	timestamp with time zone	-	Last Autoanalyze time.
autovac_analyze_count	bigint	-	Total number of Autoanalyze times.
vacuum_timestamp	timestamp with time zone	-	Time of the latest Vacuum.
vacuum_count	bigint	-	Total number of Vacuum times.
autovac_vacuum_timestamp	timestamp with time zone	-	Last Autovacuum time.
autovac_vacuum_count	bigint	-	Total number of Autovacuum times.
autovacuum_success_count	bigint	-	Total number of successful Autovacuum operations.
last_autovacuum_time_cost	bigint	-	Time spent on the latest successful Autovacuum, in microseconds.
avg_autovacuum_time_cost	bigint	-	Average execution time of successful Autovacuum operations. Unit: μs.
last_autovacuum_failed_count	bigint	-	Total number of autovacuum failures since the last successful Autovacuum.

Column	Type	Reference	Description
last_autovacuum_trigger	smallint	-	Triggering mode of the latest autovacuum, which helps maintenance personnel determine the Vacuum status.
last_autovacuum_oldestxmin	bigint	-	**oldestxmin** after the latest successful Autovacuum execution. If the table-level **oldestxmin** feature is enabled, this field records the value of **oldestxmin** used by the latest **(AUTO)VACUUM** of the table.
last_autovacuum_scan_pages	bigint	-	Number of pages last scanned by autovacuum (only for row-store tables).
last_autovacuum_dirty_pages	bigint	-	Number of pages last modified by Autovacuum (only for row-store tables).
last_autovacuum_clear_deadtuples	bigint	-	Number of dead tuples last cleared by Autovacuum (only for row-store tables)
sum_autovacuum_scan_pages	bigint	-	Total number of pages scanned by Autovacuum since database initialization (only for row-store tables).
sum_autovacuum_dirty_pages	bigint	-	Number of pages modified by Autovacuum since database initialization (only for row-store tables).
sum_autovacuum_clear_deadtuples	bigint	-	Total number of dead tuples cleared by Autovacuum since database initialization (only for row-store tables).
last_autovacuum_begin_cu_size	bigint	-	Size of the CU file before the latest Autovacuum operation (only for column-store tables)
last_autovacuum_cu_size	bigint	-	Size of the CU file after the latest Autovacuum (only for column-store tables)
last_autovacuum_rewrite_size	bigint	-	Size of the column-store file last rewritten by autovacuum (only for column-store tables).

Column	Type	Reference	Description
last_autovacuum_clear_size	bigint	-	Size of the column-store file last cleared by Autovacuum (only for column-store tables).
last_autovacuum_clear_cbtree_tuples	bigint	-	Number of cbtree tuples last cleared by Autovacuum (only for column-store tables)
sum_autovacuum_rewrite_size	bigint	-	Total size of column-store files rewritten by Autovacuum since database initialization (only for column-store tables).
sum_autovacuum_clear_size	bigint	-	Total size of column-store files cleared by Autovacuum since database initialization (only for column-store tables).
sum_autovacuum_clear_cbtree_tuples	bigint	-	Total number of cbtree tuples cleared by Autovacuum since database initialization (only for column-store tables).
last_autovacuum_csn	bigint	-	If the table-level **oldestxmin** feature is enabled, this field records the CSN value corresponding to the latest **oldestxmin** value used by the table **(AUTO)VACUUM**.
extra1	bigint	-	Reserved field 1.
extra2	bigint	-	Reserved field 2.
extra3	bigint	-	Reserved field 3.
extra4	bigint	-	Reserved field 4.

15.2.68 PG_SUBSCRIPTION

PG_SUBSCRIPTION records all existing subscriptions.

Table 15-68 PG_SUBSCRIPTION columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; displayed only when explicitly selected)

Name	Type	Reference	Description
subdbid	oid	PG_DATABASE.oid	OID of the database that the subscription belongs to
subname	name	-	Name of a subscription
subowner	oid	PG_AUTHID.oid	Owner of a subscription
subenabled	boolean	-	If it is **true**, the subscription is enabled and should be replicated.
subconninfo	text	-	Information about the connection to the database at the publisher end
subslotname	text	-	Name of the replication slot in the publisher database If this parameter is left blank, the value is **NONE**.
subpublications	text[]	-	Array of subscribed publication names. These are the references to the publications on the publisher server.

Examples

View all subscriptions.

```
SELECT * FROM pg_subscription;
 subdbid | subname | subowner | subenabled |
subconninfo                                  | subslotname | subpublications
---------+---------+----------+------------
+---------------------------------------------------------------------------------------------+-------------+-----------------
   15992 | mysub   |       10 | t          | host=1.1.1.1,2.2.2.2 port=10000,20000 dbname=postgres user=repusr1
password=password_123 | mysub       | {mypub}
(1 row)
```

15.2.69 PG_SYNONYM

PG_SYNONYM records the mapping between synonym object names and other database object names.

Table 15-69 PG_SYNONYM columns

Name	Type	Description
synname	name	Synonym name.
synnamespace	oid	OID of the namespace where the synonym is located.

Name	Type	Description
synowner	oid	Owner of a 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.

15.2.70 PG_TABLESPACE

PG_TABLESPACE records tablespace information.

Table 15-70 PG_TABLESPACE columns

Name	Type	Description
spcname	name	Name of the tablespace
spcowner	oid	Owner of the tablespace, usually the user who created it
spcacl	aclitem[]	Access permissions For details, see GRANT and REVOKE.
spcoptions	text[]	Specifies options of the tablespace.
spcmaxsize	text	Maximum size of the available disk space, in bytes

15.2.71 PG_TRIGGER

PG_TRIGGER records the trigger information.

Name	Type	Description
tgrelid	oid	OID of the table where the trigger is located.
tgname	name	Trigger name.
tgfoid	oid	Trigger OID.
tgtype	smallint	Trigger type
tgenabled	"char"	**O**: The trigger fires in "origin" or "local" mode. **D**: The trigger is disabled. **R**: The trigger fires in "replica" mode. **A**: The trigger always fires.

Name	Type	Description
tgisinternal	boolean	Internal trigger ID. If the value is true, it indicates an internal trigger.
tgconstrrelid	oid	The table referenced by the integrity constraint
tgconstrindid	oid	Index of the integrity constraint
tgconstraint	oid	OID of the constraint trigger in the **pg_constraint**
tgdeferrable	boolean	The constraint trigger is of the DEFERRABLE type.
tginitdeferred	boolean	whether the trigger is of the INITIALLY DEFERRED type
tgnargs	smallint	Input parameters number 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	Indicates the WHEN condition of the trigger. If the WHEN condition does not exist, the value is null.

15.2.72 PG_TS_CONFIG

PG_TS_CONFIG records 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 **PG_TS_CONFIG_MAP**.

Table 15-71 PG_TS_CONFIG columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
cfgname	name	-	Text search configuration name
cfgnamespace	oid	**PG_NAMESPACE**.oid	OID of the namespace where the configuration resides
cfgowner	oid	**PG_AUTHID**.oid	Owner of the configuration

Name	Type	Reference	Description
cfgparser	oid	PG_TS_PARSER.oid	OID of the text search parser for this configuration
cfoptions	text[]	-	Configuration options

15.2.73 PG_TS_CONFIG_MAP

PG_TS_CONFIG_MAP records 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 15-72 PG_TS_CONFIG_MAP columns

Name	Type	Reference	Description
mapcfg	oid	PG_TS_CONFIG.oid	OID of the PG_TS_CONFIG entry owning this map entry
maptokentype	integer	-	A token type emitted by the configuration's parser
mapseqno	integer	-	Order in which to consult this entry
mapdict	oid	PG_TS_DICT.oid	OID of the text search dictionary to consult

15.2.74 PG_TS_DICT

PG_TS_DICT records 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.

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 15-73 PG_TS_DICT columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
dictname	name	-	Text search dictionary name

Name	Type	Reference	Description
dictnamespace	oid	PG_NAMESPACE.oid	OID of the namespace that contains the dictionary
dictowner	oid	PG_AUTHID.oid	Owner of the dictionary
dicttemplate	oid	PG_TS_TEMPLATE.oid	OID of the text search template for this dictionary
dictinitoption	text	-	Initialization option string for the template

15.2.75 PG_TS_PARSER

PG_TS_PARSER records entries defining text search parsers. A parser splits input text into lexemes and assigns a token type to each lexeme. Since a parser must be implemented by C functions, parsers can be created only by database administrators.

Table 15-74 PG_TS_PARSER columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
prsname	name	-	Text search parser name
prsnamespace	oid	PG_NAMESPACE.oid	OID of the namespace that contains the parser
prsstart	regproc	PG_PROC.oid	OID of the parser's startup function
prstoken	regproc	PG_PROC.oid	OID of the parser's next-token function
prsend	regproc	PG_PROC.oid	OID of the parser's shutdown function
prsheadline	regproc	PG_PROC.oid	OID of the parser's headline function
prslextype	regproc	PG_PROC.oid	OID of the parser's lextype function

15.2.76 PG_TS_TEMPLATE

PG_TS_TEMPLATE records entries defining text search templates. A template provides a framework for text search dictionaries. Since a template must be

implemented by C functions, templates can be created only by database administrators.

Table 15-75 PG_TS_TEMPLATE columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)
tmplname	name	-	Text search template name
tmplnamespace	oid	PG_NAMESPACE.oid	OID of the namespace that contains the template
tmplinit	regproc	PG_PROC.oid	OID of the template's initialization function
tmpllexize	regproc	PG_PROC.oid	OID of the template's lexize function

15.2.77 PG_TYPE

PG_TYPE records the information about data types.

Table 15-76 PG_TYPE columns

Name	Type	Description
typname	name	Data type name
typnamespace	oid	OID of the namespace that contains this type
typowner	oid	Owner of this type
typlen	smallint	Number of bytes in the internal representation of the type for a fixed-size type. But for a variable-length type, **typlen** is negative. • **-1** indicates a "varlena" type (one that has a length word). • **-2** indicates a null-terminated C string.
typbyval	boolean	Whether the value of this type is passed by parameter or reference of this column. **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 the **TYPLEN** is passed by parameter of this column.

Name	Type	Description
typtype	char	• **b** indicates a basic type. • **c** indicates a composite type, for example, a table's row type. • **e** indicates an enumeration type. • **p** indicates a pseudo type. 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	Whether data is converted. It is **true** if conversion is performed when data meets the conversion rules specified by **TYPCATEGORY**.
typisdefined	boolean	The value is **true** if the type is defined. The value is **false** if this is a placeholder entry for a not-yet-defined type. When it is **false**, type name, namespace, and OID are the only dependable objects.
typdelim	"char"	Character that separates two values of this type when parsing array input. Note that the delimiter is associated with the array element data type, not the array data type.
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. The value is **0** for non-composite types.
typelem	oid	If **typelem** is not 0 then it identifies another row in **pg_type**. The current type can be subscripted like an array yielding values of type **typelem**. The current type can then be subscripted like an array yielding values of type **typelem**. A "true" array type is variable length (**typlen** = -1), but some fixed-length (**typlen** > 0) types also have nonzero **typelem**, for example **name** and **point**. If a fixed-length type has a **typelem**, its internal representation must be some 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	Indicates that the corresponding type record is available in **pg_type** if the value is not **0**.
typinput	regproc	Input conversion function (text format)
typoutput	regproc	Output conversion function (text format)

Name	Type	Description
typreceive	regproc	Input conversion function (binary format). If no input conversion function, the value is **0**.
typsend	regproc	output conversion function (binary format). If no output conversion function, the value is **0**.
typmodin	regproc	Type modifier input function. The value is **0** if the type does not support modifiers.
typmodout	regproc	Type modifier output function. The value is **0** if the type does not support modifiers.
typanalyze	regproc	Custom **ANALYZE** function. The value is **0** if the standard function is used.
typalign	char	Alignment required when storing a value of this type. It applies to storage on disk as well as most representations of the value inside PostgreSQL. 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: ● **c**: char alignment, that is, no alignment needed ● **s**: short alignment (2 bytes on most machines) ● **i**: **int** alignment (4 bytes on most machines). ● **d**: **double** alignment (8 bytes on many machines, but by no means all) **NOTICE** 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: ● **p** indicates that values are always stored plain. ● **e**: Value can be stored in a "secondary" relationship (if the relation has one, see **pg_class.reltoastrelid**). ● **m**: Values can be stored compressed inline. ● **x**: Values can be stored compressed inline or stored in secondary storage. **NOTICE** **m** domains can also be moved out to secondary storage, but only as a last resort (**e** and **x** domains are moved first).

Name	Type	Description
typenotnull	boolean	Represents a **NOTNULL** constraint on a type. 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**). The value is **-1** if this type is not a domain.
typndims	integer	Number of array dimensions for a domain that is an array (that is, **typbasetype** is an array type; the domain's **typelem** matches the base type's **typelem**). The value is **0** for types other than domains over array types.
typcollation	oid	Sequence rule for specified types. Sequencing is not supported if the value is 0.
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 null, **typdefault** must contain a human-readable version of the 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 permissions

15.2.78 PG_USER_MAPPING

PG_USER_MAPPING records the mappings from local users to remote.

It is accessible only to users with system administrator rights. You can use view **PG_USER_MAPPINGS** to query common users.

Table 15-77 PG_USER_MAPPING columns

Name	Type	Reference	Description
oid	oid	-	Row identifier (hidden attribute; must be explicitly selected)

Name	Type	Reference	Description
umuser	oid	PG_AUTHID.oid	OID of the local role being mapped, 0 if the user mapping is public
umserver	oid	PG_FOREIGN_SERVER.oid	OID of the foreign server that contains this mapping
umoptions	text[]	-	Option used for user mapping. It is a keyword=value string.

15.2.79 PG_USER_STATUS

PG_USER_STATUS records the states of users that access to the database. It is accessible only to users with system administrator rights.

Table 15-78 PG_USER_STATUS columns

Name	Type	Description
roloid	oid	ID of the role
failcount	integer	Specifies the number of failed attempts.
locktime	timestamp with time zone	Time at which the role is locked
rolstatus	smallint	Role state • **0**: normal • **1** indicates that the role is locked for some time because the failed login attempts exceed the threshold • **2** indicates that the role is locked by the administrator.
permspace	bigint	Size of the permanent table storage space used by a role in the current instance.
tempspace	bigint	Size of the temporary table storage space used by a role in the current instance.

15.2.80 PG_WORKLOAD_ACTION

PG_WORKLOAD_ACTION records information about **query_band**.

Table 15-79 PG_WORKLOAD_ACTION columns

Name	Type	Description
qband	name	**query_band** key-value pairs
class	name	Class of the object associated with **query_band**
object	name	Object associated with **query_band**
action	name	Action of the object associated with **query_band**

15.2.81 PGXC_CLASS

PGXC_CLASS records the replicated or distributed information for each table.

Table 15-80 PGXC_CLASS columns

Name	Type	Description
pcrelid	oid	Table OID
pclocatortype	"char"	Locator type • **H**: hash • **M**: Modulo • **N**: Round Robin • **R**: Replicate
pchashalgorithm	smallint	Distributed tuple using the hash algorithm
pchashbuckets	smallint	Value of a harsh container
pgroup	name	Name of the node group
redistributed	"char"	The table has been redistributed.
redis_order	integer	Redistribution sequence
pcattnum	int2vector	Column number used as a distribution key
nodeoids	oidvector_extend	List of distributed table node OIDs
options	text	Extension status information. This is a reserved column in the system.

15.2.82 PGXC_GROUP

PGXC_GROUP records information about node groups.

Table 15-81 PGXC_GROUP columns

Name	Type	Description
group_name	name	Name of the node group
in_redistribution	"char"	Whether redistribution is required • **n** indicates that the Node Group is not redistributed. • **y** indicates the source Node Group in redistribution. • **t** indicates the destination Node Group 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
group_acl	aclitem[]	Access permissions
group_kind	"char"	Node Group type • **i** indicates an installation Node Group. • **n** indicates a Node Group in a common, non-logical cluster. • **v** indicates a Node Group in a logical cluster. • **e** indicates an elastic cluster.

15.2.83 PGXC_NODE

PGXC_NODE records information about cluster nodes.

Table 15-82 PGXC_NODE columns

Name	Type	Description
node_name	name	Node name
node_type	"char"	Node type **C**: CN **D**: 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.)

Name	Type	Description
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 the standby server on the current node
nodeis_primary	boolean	Whether the current node is preferred to execute non-query operations in the **replication** table
nodeis_preferred	boolean	Whether the current node is preferred to execute queries in the **replication** table
node_id	integer	Node identifier
sctp_port	integer	Specifies the port used by the TCP proxy communication library or SCTP communication library of the primary node to listen to the data channel.
control_port	integer	Specifies the port used by the TCP proxy communication library or SCTP communication library of the primary node to listen to the control channel.
sctp_port1	integer	Specifies the port used by the TCP proxy communication library or SCTP communication library of the standby node to listen to the data channel.
control_port1	integer	Specifies the port used by the TCP proxy communication library or SCTP communication library of the standby node to listen to the control channel.
nodeis_central	boolean	Indicates that the current node is the central node.

Examples

Query the CN and DN information of the cluster.

```
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 | nodeis_central
--------------+-----------+-----------+----------------+------------+----------------+----------------+----------------
+-----------------
-+-------------+-----------+--------------+------------+---------------+----------------
 dn_6001_6002 | D         |     40000 | 192.**.***.**1 |      45000 | 192.**.**.**2  | t              | f              | f
 |  1644780306 |     40002 |         40003 |      45002 |         45003 | f
```



```
dn_6003_6004 | D        |     40000 | 192.**.**.**2  |      45000 | 192.**.**.**3  | t            | f            | f
|  -966646068 |     40002 |        40003 |      45002 |        45003 | f
dn_6005_6006 | D        |     40000 | 192.**.**.**3  |      45000 | 192.**.***.**1 | t            | f            | f
|   868850011 |     40002 |        40003 |      45002 |        45003 | f
cn_5001      | C        |      8000 | 192.**.***.**1 |       8000 | 192.**.***.**1 | t            | f            | f
|  1120683504 |      8002 |         8003 |          0 |            0 | f
cn_5002      | C        |      8000 | 192.**.**.**2  |       8000 | 192.**.**.**2  | t            | f            | f
| -1736975100 |      8002 |         8003 |          0 |            0 | f
cn_5003      | C        |      8000 | localhost      |       8000 | localhost      | t            | f            | f
|  -125853378 |      8002 |         8003 |          0 |            0 | t
(6 rows)
```

15.2.84 PLAN_TABLE_DATA

PLAN_TABLE_DATA stores the plan information collected by **EXPLAIN PLAN**. Different from the **PLAN_TABLE** view, the system catalog **PLAN_TABLE_DATA** stores the plan information collected by all sessions and users.

Table 15-83 PLAN_TABLE 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	varchar2(30)	Query tag specified by a user
plan_id	bigint	ID of a plan to be queried
id	int	Node ID in a plan
operation	varchar2(30)	Operation description
options	varchar2(255)	Operation parameters
object_name	name	Name of an operated object. It is defined by users.
object_type	varchar2(30)	Object type
object_owner	name	User-defined schema to which an object belongs
projection	varchar2(4000)	Returned column information

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 only their own data in the **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..
- 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. To delete data from **PLAN_TABLE_DATA**, you are advised to use the **PLAN_TABLE** view.
- 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.

15.2.85 SNAPSHOT

SNAPSHOT records the start and end time of each performance view snapshot creation. After **enable_wdr_snapshot** is set to **on**, this catalog is created and maintained by the background snapshot thread. It is accessible only to users with system administrator rights.

Table 15-84 dbms_om.snapshot columns

Name	Type	Description
snapshot_id	name	Snapshot ID. This column is the primary key and distribution key.
start_ts	timestamp with time zone	Snapshot start time
end_ts	timestamp with time zone	Snapshot end time

NOTICE

- This system catalog's schema is **dbms_om**.
- Do not modify or delete this catalog externally. Otherwise, functions related to view snapshots may not work properly.

15.2.86 TABLES_SNAP_TIMESTAMP

TABLES_SNAP_TIMESTAMP records the start and end time of the snapshots created for each performance view. After **enable_wdr_snapshot** is set to **on**, this catalog is created and maintained by the background snapshot thread. It is accessible only to users with system administrator rights.

Table 15-85 dbms_om.tables_snap_timestamp columns

Name	Type	Description
snapshot_id	name	Snapshot ID. This column is the primary key and distribution key.
db_name	text	Name of the database to which the view belongs
tablename	text	View name
start_ts	timestamp with time zone	Snapshot start time
end_ts	timestamp with time zone	Snapshot end time

NOTICE

- This system catalog's schema is **dbms_om**.
- Do not modify or delete this catalog externally. Otherwise, functions related to view snapshots may not work properly.

15.2.87 PG_JOB_INFO

PG_JOB_INFO records the execution results of scheduled tasks. The schema of the system catalog is dbms_om.

Table 15-86 pg_job_info columns

Name	Type	Description
job_id	integer	Job ID
job_db	oid	OID of the database where the task is located.
start_time	timestamp with zone	Task execution start time
status	character(8)	Task execution status
end_time	timestamp with zone	Task execution end time
err_msg	text	Task execution error information

15.2.88 System Catalogs for Performance View Snapshot

After **enable_wdr_snapshot** is set to **on**, the background snapshot thread creates and maintains a system catalog named in the format of **SNAP**_*View name* to

record the snapshot result of each performance view. The following system catalogs are accessible only to users with system administrator rights:

- SNAP_**PGXC_OS_RUN_INFO**
- SNAP_**PGXC_WAIT_EVENTS**
- SNAP_**PGXC_INSTR_UNIQUE_SQL**
- SNAP_**PGXC_STAT_BAD_BLOCK**
- SNAP_**PGXC_STAT_BGWRITER**
- SNAP_**PGXC_STAT_REPLICATION**
- SNAP_**PGXC_REPLICATION_SLOTS**
- SNAP_**PGXC_SETTINGS**
- SNAP_**PGXC_INSTANCE_TIME**
- SNAP_**GLOBAL_WORKLOAD_TRANSACTION**
- SNAP_**PGXC_WORKLOAD_SQL_COUNT**
- SNAP_**PGXC_STAT_DATABASE**
- SNAP_**GLOBAL_STAT_DATABASE**
- SNAP_**PGXC_REDO_STAT**
- SNAP_**GLOBAL_REDO_STAT**
- SNAP_**PGXC_REL_IOSTAT**
- SNAP_**GLOBAL_REL_IOSTAT**
- SNAP_**PGXC_TOTAL_MEMORY_DETAIL**
- SNAP_**PGXC_NODE_STAT_RESET_TIME**
- SNAP_**PGXC_SQL_COUNT**
- SNAP_**GLOBAL_TABLE_STAT**
- SNAP_**GLOBAL_TABLE_CHANGE_STAT**
- SNAP_**GLOBAL_COLUMN_TABLE_IO_STAT**
- SNAP_**GLOBAL_ROW_TABLE_IO_STAT**

Except the new **snapshot_id** column (of the bigint type), the definitions of the other columns in these system catalogs are the same as those of the corresponding views, and the distribution key of each system catalog is **snapshot_id**.

For example, **SNAP_PGXC_OS_RUN_INFO** is used to record snapshots of the **PGXC_OS_RUN_INFO** view. The **snapshot_id** column is new, and other columns are the same as those of the **PGXC_OS_RUN_INFO** view.

NOTICE

- The schema of all above system catalogs is **dbms_om**.
- Do not modify or delete these catalogs externally. Otherwise, functions related to view snapshots may not work properly.

15.3 System Views

15.3.1 ALL_ALL_TABLES

ALL_ALL_TABLES displays the tables or views accessible to the current user.

Table 15-87 ALL_ALL_TABLES columns

Name	Type	Description
owner	name	Owner of the table or the view
table_name	name	Name of the table or the view
tablespace_name	name	Tablespace where the table or view is located

15.3.2 ALL_CONSTRAINTS

ALL_CONSTRAINTS displays information about constraints accessible to the current user.

Table 15-88 ALL_CONSTRAINTS columns

Name	Type	Description
constraint_name	vcharacter varying(64)	Constraint name
constraint_type	text	Constraint type • C: Check constraint. • F: Foreign key constraint • P: Primary key constraint • U: Unique constraint.
table_name	character varying(64)	Name of constraint-related table
index_owner	character varying(64)	Owner of constraint-related index (only for the unique constraint and primary key constraint)
index_name	character varying(64)	Name of constraint-related index (only for the unique constraint and primary key constraint)

15.3.3 ALL_CONS_COLUMNS

ALL_CONS_COLUMNS displays information about constraint columns accessible to the current user.

Table 15-89 ALL_CONS_COLUMNS columns

Name	Type	Description
table_name	character varying(64)	Name of constraint-related table
column_name	character varying(64)	Name of constraint-related column
constraint_name	character varying(64)	Constraint name
position	smallint	Position of the column in the table

15.3.4 ALL_COL_COMMENTS

ALL_COL_COMMENTS displays column comments of tables and views that the current user can access.

Table 15-90 ALL_COL_COMMENTS columns

Name	Type	Description
column_name	character varying(64)	Column name
table_name	character varying(64)	Table/View name
owner	character varying(64)	Owner of a table/view
comments	text	Comments

15.3.5 ALL_DEPENDENCIES

ALL_DEPENDENCIES displays dependencies between functions and advanced packages accessible to the current user.

NOTICE

Currently in GaussDB(DWS), this table is empty without any record due to information constraints.

Table 15-91 ALL_DEPENDENCIES columns

Name	Type	Description
owner	character varying(30)	Owner of the object
name	character varying(30)	Object name
type	character varying(17)	Type of the object
referenced_owner	character varying(30)	Owner of the 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
dependency_type	character varying(4)	Dependency type (REF or HARD)

15.3.6 ALL_IND_COLUMNS

ALL_IND_COLUMNS displays all index columns accessible to the current user.

Table 15-92 ALL_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 column in the index

15.3.7 ALL_IND_EXPRESSIONS

ALL_IND_EXPRESSIONS displays information about the expression indexes accessible to the current user.

Table 15-93 ALL_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
column_position	smallint	Position of a column in the index

15.3.8 ALL_INDEXES

ALL_INDEXES displays information about indexes accessible to the current user.

Table 15-94 ALL_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
generated	character varying(1)	Whether the index name is generated by the system
partitioned	character(3)	Whether the index has the property of the partition table

15.3.9 ALL_OBJECTS

ALL_OBJECTS displays all database objects accessible to the current user.

Table 15-95 ALL_OBJECTS columns

Name	Type	Description
owner	name	Owner of the object
object_name	name	Object name
object_id	oid	OID of the object
object_type	name	Type of the object
namespace	oid	ID of the namespace where the object resides
created	timestamp with time zone	Object creation time
last_ddl_time	timestamp with time zone	The last time when an object was modified.

NOTICE

For details about the value ranges of **last_ddl_time** and **last_ddl_time**, see **PG_OBJECT**.

15.3.10 ALL_PROCEDURES

ALL_PROCEDURES displays information about all stored procedures or functions accessible to the current user.

Table 15-96 ALL_PROCEDURES columns

Name	Type	Description
owner	name	Owner of the object
object_name	name	Object name

15.3.11 ALL_SEQUENCES

ALL_SEQUENCES displays all sequences accessible to the current user.

Table 15-97 ALL_SEQUENCES columns

Name	Type	Description
sequence_owner	name	Owner of the sequence
sequence_name	name	Name of the sequence

Name	Type	Description
min_value	bigint	Minimum value of the sequence
max_value	bigint	Maximum value of the sequence
increment_by	bigint	Value by which the sequence is incremented
cycle_flag	character(1)	Whether the sequence is a cycle sequence. The value can be **Y** or **N**. • **Y** indicates that it is a cycle sequence. • **N** indicates that it is not a cycle sequence.

15.3.12 ALL_SOURCE

ALL_SOURCE displays information about stored procedures or functions accessible to the current user, and provides the columns defined by the stored procedures and functions.

Table 15-98 ALL_SOURCE columns

Name	Type	Description
owner	name	Owner of the object
name	name	Object name
type	name	Type of the object
text	text	Definition of the object

15.3.13 ALL_SYNONYMS

ALL_SYNONYMS displays all synonyms accessible to the current user.

Table 15-99 ALL_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.

Name	Type	Description
table_schema_name	text	Schema name of the associated object.
table_name	text	Name of the associated object.

15.3.14 ALL_TAB_COLUMNS

ALL_TAB_COLUMNS displays description of columns of the tables and views that the current user can access.

Table 15-100 ALL_TAB_COLUMNS columns

Name	Type	Description
owner	character varying(64)	Owner of a table/view
table_name	character varying(64)	Table/View name
column_name	character varying(64)	Column name
data_type	character varying(128)	Data type of a column
column_id	integer	Column ID generated when an object is created or a column is added
data_length	integer	Length of the column, in bytes
avg_col_len	numeric	Average length of a column, in bytes
nullable	bpchar	Whether the column can be empty. For the primary key constraint and non-null constraint, the value is n.
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.
char_length	numeric	Length of a column, in characters. This parameter is valid only for the varchar, nvarchar2, bpchar, and char types.
schema	character varying(64)	Namespace that contains the table or view.

Name	Type	Description
kind	text	Type of the current record. If the column belongs to a table, the value of this column is **table**. If the column belongs to a view, the value of this column is **view**.

15.3.15 ALL_TAB_COMMENTS

ALL_TAB_COMMENTS displays comments about all tables and views accessible to the current user.

Table 15-101 ALL_TAB_COMMENTS columns

Name	Type	Description
owner	character varying(64)	Owner of the table or the view
table_name	character varying(64)	Name of the table or the view
comments	text	Comments

15.3.16 ALL_TABLES

ALL_TABLES displays all the tables accessible to the current user.

Table 15-102 ALL_TABLES columns

Name	Type	Description
owner	character varying(64)	Table owner
table_name	character varying(64)	Table name
tablespace_name	character varying(64)	Name of the tablespace that contains the table
status	character varying(8)	Whether the current record is valid
temporary	character(1)	Whether the table is a temporary table • **Y** indicates that it is a temporary table. • **N** indicates that it is not a temporary table.

Name	Type	Description
dropped	character varying	Whether the current record is deleted • **YES** indicates that it is deleted. • **NO** indicates that it is not deleted.
num_rows	numeric	The estimated number of rows in the table

15.3.17 ALL_USERS

ALL_USERS displays all users of the database visible to the current user, however, it does not describe the users.

Table 15-103 ALL_USERS columns

Name	Type	Description
username	name	User name
user_id	oid	OID of the user

15.3.18 ALL_VIEWS

ALL_VIEWS displays the description about all views accessible to the current user.

Table 15-104 ALL_VIEWS columns

Name	Type	Description
owner	name	Owner of the view
view_name	name	Name of the view
text_length	integer	Text length of the view
text	text	Text in the view

15.3.19 DBA_DATA_FILES

DBA_DATA_FILES displays the description of database files. It is accessible only to users with system administrator rights.

Table 15-105 DBA_DATA_FILES columns

Name	Type	Description
tablespace_name	name	Name of the tablespace to which the file belongs
bytes	double precision	Length of the file in bytes

15.3.20 DBA_USERS

DBA_USERS displays all user names in the database. It is accessible only to users with system administrator rights.

Table 15-106 DBA_USERS columns

Name	Type	Description
username	character varying(64)	User name

15.3.21 DBA_COL_COMMENTS

DBA_COL_COMMENTS displays column comments in the tables and views of a database. Only users with system administrator permissions can access this view.

Name	Type	Description
column_name	character varying(64)	Column name
table_name	character varying(64)	Table/View name
owner	character varying(64)	Owner of a table/view
comments	text	Comments

15.3.22 DBA_CONSTRAINTS

DBA_CONSTRAINTS displays information about table constraints in database. It is accessible only to users with system administrator rights.

Name	Type	Description
constraint_name	vcharacter varying(64)	Constraint name

Name	Type	Description
constraint_type	text	Constraint type • C: Check constraint. • F: Foreign key constraint • P: Primary key constraint • U: Unique constraint.
table_name	character varying(64)	Name of constraint-related table
index_owner	character varying(64)	Owner of constraint-related index (only for the unique constraint and primary key constraint)
index_name	character varying(64)	Name of constraint-related index (only for the unique constraint and primary key constraint)

15.3.23 DBA_CONS_COLUMNS

DBA_CONS_COLUMNS displays information about constraint columns in database tables. It is accessible only to users with system administrator rights.

Name	Type	Description
table_name	character varying(64)	Name of constraint-related table
column_name	character varying(64)	Name of constraint-related column
constraint_name	character varying(64)	Constraint name
position	smallint	Position of the column in the table

15.3.24 DBA_IND_COLUMNS

DBA_IND_COLUMNS displays column information about all indexes in the database. It is accessible only to users with system administrator rights.

Name	Type	Description
index_owner	character varying(64)	Index owner
index_name	character varying(64)	Index name
table_owner	character varying(64)	Table owner

Name	Type	Description
table_name	character varying(64)	Table name
column_name	name	Column name
column_position	smallint	Position of column in the index

15.3.25 DBA_IND_EXPRESSIONS

DBA_IND_EXPRESSIONS displays the information about expression indexes in the database. It is accessible only to users with system administrator rights.

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	The function-based index expression of a specified column
column_position	smallint	Position of column in the index

15.3.26 DBA_IND_PARTITIONS

DBA_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 **DBA_IND_PARTITIONS**. This view is accessible only to users with system administrator rights.

Name	Type	Description
index_owner	character varying(64)	Name of the owner of the partitioned index to which the index partition belongs
schema	character varying(64)	Schema of the partitioned index to which the index partition belongs
index_name	character varying(64)	Index name of the partitioned table to which the index partition belongs
partition_name	character varying(64)	Specifies the name of the index partition.

Name	Type	Description
index_partition_usable	boolean	Whether the index partition is available
high_value	text	Boundary of the table partition corresponding to the index partition. For a range partition, the boundary is the upper boundary. For a list partition, the boundary is the boundary value set. Reserved field for forward compatibility. The parameter **pretty_high_value** is added in version 8.1.3 to record the information.
pretty_high_value	text	Boundary of the table partition corresponding to the index partition. For a range partition, the boundary is the upper boundary. For a list partition, the boundary is the boundary value set. The query result is the instant decompilation output of the partition boundary expression. The output of this column is more detailed than that of **high_value**. The output information can be collation and column data type.
def_tablespace_name	name	Tablespace name of the index partition

15.3.27 DBA_INDEXES

DBA_INDEXES displays all indexes in the database. This view is accessible only to users with system administrator rights.

Name	Type	Description
owner	character varying(64)	Owner of the index
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
generated	character varying(1)	Whether the index name is generated by the system

Name	Type	Description
partitioned	character(3)	Whether the index has the property of the partition table

15.3.28 DBA_OBJECTS

DBA_OBJECTS displays all database objects in the database. This view is accessible only to users with system administrator rights.

Name	Type	Description
owner	name	Owner of the object
object_name	name	Object name
object_id	oid	OID of the object
object_type	name	Type of the object
namespace	oid	Namespace containing the object
created	timestamp with time zone	Object creation time
last_ddl_time	timestamp with time zone	The last time when an object was modified.

NOTICE

For details about the value ranges of **last_ddl_time** and **last_ddl_time**, see **PG_OBJECT**.

15.3.29 DBA_PART_INDEXES

DBA_PART_INDEXES displays information about all partitioned table indexes in the database. It is accessible only to users with system administrator rights.

Name	Type	Description
index_owner	character varying(64)	Name of the owner of the partitioned table index
schema	character varying(64)	Schema of the partitioned table index
index_name	character varying(64)	Name of the partitioned table index

Name	Type	Description
table_name	character varying(64)	Name of the partitioned table to which the partitioned table index belongs
partitioning_type	text	Partition policy of the partitioned table **NOTE** Currently, only range partitioning and list partitioning are supported.
partition_count	bigint	Number of index partitions of the partitioned table index
def_tablespace_name	name	Tablespace name of the partitioned table index
partitioning_key_count	integer	Number of partition keys of the partitioned table

15.3.30 DBA_PART_TABLES

DBA_PART_TABLES displays information about all partitioned tables in the database. It is accessible only to users with system administrator rights.

Name	Type	Description
table_owner	character varying(64)	Name of the owner of the partitioned table
schema	character varying(64)	Schema of the partitioned table
table_name	character varying(64)	Name of the partitioned table
partitioning_type	text	Partition policy of the partitioned table **NOTE** Currently, only range partitioning and list partitioning are supported.
partition_count	bigint	Number of partitions of the partitioned table
def_tablespace_name	name	Tablespace name of the partitioned table
partitioning_key_count	integer	Number of partition keys of the partitioned table

15.3.31 DBA_PROCEDURES

DBA_PROCEDURES displays information about all stored procedures and functions in the database. This view is accessible only to users with system administrator rights.

Name	Type	Description
owner	character varying(64)	Owner of the stored procedure or the function
object_name	character varying(64)	Name of the stored procedure or the function
argument_number	smallint	Number of the input parameters in the stored procedure

15.3.32 DBA_SEQUENCES

DBA_SEQUENCES displays information about all sequences in the database. This view is accessible only to users with system administrator rights.

Name	Type	Description
sequence_owner	character varying(64)	Owner of the sequence
sequence_name	character varying(64)	Name of the sequence

15.3.33 DBA_SOURCE

DBA_SOURCE displays all stored procedures or functions in the database, and it provides the columns defined by the stored procedures or functions. It is accessible only to users with system administrator rights.

Name	Type	Description
owner	character varying(64)	Owner of the stored procedure or the function
name	character varying(64)	Name of the stored procedure or the function
text	text	Definition of the stored procedure or the function

15.3.34 DBA_SYNONYMS

DBA_SYNONYMS displays all synonyms in the database. It is accessible only to users with system administrator rights.

Table 15-107 DBA_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.
table_schema_name	text	Schema name of the associated object.
table_name	text	Name of the associated object.

15.3.35 DBA_TAB_COLUMNS

DBA_TAB_COLUMNS stores the columns of tables and views. Each column of a table in the database has a row in **DBA_TAB_COLUMNS**. Only users with system administrator permissions can access this view.

Name	Type	Description
owner	character varying(64)	Owner of a table/view
table_name	character varying(64)	Table/View name
column_name	character varying(64)	Column name
data_type	character varying(128)	Data type of the column
column_id	integer	Sequence number of the column when a table/view is created
data_length	integer	Length of the column, in bytes
comments	text	Comments
avg_col_len	numeric	Average length of a column, in bytes
nullable	bpchar	Whether the column can be empty. For the primary key constraint and non-null constraint, the value is n.

Name	Type	Description
data_precision	integer	Precision of the data type. This parameter is valid for the numeric data type and **NULL** for other data types.
data_scale	integer	Number of decimal places. This parameter is valid for the numeric data type and **0** for other data types.
char_length	numeric	Length of a column, in characters. This parameter is valid only for the varchar, nvarchar2, bpchar, and char types.
schema	character varying(64)	Namespace that contains the table or view.
kind	text	Type of the current record. If the column belongs to a table, the value of this column is **table**. If the column belongs to a view, the value of this column is **view**.

15.3.36 DBA_TAB_COMMENTS

DBA_TAB_COMMENTS displays comments about all tables and views in the database. It is accessible only to users with system administrator rights.

Name	Type	Description
owner	character varying(64)	Owner of the table or the view
table_name	character varying(64)	Name of the table or the view
comments	text	Comments

15.3.37 DBA_TAB_PARTITIONS

DBA_TAB_PARTITIONS displays information about all partitions in the database.

Name	Type	Description
table_owner	character varying(64)	Owner of the table that contains the partition
schema	character varying(64)	Schema of the partitioned table
table_name	character varying(64)	Table name
partition_name	character varying(64)	Name of the partition

Name	Type	Description
high_value	text	Upper boundary of a range partition or boundary value set of a list partition Reserved field for forward compatibility. The parameter **pretty_high_value** is added in version 8.1.3 to record the information.
pretty_high_value	text	Upper boundary of a range partition or boundary value set of a list partition The query result is the instant decompilation output of the partition boundary expression. The output of this column is more detailed than that of **high_value**. The output information can be collation and column data type.
tablespace_name	name	Name of the tablespace that contains the partition

Example

View the partition information of a partitioned table:

```
CREATE TABLE web_returns_p1
(
    wr_returned_date_sk       integer,
    wr_returned_time_sk       integer,
    wr_item_sk                integer NOT NULL,
    wr_refunded_customer_sk   integer
)
WITH (orientation = column)
DISTRIBUTE BY HASH (wr_item_sk)
PARTITION BY RANGE (wr_returned_date_sk)
(
    PARTITION p2016 VALUES LESS THAN(20161231),
    PARTITION p2017 VALUES LESS THAN(20171231),
    PARTITION p2018 VALUES LESS THAN(20181231),
    PARTITION p2019 VALUES LESS THAN(20191231),
    PARTITION p2020 VALUES LESS THAN(maxvalue)
);

SELECT * FROM dba_tab_partitions where table_name='web_returns_p1';
 table_owner | schema |    table_name    | partition_name | high_value | pretty_high_value |  tablespace_name
-------------+--------+------------------+----------------+------------+-------------------+-------------------
 dbadmin     | public | web_returns_p1 | p2016          | 20161231   | 20161231          | DEFAULT TABLESPACE
 dbadmin     | public | web_returns_p1 | p2017          | 20171231   | 20171231          | DEFAULT TABLESPACE
 dbadmin     | public | web_returns_p1 | p2018          | 20181231   | 20181231          | DEFAULT TABLESPACE
 dbadmin     | public | web_returns_p1 | p2019          | 20191231   | 20191231          | DEFAULT TABLESPACE
 dbadmin     | public | web_returns_p1 | p2020          | MAXVALUE   | MAXVALUE          | DEFAULT
TABLESPACE
(5 rows)
```


15.3.38 DBA_TABLES

DBA_TABLES displays all tables in the database. This view is accessible only to users with system administrator rights.

Name	Type	Description
owner	character varying(64)	Table owner
table_name	character varying(64)	Table name
tablespace_name	character varying(64)	Name of the tablespace that contains the table
status	character varying(8)	Whether the current record is valid
temporary	character(1)	Whether the table is a temporary table • **Y** indicates that it is a temporary table. • **N** indicates that it is not a temporary table.
dropped	character varying	Whether the current record is deleted • **YES** indicates that it is deleted. • **NO** indicates that it is not deleted.
num_rows	numeric	The estimated number of rows in the table

15.3.39 DBA_TABLESPACES

DBA_TABLESPACES displays information about available tablespaces. It is accessible only to users with system administrator rights.

Table 15-108 DBA_TABLESPACES columns

Name	Type	Description
tablespace_name	character varying(64)	Name of the tablespace

15.3.40 DBA_TRIGGERS

DBA_TRIGGERS displays information about triggers in the database. This view is accessible only to users with system administrator rights.

Name	Type	Description
trigger_name	character varying(64)	Trigger name
table_name	character varying(64)	Name of the table that defines the trigger
table_owner	character varying(64)	Owner of the table that defines the trigger

15.3.41 DBA_VIEWS

DBA_VIEWS displays views in the database. This view is accessible only to users with system administrator rights.

Name	Type	Description
owner	character varying(64)	Owner of the view
view_name	character varying(64)	View name

15.3.42 DUAL

DUAL 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.

Table 15-109 DUAL columns

Name	Type	Description
dummy	text	Expression calculation result

15.3.43 GET_ALL_TSC_INFO

Obtains the TSC information of all nodes again. This view is supported only by clusters of version 8.2.1 or later.

Table 15-110 show_tsc_info() return columns

Column	Type	Description
node_name	text	Node name
tsc_mult	bigint	TSC conversion multiplier
tsc_shift	bigint	TSC conversion shifts

Column	Type	Description
tsc_frequency	float8	TSC frequency
tsc_use_freqency	boolean	Indicates whether to use the TSC frequency for time conversion.
tsc_ready	boolean	Indicates whether the TSC frequency can be used for time conversion
tsc_scalar_error_info	text	Error information about obtaining TSC conversion information
tsc_freq_error_info	text	Error information about obtaining TSC frequency information

15.3.44 GET_TSC_INFO

Obtains the TSC information of the current node again. This view is supported only by clusters of version 8.2.1 or later.

Table 15-111 show_tsc_info() return columns

Column	Type	Description
node_name	text	Node name
tsc_mult	bigint	TSC conversion multiplier
tsc_shift	bigint	TSC conversion shifts
tsc_frequency	float8	TSC frequency
tsc_use_freqency	boolean	Indicates whether to use the TSC frequency for time conversion.
tsc_ready	boolean	Indicates whether the TSC frequency can be used for time conversion
tsc_scalar_error_info	text	Error information about obtaining TSC conversion information
tsc_freq_error_info	text	Error information about obtaining TSC frequency information

15.3.45 GLOBAL_COLUMN_TABLE_IO_STAT

GLOBAL_COLUMN_TABLE_IO_STAT provides I/O statistics of all column-store tables in the current database. The names, types, and sequences of the columns in the view are the same as those in the **GS_COLUMN_TABLE_IO_STAT** view. For details about the columns, see **GS_COLUMN_TABLE_IO_STAT**. The value of each statistical column is the sum of the values of the corresponding columns of all nodes.

15.3.46 GLOBAL_REDO_STAT

GLOBAL_REDO_STAT displays the total statistics of XLOG redo operations on all nodes in a cluster. Except the **avgiotim** column (indicating the average redo write time of all nodes), the names of the other columns in this view are the same as those in the **PV_REDO_STAT** view. The respective meanings of the other columns are the sum of the values of the same columns in the **PV_REDO_STAT** view on each node.

NOTE

This view is accessible only to users with system administrator rights.

15.3.47 GLOBAL_REL_IOSTAT

GLOBAL_REL_IOSTAT displays the total disk I/O statistics of all nodes in a cluster. The name of each column in this view is the same as that in the **GS_REL_IOSTAT** view, but the column meaning is the sum of the value of the same column in the **GS_REL_IOSTAT** view on each node.

NOTE

This view is accessible only to users with system administrator rights.

15.3.48 GLOBAL_ROW_TABLE_IO_STAT

GLOBAL_ROW_TABLE_IO_STAT provides I/O statistics of all row-store tables in the current database. The names, types, and sequences of the columns in the view are the same as those in the **GS_ROW_TABLE_IO_STAT** view. For details about the columns, see **GS_ROW_TABLE_IO_STAT**. The value of each statistical column is the sum of the values of the corresponding columns of all nodes.

15.3.49 GLOBAL_STAT_DATABASE

GLOBAL_STAT_DATABASE displays the status and statistics of databases on all nodes in a cluster.

- When you query the **GLOBAL_STAT_DATABASE** view on a CN, the respective values of all columns returned, except **stats_reset** (indicating the status reset time on the current CN), are the sum of values on related nodes in the cluster. Note that the sum range varies depending on the logical meaning of each column in the **GLOBAL_STAT_DATABASE** view.
- When you query the **GLOBAL_STAT_DATABASE** view on a DN, the query result is the same as that in **Table 15-112**.

Table 15-112 GLOBAL_STAT_DATABASE columns

Name	Type	Description	Sum Range
datid	oid	Database OID	-
datname	name	Database name	-

Name	Type	Description	Sum Range
numbackends	integer	Number of backends currently connected to this database on the current node. This is the only column in this view that reflects the current state value. All columns return the accumulated value since the last reset.	CN
xact_commit	bigint	Number of transactions in this database that have been committed on the current node	CN
xact_rollback	bigint	Number of transactions in this database that have been rolled back on the current node	CN
blks_read	bigint	Number of disk blocks read in this database on the current node	DN
blks_hit	bigint	Number of disk blocks found in the buffer cache on the current node, that is, the number of blocks hit in the cache. (This only includes hits in the GaussDB(DWS) buffer cache, not in the file system cache.)	DN
tup_returned	bigint	Number of rows returned by queries in this database on the current node	DN
tup_fetched	bigint	Number of rows fetched by queries in this database on the current node	DN
tup_inserted	bigint	Number of rows inserted in this database on the current node	DN
tup_updated	bigint	Number of rows updated in this database on the current node	DN
tup_deleted	bigint	Number of rows deleted from this database on the current node	DN
conflicts	bigint	Number of queries canceled due to database recovery conflicts on the current node (conflicts occurring only on the standby server). For details, see **PG_STAT_DATABASE_CONFLICTS**.	CN and DN

Name	Type	Description	Sum Range
temp_files	bigint	Number of temporary files created by this database on the current node. 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.	DN
temp_bytes	bigint	Size of temporary files written to this database on the current node. All temporary files are counted, regardless of why the temporary file was created, and regardless of the **log_temp_files** setting.	DN
deadlocks	bigint	Number of deadlocks in this database on the current node	CN and DN
blk_read_time	double precision	Time spent reading data file blocks by backends in this database on the current node, in milliseconds	DN
blk_write_time	double precision	Time spent writing into data file blocks by backends in this database on the current node, in milliseconds	DN
stats_reset	timestamp with time zone	Time when the database statistics are reset on the current node	-

15.3.50 GLOBAL_TABLE_CHANGE_STAT

GLOBAL_TABLE_CHANGE_STAT displays the changes of all tables (excluding foreign tables) in the current database. The value of each column that indicates the number of times is the accumulated value since the instance was started.

Table 15-113 GLOBAL_TABLE_CHANGE_STAT columns

Name	Type	Description
schemaname	name	Namespace of a table
relname	name	Table name
last_vacuum	timestamp with time zone	Time when the last **VACUUM** operation is performed manually

Name	Type	Description
vacuum_count	bigint	Number of times of manually performing the **VACUUM** operation. The value is the sum of the number of times on each CN.
last_autovacuum	timestamp with time zone	Time when the last **VACUUM** operation is performed automatically
autovacuum_count	bigint	Number of times of automatically performing the **VACUUM** operation. The value is the sum of the number of times on each CN.
last_analyze	timestamp with time zone	Time when the **ANALYZE** operation is performed (both manually and automatically)
analyze_count	bigint	Number of times of performing the **ANALYZE** operation (both manually and automatically). The **ANALYZE** operation is performed on all CNs at the same time. Therefore, the value of this column is the maximum value on all CNs.
last_autoanalyze	timestamp with time zone	Time when the last **ANALYZE** operation is performed automatically
autoanalyze_count	bigint	Number of times of automatically performing the **ANALYZE** operation. The value is the sum of the number of times on each CN.
last_change	bigint	Time when the last modification (**INSERT**, **UPDATE**, or **DELETE**) is performed

15.3.51 GLOBAL_TABLE_STAT

GLOBAL_TABLE_STAT displays statistics about all tables (excluding foreign tables) in the current database. The values of **live_tuples** and **dead_tuples** are real-time values, and the values of other statistical columns are accumulated values since the instance was started.

Table 15-114 GLOBAL_TABLE_STAT columns

Name	Type	Description
schemaname	name	Namespace of a table
relname	name	Table name

Name	Type	Description
distribute_mode	char	Distribution mode of a table. The meaning of this column is the same as that of the **pclocatortype** column in the **pgxc_class** system catalog.
seq_scan	bigint	Number of sequential scans. It is counted only for row-store tables. For a partitioned table, the sum of the number of scans of each partition is displayed.
seq_tuple_read	bigint	Number of rows scanned in sequence. It is counted only for row-store tables.
index_scan	bigint	Number of index scans. It is counted only for row-store tables.
index_tuple_read	bigint	Number of rows scanned by the index. It is counted only for row-store tables.
tuple_inserted	bigint	Number of rows inserted. For a replication table, the maximum value of each node is displayed. For a distribution table, the sum of all nodes is displayed.
tuple_updated	bigint	Number of rows updated. For a replication table, the maximum value of each node is displayed. For a distribution table, the sum of all nodes is displayed.
tuple_deleted	bigint	Number of rows deleted. For a replication table, the maximum value of each node is displayed. For a distribution table, the sum of all nodes is displayed.
tuple_hot_updated	bigint	Number of rows with HOT updates. For a replication table, the maximum value of each node is displayed. For a distribution table, the sum of all nodes is displayed.
live_tuples	bigint	Number of live tuples. The maximum value of each node is displayed. For a distribution table, the sum of all nodes is displayed. This indicator applies only to row-store tables.
dead_tuples	bigint	Number of dead tuples. The maximum value of each node is displayed. For a distribution table, the sum of all nodes is displayed. This indicator applies only to row-store tables.

15.3.52 GLOBAL_WORKLOAD_SQL_COUNT

GLOBAL_WORKLOAD_SQL_COUNT displays statistics on the number of SQL statements executed in all workload Cgroups in a cluster, including the number of

SELECT, **UPDATE**, **INSERT**, and **DELETE** statements and the number of DDL, DML, and DCL statements.

Table 15-115 GLOBAL_WORKLOAD_SQL_COUNT columns

Name	Type	Description
workload	name	Workload Cgroup 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

15.3.53 GLOBAL_WORKLOAD_SQL_ELAPSE_TIME

GLOBAL_WORKLOAD_SQL_ELAPSE_TIME displays statistics on the response time of SQL statements in all workload Cgroups in a cluster, including the maximum, minimum, average, and total response time of **SELECT**, **UPDATE**, **INSERT**, and **DELETE** statements. The unit is microsecond.

Table 15-116 GLOBAL_WORKLOAD_SQL_ELAPSE_TIME columns

Name	Type	Description
workload	name	Workload Cgroup name
total_select_elapse	bigint	Total response time of **SELECT** statements
max_select_elapse	bigint	Maximum response time of **SELECT** statements
min_select_elapse	bigint	Minimum response time of **SELECT** statements
avg_select_elapse	bigint	Average response time of **SELECT** statements

Name	Type	Description
total_update_elapse	bigint	Total response time of **UPDATE** statements
max_update_elapse	bigint	Maximum response time of **UPDATE** statements
min_update_elapse	bigint	Minimum response time of **UPDATE** statements
avg_update_elapse	bigint	Average response time of **UPDATE** statements
total_insert_elapse	bigint	Total response time of **INSERT** statements
max_insert_elapse	bigint	Maximum response time of **INSERT** statements
min_insert_elapse	bigint	Minimum response time of **INSERT** statements
avg_insert_elapse	bigint	Average response time of **INSERT** statements
total_delete_elapse	bigint	Total response time of **DELETE** statements
max_delete_elapse	bigint	Maximum response time of **DELETE** statements
min_delete_elapse	bigint	Minimum response time of **DELETE** statements
avg_delete_elapse	bigint	Average response time of **DELETE** statements

15.3.54 GLOBAL_WORKLOAD_TRANSACTION

GLOBAL_WORKLOAD_TRANSACTION provides the total transaction information about workload Cgroups on all CNs in the cluster. This view is accessible only to users with system administrator rights. It is valid only when the real-time resource monitoring function is enabled, that is, **enable_resource_track** is **on**.

Table 15-117 GLOBAL_WORKLOAD_TRANSACTION columns

Name	Type	Description
workload	name	Workload Cgroup name
commit_counter	bigint	Total number of submission times on each CN
rollback_counter	bigint	Total number of rollback times on each CN

Name	Type	Description
resp_min	bigint	Minimum response time of the cluster
resp_max	bigint	Maximum response time of the cluster
resp_avg	bigint	Average response time on each CN
resp_total	bigint	Total response time on each CN

15.3.55 GS_ALL_CONTROL_GROUP_INFO

GS_ALL_CONTROL_GROUP_INFO displays all Cgroup information in a database.

Table 15-118 GS_ALL_CONTROL_GROUP_INFO columns

Name	Type	Description
name	text	Name of the Cgroup
type	text	Type of the Cgroup
gid	bigint	Cgroup ID
classgid	bigint	ID of the Class Cgroup to which a Workload 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

15.3.56 GS_BLOCKLIST_QUERY

GS_BLOCKLIST_QUERY is used to query job blocklist and exception information. This view is obtained by associating system catalogs **GS_BLOCKLIST_QUERY** and **GS_WLM_SESSION_INFO**, and deduplicating query results. If the **GS_WLM_SESSION_INFO** table is large, the query may take a long time.

Table 15-119 GS_BLOCKLIST_QUERY columns

Name	Type	Reference	Description
unique_sql_id	bigint	-	Unique query ID generated based on the query parsing tree.
block_list	boolean	-	Check whether a job is in the blocklist.
except_num	integer	-	Query the number of job exceptions.
except_time	timestamp	-	Query the time when the last job exception occurred.
query	text	-	Statement to be executed.

NOTE

- This view can be queried only in the **gaussdb** database. If it is queried in other databases, an error will be reported.
- Generally, constant values are ignored during unique SQL ID calculation in DML statements. However, constant values cannot be ignored in DDL, DCL, and parameter setting statements. A **unique_sql_id** may correspond to one or more queries.

15.3.57 GS_CLUSTER_RESOURCE_INFO

GS_CLUSTER_RESOURCE_INFO displays a DN resource summary.

Table 15-120 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 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 physical memory usage

15.3.58 GS_COLUMN_TABLE_IO_STAT

GS_COLUMN_TABLE_IO_STAT displays the I/O of all column-store tables of the database on the current node. The value of each statistical column is the accumulated value since the instance was started.

Table 15-121 GS_COLUMN_TABLE_IO_STAT columns

Name	Type	Description
schemaname	name	Namespace of a table
relname	name	Table name
heap_read	bigint	Number of blocks logically read in the heap
heap_hit	bigint	Number of block hits in the heap
idx_read	bigint	Number of blocks logically read in the index
idx_hit	bigint	Number of block hits in the index
cu_read	bigint	Number of logical reads in the Compression Unit
cu_hit	bigint	Number of hits in the Compression Unit
cidx_read	bigint	Number of indexes logically read in the Compression Unit
cidx_hit	bigint	Number of index hits in the Compression Unit

15.3.59 GS_OBS_READ_TRAFFIC

Collects statistics on the OBS read traffic and average read bandwidth. The statistical results are aggregated every 10 minutes. This view is supported only by clusters of version 8.2.0 or later.

Name	Type	Description
nodename	TEXT	Cluster node
hostname	TEXT	Server
traffic_mb	float8	OBS read traffic statistics during the 10 minutes before **logtime**
bandwidth_mb_per_s	float8	Average bandwidth, in MB/s
reqcount	bigint	Number of OBS reads during the 10 minutes before **logtime**
logtime	timestamp with time zone	Time when statistics are recorded

Examples

Query statistics on the OBS read traffic and average read bandwidth. The statistical results are aggregated every 10 minutes.


```
select * from gs_obs_read_traffic;
 nodename |     hostname     |    traffic_mb     | bandwidth_mb_per_s | reqcount |        logtime
----------+------------------+-------------------+--------------------+----------+------------------------
 dn_1     | rhel_10_90_45_56 | 101.959338188171 |   5.14830159670447 |       23 | 2022-11-26 09:50:00+08
(1 row)
```

15.3.60 GS_OBS_WRITE_TRAFFIC

Collects statistics on the OBS write traffic and average write bandwidth. The statistical results are aggregated every 10 minutes. This view is supported only by clusters of version 8.2.0 or later.

Name	Type	Description
nodename	TEXT	Cluster node
hostname	TEXT	Server
traffic_mb	float8	OBS write traffic statistics during the 10 minutes before **logtime**
bandwidth_mb_per_s	float8	Average bandwidth, in MB/s
reqcount	bigint	Number of OBS writes during the 10 minutes before **logtime**
logtime	timestamp with time zone	Time when statistics are recorded

Examples

Query statistics on the OBS write traffic and average write bandwidth. The statistical results are aggregated every 10 minutes.

```
select * from gs_obs_write_traffic;
  nodename   |     hostname     |      traffic_mb       | bandwidth_mb_per_s  | reqcount |        logtime
-------------+------------------+-----------------------+---------------------+----------+------------------------
 dn_1        | rhel_10_90_45_56 |  .000738143920898438 | .000289970820362525 |       12 | 2022-10-24
16:10:00+08
 dn_1        | rhel_10_90_45_56 |  .000354766845703125 | .000386063466694153 |        7 | 2022-10-24
18:50:00+08
 dn_1        | rhel_10_90_45_56 | 9.34600830078125e-05 | .000143659648687162 |        2 | 2022-11-07
09:20:00+08
 dn_1        | rhel_10_90_45_56 | 4.10079956054688e-05 | .000186667253592502 |        1 | 2022-11-07
09:30:00+08
 dn_1        | rhel_10_90_45_56 |     2048.17834663391 |    27.2766632219637 |        2 | 2022-11-22
16:10:00+08
 dn_1        | rhel_10_90_45_56 |     3747.23722648621 |    28.0842938534546 |        4 | 2022-11-22
16:20:00+08
(6 row)
```

15.3.61 GS_INSTR_UNIQUE_SQL

Unique SQL Definition

The database parses each received SQL text string and generates an internal parsing tree. The database traverses the parsing tree and ignores constant values

in the parsing tree. In this case, an integer value is calculated using a certain algorithm. This integer is used as the Unique SQL ID to uniquely identify this type of SQL. SQL statements with the same Unique SQL ID are called Unique SQL statements.

Examples

Assume that the user enters the following SQL statements in sequence:

```
select * from t1 where id = 1;
select * from t1 where id = 2;
```

The statistics of the two SQL statements are aggregated to the same Unique SQL statement.

```
select * from t1 where id = ?;
```

GS_INSTR_UNIQUE_SQL View

The **GS_INSTR_UNIQUE_SQL** view displays the execution information about the Unique SQL statements collected by the current node, including:

- Unique SQL ID and normalized SQL text string. The normalized SQL text is described in **Examples**. Generally, constant values are ignored during Unique SQL ID calculation in DML statements. However, constant values cannot be ignored in DDL, DCL, and parameter setting statements.
- Number of execution times (number of successful execution times) and response time (SQL execution time in the database, including the maximum, minimum, and total time)
- Cache/IO information, including the number of physical reads and logical reads of a block. Only information about successfully executed SQL statements on each DN is collected. The statistical value is related to factors such as the amount of data processed during query execution, used memory, whether the query is executed for multiple times, memory management policy, and whether there are other concurrent queries. The statistical value reflects the number of physical reads and logical reads of the buffer block in the entire query execution process. The statistical value may vary according to the execution time.
- Row activities, such as the number of returned rows, updated rows, inserted rows, deleted rows, sequentially scanned rows, and randomly scanned rows in the result set of the **SELECT** statement. Except that the number of rows returned by the result set is the same as the number of rows in the result set of the **SELECT** statement and is recorded only on the CN, the activity information of other rows is recorded on the DN. The statistical value reflects the row activities during the entire query execution process, including scanning and modifying related system tables, metadata tables, and data tables. The value of this parameter is related to the data volume and related parameter settings. That is, the statistical value is greater than or equal to the scanning and modification times of actual data tables.
- Time distribution, including DB_TIME/CPU_TIME/EXECUTION_TIME/PARSE_TIME/PLAN_TIME/REWRITE_TIME/PL_EXECUTION_TIME/PL_COMPILATION_TIME/NET_SEND_TIME/DATA_IO_TIME. For details, see **Table 15-122**. The information is collected on both CNs and DNs and is displayed during view query.

- Number of soft and hard parsing times, such as the number of soft parsing times (cache plan) and hard parsing times (generation plan). If the cache plan is executed this time, the number of soft parsing times increases by 1. If the generation plan is regenerated this time, the number of hard parsing times increases by 1. This number is counted on both CNs and DNs and is displayed during view query.

The Unique SQL statistics function has the following restrictions:

- Detailed statistics are displayed only for successfully executed SQL statements. Otherwise, only query, node, and user information are recorded.
- If the Unique SQL statistics collection function is enabled, the CN collects statistics on all received queries, including tool and user queries.
- If an SQL statement contains multiple SQL statements or similar stored procedures, a Unique SQL statement is generated for the outermost SQL statement. The statistics of all sub-SQL statements are summarized to the Unique SQL record.
- The response time statistics of Unique SQL does not include the time of the **NET_SEND_TIME** phase. Therefore, there is no comparison between **EXECUTION_TIME** and **elapse_time**.
- **parse_time** of clauses cannot be calculated for **begin;...;commit** and similar transaction blocks.

When a common user accesses the **GS_INSTR_UNIQUE_SQL** view, only the Unique SQL information about the user is displayed. When an administrator accesses the **GS_INSTR_UNIQUE_SQL** view, all Unique SQL information about the current node is displayed. The **GS_INSTR_UNIQUE_SQL** view can be queried on both CNs and DNs. The DN displays the Unique SQL statistics of the local node, and the CN displays the complete Unique SQL statistics of the local node. That is, the CN collects the Unique SQL execution information of the CN from other CNs and DNs and displays the information. You can query the **GS_INSTR_UNIQUE_SQL** view to locate the Top SQL statements that consume different resources, providing a basis for cluster tuning and maintenance.

The GUC parameter **instr_unique_sql_timeout** specifies the timeout interval of the Unique SQL statement (in hours). The background thread checks all Unique SQL statements every hour and deletes the Unique SQL statements whose **last_time** is **instr_unique_sql_timeout** hours ago.

Table 15-122 GS_INSTR_UNIQUE_SQL columns

Name	Type	Description
node_name	name	Name of the CN that receives SQL statements
node_id	integer	Node ID, which is the same as the value of **node_id** in the **pgxc_node** table
user_name	name	Username
user_id	oid	User ID

Name	Type	Description
unique_sql_id	bigint	Normalized Unique SQL ID
query	text	Normalized SQL text
n_calls	bigint	Number of successful execution times
min_elapse_time	bigint	Minimum running time of the SQL statement in the database (unit: μs)
max_elapse_time	bigint	Maximum running time of SQL statements in the database (unit: μs)
total_elapse_time	bigint	Total running time of SQL statements in the database (unit: μs)
n_returned_rows	bigint	Row activity - Number of rows in the result set returned by the **SELECT** statement
n_tuples_fetched	bigint	Row activity - Randomly scan rows (column-store tables/foreign tables are not counted.)
n_tuples_returned	bigint	Row activity - Sequential scan rows (Column-store tables/foreign tables are not counted.)
n_tuples_inserted	bigint	Row activity - Inserted rows
n_tuples_updated	bigint	Row activity - Updated rows
n_tuples_deleted	bigint	Row activity - Deleted rows
n_blocks_fetched	bigint	Block access times of the buffer, that is, physical read/I/O
n_blocks_hit	bigint	Block hits of the buffer, that is, logical read/ cache
n_soft_parse	bigint	Number of soft parsing times (cache plan)

Name	Type	Description
n_hard_parse	bigint	Number of hard parsing times (generation plan)
db_time	bigint	Valid DB execution time, including the waiting time and network sending time. If multiple threads are involved in query execution, the value of **DB_TIME** is the sum of **DB_TIME** of multiple threads (unit: μs).
cpu_time	bigint	CPU execution time, excluding the sleep time (unit: μs)
execution_time	bigint	SQL execution time in the query executor, DDL statements, and statements (such as Copy statements) that are not executed by the executor are not counted (unit: μs).
parse_time	bigint	SQL parsing time (unit: μs)
plan_time	bigint	SQL generation plan time (unit: μs)
rewrite_time	bigint	SQL rewriting time (unit: μs)
pl_execution_time	bigint	Execution time of the plpgsql procedural language function (unit: μs)
pl_compilation_time	bigint	Compilation time of the plpgsql procedural language function (unit: μs)
net_send_time	bigint	Network time, including the time spent by the CN in sending data to the client and the time spent by the DN in sending data to the CN (unit: μs)

Name	Type	Description
data_io_time	bigint	File I/O time (unit: μs)
first_time	timestamp with time zone	Time of the first SQL statement execution
last_time	timestamp with time zone	Time of the last SQL statement execution

15.3.62 GS_NODE_STAT_RESET_TIME

GS_NODE_STAT_RESET_TIME provides the statistics reset time of the current node and returns a timestamp with the time zone.

For details, see the **get_node_stat_reset_time()** function.

15.3.63 GS_OBS_LATENCY

GS_OBS_LATENCY records the average latency of OBS during the 10 minutes before **logtime**. The latency is estimated based on OBS operations. This view is supported only by clusters of version 8.2.0 or later.

Table 15-123 GS_OBS_LATENCY columns

Name	Type	Description
nodename	text	Node
hostname	text	Server node.
latency_ms	double precision	Average delay of OBS during the 10 minutes before **logtime**. The unit is ms.
reqcount	bigint	Number of OBS requests during the 10 minutes before **logtime**.
logtime	timestamp with time zone	Time when the delay information is recorded.

15.3.64 GS_QUERY_MONITOR

Displays the running/queuing information and resource usage of ongoing queries. Only queuing and running jobs are displayed. This view can be queried only on CNs and displays only the monitoring information about the main statement. This view is supported only by clusters of 8.2.1.100 and later versions.

Table 15-124 GS_QUERY_MONITOR columns

Column	Type	Description
usename	name	Name of the user who performs the query.
nodename	name	Name of the CN that executes the query.
nodegroup	name	Name of the cluster where the query is performed. The default cluster name is **installation**.
rpname	name	Name of the resource pool associated with the query.
priority	name	Priority of the query, which can be **Rush**, **High**, **Medium**, and **Low**.
xact_start	timestamp	Start time of the transaction to which the query belongs.
query_start	timestamp	Start time of query execution.
block_time	bigint	Accumulated queuing time of jobs. Stored procedures and multi-statement task may be queued for multiple times. Unit: second.
duration	bigint	Running time of a job, excluding the queuing time. Unit: second.
query_band	text	Job ID, which can be set using the GUC parameter **query_band**. By default, this parameter is left blank.
attribute	text	Job attributes: ● **Simple**: simple job. ● **Complicated**: complex job. This column is invalid before a job is under resource pool management and control. This column is valid only when the job is under or has been under resource pool management and control.
lane	text	Resource pool lane where a job is queued or executed: ● **fast**: fast lane. ● **slow**: slow lane. This column is invalid before a job is under resource pool management and control. This column is valid only when the job is under or has been under resource pool management and control.
status	text	Current status of a job. The value can be **pending** or **running**.

Column	Type	Description
queue	text	Job queuing information: • **None**: The job is running. • **Global**: The job is queued in the global queue of the CN. • **Respool**: The job is queued in the resource pool. • **CCN**: The job is queued in the CCN.
used_mem	integer	Maximum peak memory usage of a job across all DNs. The unit is MB.
estimate_mem	integer	Estimated memory of a job. The unit is MB.
used_cpu	double precision	Average number of CPU cores occupied by a job since the job starts to run.
read_speed	integer	Average logical I/O read rate of a job on all DNs. The unit is KB/s.
write_speed	integer	Average logical I/O write rate of a job on all DNs. The unit is KB/s.
send_speed	integer	Average transmit rate on all DNs since a job starts to run. The unit is KB/s.
recv_speed	integer	Average receive rate on all DNs since a job starts to run. The unit is KB/s.
dn_count	bigint	Number of DNs that execute the job.
stream_count	bigint	Total number of stream threads of a job on all DNs.
pid	bigint	ID of the backend thread
lwtid	integer	Lightweight thread ID of a background thread.
query_id	bigint	Query ID.
unique_sql_id	bigint	ID of the normalized unique SQL.
query	text	Query that is being executed.

15.3.65 GS_REL_IOSTAT

GS_REL_IOSTAT displays disk I/O statistics on the current node. In the current version, only one page is read or written in each read or write operation. Therefore, the number of read/write times is the same as the number of pages.

Table 15-125 GS_REL_IOSTAT columns

Name	Type	Description
phyrds	bigint	Number of disk reads
phywrts	bigint	Number of disk writes
phyblkrd	bigint	Number of read pages
phyblkwrt	bigint	Number of written pages

15.3.66 GS_RESPOOL_RUNTIME_INFO

GS_RESPOOL_RUNTIME_INFO displays information about the running of jobs in all resource pools on the current CN.

Table 15-126 GS_RESPOOL_RUNTIME_INFO columns

Name	Type	Description
nodegroup	name	Name of the logical cluster of the resource pool. The default value is **installation**.
rpname	name	Resource pool name
ref_count	int	Number of jobs referenced by resource pools. The number is counted regardless of whether a job is controlled by a resource pool.
fast_run	int	Number of running jobs in the fast lane of the resource pool
fast_wait	int	Number of jobs queued in the fast lane of the resource pool
slow_run	int	Number of running jobs in the slow lane of the resource pool
slow_wait	int	Number of jobs queued in the slow lane of the resource pool

15.3.67 GS_RESPOOL_RESOURCE_INFO

GS_RESPOOL_RESOURCE_INFO displays job running information about all resource pools on a CN and the information about resource pool usage of an instance (CN/DN).

NOTE

On a DN, it only displays the monitoring information of the logical cluster that the DN belongs to.

Table 15-127 GS_RESPOOL_RESOURCE_INFO columns

Name	Type	Description
nodegroup	name	Name of the logical cluster of the resource pool. The default value is **installation**.
rpname	name	Resource pool name
cgroup	name	Name of the Cgroup associated with the resource pool
ref_count	int	Number of jobs referenced by the resource pool. The number is counted regardless of whether the job is controlled by the resource pool. This parameter is valid only on CNs.
fast_run	int	Number of running jobs in the fast lane of the resource pool. This parameter is valid only on CNs.
fast_wait	int	Number of jobs queued in the fast lane of the resource pool. This parameter is valid only on CNs.
fast_limit	int	Limit on the number of concurrent jobs in the fast lane in a resource pool. This parameter is valid only on CNs.
slow_run	int	Number of running jobs in the slow lane of the resource pool. This parameter is valid only on CNs.
slow_wait	int	Number of jobs queued in the slow lane of the resource pool. This parameter is valid only on CNs.
slow_limit	int	Limit on the number of concurrent jobs in the slow lane in a resource pool. This parameter is valid only on CNs.
used_cpu	double	Average number of CPUs used by the resource pool in a 5s monitoring period. The value is accurate to two decimal places. • On a DN, it indicates the number of CPUs used by the resource pool on the current DN. • On a CN, it indicates the total CPU usage of resource pools on all DNs.

Name	Type	Description
cpu_limit	int	It indicates the upper limit of available CPUs for resource pools. If the CPU share is limited, this parameter indicates the available CPUs for GaussDB(DWS). If the CPU limit is specified, this parameter indicates the available CPUs for associated Cgroups. ● On a DN, it indicates the upper limit of available CPUs for the resource pool on the current DN. ● On a CN, it indicates the total upper limit of available CPUs for resource pools on all DNs.
used_mem	int	Memory size used by the resource pool (unit: MB) ● On a DN, it indicates the memory usage of the resource pool on the current DN. ● On a CN, it indicates the total memory usage of resource pools on all DNs.
estimate_mem	int	Estimated memory used by the jobs running in the resource pools on the current CN. This parameter is valid only on CNs.
mem_limit	int	Upper limit of available memory for the resource pool (unit: MB). ● On a DN, it indicates the upper limit of available memory for the resource pool on the current DN. ● On a CN, it indicates the total upper limit of available memory for resource pools on all DNs.
read_kbytes	bigint	Number of logical read bytes in the resource pool within a 5s monitoring period (unit: KB). ● On a DN, it indicates the number of logical read bytes in the resource pool on the current DN. ● On a CN, it indicates the total logical read bytes of resource pools on all DNs.
write_kbytes	bigint	Number of logical write bytes in the resource pool within a 5s monitoring period (unit: KB). ● On a DN, it indicates the number of logical write bytes in the resource pool on the current DN. ● On a CN, it indicates the total logical write bytes of resource pools on all DNs.

Name	Type	Description
read_counts	bigint	Number of logical reads in the resource pool within a 5s monitoring period. ● On a DN, it indicates the number of logical reads in the resource pool on the current DN. ● On a CN, it indicates the total number of logical reads in resource pools on all DNs.
write_counts	bigint	Number of logical writes in the resource pool within a 5s monitoring period. ● On a DN, it indicates the number of logical writes in the resource pool on the current DN. ● On a CN, it indicates the total number of logical writes in resource pools on all DNs.
read_speed	double	Average rate of logical reads of the resource pool in a 5s monitoring period. ● On a DN, it indicates the logical read rate of the resource pool on the current DN. ● On a CN, it indicates the overall logical read rate of resource pools on all DNs.
write_speed	double	Average rate of logical writes of resource pools in a 5s monitoring period, in KB/s. ● On a DN, it indicates the logical write rate of the resource pool on the current DN. ● On a CN, it indicates the overall logical write rate of resource pools on all DNs.
send_speed	double	Average network sending rate of a resource pool in a 5-second monitoring period. The unit is KB/s. ● On a DN, it indicates the network sending rate of the resource pool on the current DN. ● On a CN, it indicates that the cumulative sum of the network sending rates of the resource pool on all DNs.
recv_speed	double	Average network receiving rate of a resource pool in a 5-second monitoring period. The unit is KB/s. ● On a DN, it indicates the network receiving rate of the resource pool on the current DN. ● On a CN, it indicates that the cumulative sum of the network receiving rates of the resource pool on all DNs.

15.3.68 GS_RESPOOL_MONITOR

Displays the job running information and resource usage information of all resource pools. This view can be queried only on CNs. This view is supported only by clusters of 8.2.1.100 and later versions.

Table 15-128 GS_RESPOOL_MONITOR columns

Column	Type	Description
rpname	name	Resource pool name.
nodegroup	name	Name of the logical cluster the resource pool belongs to. The default value is **installation**.
cn_count	bigint	Number of CNs in the cluster. This parameter is used to determine whether the management and control result of a single CN is proper in a multi-CN environment.
short_acc	boolean	Whether to enable short query acceleration for a resource pool.
session_count	bigint	Number of sessions associated with the resource pool, that is, the number of sessions initiated by users associated with the resource pool, including idle and active sessions.
active_count	bigint	Number of active sessions associated with the resource pool, that is, the number of sessions that are performing queries.
global_wait	bigint	Number of jobs associated with the resource pool that are queued because the number of concurrent jobs on a single CN exceeds the value of **max_active_statements**.
fast_run	bigint	Number of jobs associated with the resource pool that are running on the fast lane.
fast_wait	bigint	Number of jobs associated with the resource pool that are queued on the fast lane.
fast_limit	bigint	Maximum number of concurrent jobs on the fast lane in a resource pool.
slow_run	bigint	Number of jobs associated with the resource pool that are running on the slow lane.
slow_wait	bigint	Number of jobs associated with the resource pool that are queued on the slow lane.
slow_limit	bigint	Maximum number of concurrent jobs on the slow lane in a resource pool.

Column	Type	Description
used_mem	text	Average memory usage of the resource pool on all DNs. The result has been formatted using **pg_size_pretty**.
estimate_mem	text	Total estimated memory of jobs running in the resource pool. The result has been formatted using **pg_size_pretty**.
mem_limit	text	Upper limit of the available memory in the resource pool. The result has been formatted using **pg_size_pretty**.
query_mem_limit	name	Maximum memory that can be used by a single query in a resource pool. This parameter is used to limit the estimated query memory to prevent abnormal queuing caused by overestimation. The estimated memory is used to limit the actually used query memory. The displayed result has been formatted using **pg_size_pretty**.
used_cpu	double precision	Average number of CPU cores occupied by a resource pool on all DNs. CPU isolation is performed by node and resource pool. If a single node contains multiple DNs, the number of CPU cores occupied by a resource pool on a single node must be multiplied by the number of DNs.
cpu_limit	double precision	Average upper limit of available CPUs for a resource pool on all nodes. If CPU Time Limit is enabled, the value is the total number of available CPU cores of GaussDB(DWS). If CPU Usage Limit is enabled, the value is the number of available CPU cores of the associated Cgroup.
read_speed	text	Average logical I/O read rate of the resource pool on all DNs. The result has been formatted using **pg_size_pretty**.
write_speed	text	Average logical I/O write rate of the resource pool on all DNs. The result has been formatted using **pg_size_pretty**.
send_speed	text	Average network sending rate of the resource pool on all DNs. The result has been formatted using **pg_size_pretty**.
recv_speed	text	Average receiving rate of the resource pool on all DNs. The result has been formatted using **pg_size_pretty**.

15.3.69 GS_ROW_TABLE_IO_STAT

GS_ROW_TABLE_IO_STAT displays the I/O of all row-store tables of the database on the current node. The value of each statistical column is the accumulated value since the instance was started.

Table 15-129 GS_ROW_TABLE_IO_STAT columns

Name	Type	Description
schemaname	name	Namespace of a table
relname	name	Table name
heap_read	bigint	Number of blocks logically read in the heap
heap_hit	bigint	Number of block hits in the heap
idx_read	bigint	Number of blocks logically read in the index
idx_hit	bigint	Number of block hits in the index
toast_read	bigint	Number of blocks logically read in the **TOAST** table
toast_hit	bigint	Number of block hits in the **TOAST** table
tidx_read	bigint	Number of indexes logically read in the **TOAST** table
tidx_hit	bigint	Number of index hits in the **TOAST** table

15.3.70 GS_SESSION_CPU_STATISTICS

GS_SESSION_CPU_STATISTICS displays load management information about CPU usage of ongoing complex jobs executed by the current user.

Table 15-130 GS_SESSION_CPU_STATISTICS columns

Name	Type	Description
datid	oid	OID of the database this backend is connected to
usename	name	Name of the user logging in to the backend
pid	bigint	ID of a backend process
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. The unit is ms.

Name	Type	Description
max_cpu_time	bigint	Maximum CPU time of the statement across all DNs. The unit is ms.
total_cpu_time	bigint	Total CPU time of the statement across all DNs. The unit is ms.
query	text	Statement that is being executed
node_group	text	Logical cluster of the user running the statement

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.

Table 15-131 GS_SESSION_MEMORY_STATISTICS columns

Name	Type	Description
datid	oid	OID of the database the backend is connected to
usename	name	Name of the user logged in to the backend
pid	bigint	ID of the backend thread
start_time	timestamp with time zone	Time when the statement starts to be executed
min_peak_memory	integer	Minimum memory peak of a statement across all DNs, in MB
max_peak_memory	integer	Maximum memory peak of a statement across all DNs, in MB
spill_info	text	Statement spill information on all DNs **None** indicates that the statement has not been spilled to disks on any DNs. **All** indicates that the statement has been spilled to disks on every DN. **[*a*:*b*]** indicates that the statement has been spilled to disks on *a* of *b* DNs.
query	text	Statement that is being executed
node_group	text	Logical cluster of the user running the statement

15.3.72 GS_SQL_COUNT

GS_SQL_COUNT displays statistics about the five types of statements (**SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO**) executed on the current node of the database, including the number of execution times, response time (the maximum, minimum, average, and total response time of the other four types of statements except the **MERGE INTO** statement, in microseconds), and the number of execution times of **DDL**, **DML**, and **DCL statements**.

The classification of **DDL**, **DML**, and **DCL** statements in the **GS_SQL_COUNT** view is slightly different from that of the SQL syntaxt. The details are as follows:

- User-related statements, such as **CREATE**/**ALTER**/**DROP USER** and **CREATE**/**ALTER**/**DROP ROLE**, are of the DCL type.
- Transaction-related statements such as **BEGIN**/**COMMIT**/**SET CONSTRAINTS**/**ROLLBACK**/**SAVEPOINT**/**START** are of the DCL type.
- **ALTER SYSTEM KILL SESSION** is equivalent to the **SELECT pg_terminate_backend()** statement and is of the DML type.

The classification of other statements is similar to the definition in the SQL syntax.

When a common user queries the **GS_SQL_COUNT** view, only the statistics of this user in the current node can be viewed. When a user with the administrator permissions queries the **GS_SQL_COUNT** view, the statistics of all users in the current node can be viewed. When the cluster or the node is restarted, the statistics are cleared and the counting restarts. The counting is based on the number of queries received by the node, including the queries performed inside the cluster. Statistics about the **GS_SQL_COUNT** view are collected only on CNs, and SQL statements sent from other CNs are not collected. No result is returned when you query the view on a DN.

Table 15-132 GS_SQL_COUNT columns

Name	Type	Description
node_name	name	Node name
user_name	name	User 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
mergeinto_count	bigint	Number of **MERGE INTO** statements
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

Name	Type	Description
avg_select_elapse	bigint	Average response time of **SELECT** statements
max_select_elapse	bigint	Maximum response time of **SELECT** statements
min_select_elapse	bigint	Minimum response time of **SELECT** statements
total_update_elapse	bigint	Total response time of **UPDATE** statements
avg_update_elapse	bigint	Average response time of **UPDATE** statements
max_update_elapse	bigint	Maximum response time of **UPDATE** statements
min_update_elapse	bigint	Minimum response time of **UPDATE** statements
total_delete_elapse	bigint	Total response time of **DELETE** statements
avg_delete_elapse	bigint	Average response time of **DELETE** statements
max_delete_elapse	bigint	Maximum response time of **DELETE** statements
min_delete_elapse	bigint	Minimum response time of **DELETE** statements
total_insert_elapse	bigint	Total response time of **INSERT** statements
avg_insert_elapse	bigint	Average response time of **INSERT** statements
max_insert_elapse	bigint	Maximum response time of **INSERT** statements
min_insert_elapse	bigint	Minimum response time of **INSERT** statements

15.3.73 GS_STAT_DB_CU

GS_STAT_DB_CU displays CU hits of each database in each node of a cluster. You can clear it using **gs_stat_reset()**.

Table 15-133 GS_STAT_DB_CU columns

Name	Type	Description
node_name1	text	Node name

Name	Type	Description
db_name	text	Database name
mem_hit	bigint	Number of memory hits
hdd_sync_read	bigint	Number of disk synchronous reads
hdd_asyn_read	bigint	Number of disk asynchronous reads

15.3.74 GS_STAT_SESSION_CU

GS_STAT_SESSION_CU displays 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 or restart the cluster.

Table 15-134 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 hard disk synchronous reads
hdd_asyn_read	integer	Number of hard disk asynchronous reads

15.3.75 GS_TABLE_CHANGE_STAT

GS_TABLE_CHANGE_STAT displays the changes of all tables (excluding foreign tables) of the database on the current node. The value of each column that indicates the number of times is the accumulated value since the instance was started.

Table 15-135 GS_TABLE_CHANGE_STAT columns

Name	Type	Description
schemaname	name	Namespace of a table
relname	name	Table name
last_vacuum	timestamp with time zone	Time when the last **VACUUM** operation is performed manually

Name	Type	Description
vacuum_count	bigint	Number of times of manually performing the **VACUUM** operation
last_autovacuum	timestamp with time zone	Time when the last **VACUUM** operation is performed automatically
autovacuum_count	bigint	Number of times of automatically performing the **VACUUM** operation
last_analyze	timestamp with time zone	Time when the **ANALYZE** operation is performed (both manually and automatically)
analyze_count	bigint	Number of times of performing the **ANALYZE** operation (both manually and automatically)
last_autoanalyze	timestamp with time zone	Time when the last **ANALYZE** operation is performed automatically
autoanalyze_count	bigint	Number of times of automatically performing the **ANALYZE** operation
last_change	bigint	Time when the last modification (**INSERT**, **UPDATE**, or **DELETE**) is performed

15.3.76 GS_TABLE_STAT

GS_TABLE_STAT displays statistics about all tables (excluding foreign tables) of the database on the current node. The values of **live_tuples** and **dead_tuples** are real-time values, and the values of other statistical columns are accumulated values since the instance was started.

Table 15-136 GS_TABLE_STAT columns

Name	Type	Description
schemaname	name	Namespace of a table
relname	name	Table name
seq_scan	bigint	Number of sequential scans. It is counted only for row-store tables. For a partitioned table, the sum of the number of scans of each partition is displayed.
seq_tuple_read	bigint	Number of rows scanned in sequence. It is counted only for row-store tables.

Name	Type	Description
index_scan	bigint	Number of index scans. It is counted only for row-store tables.
index_tuple_read	bigint	Number of rows scanned by the index. It is counted only for row-store tables.
tuple_inserted	bigint	Number of rows inserted.
tuple_updated	bigint	Number of rows updated.
tuple_deleted	bigint	Number of rows deleted.
tuple_hot_updated	bigint	Number of rows with HOT updates.
live_tuples	bigint	Number of live tuples. Query the view on the CN. If **ANALYZE** is executed, the total number of live tuples in the table is displayed. Otherwise, **0** is displayed. This indicator applies only to row-store tables.
dead_tuples	bigint	Number of dead tuples. Query the view on the CN. If **ANALYZE** is executed, the total number of dead tuples in the table is displayed. Otherwise, **0** is displayed. This indicator applies only to row-store tables.

15.3.77 GS_TOTAL_NODEGROUP_MEMORY_DETAIL

GS_TOTAL_NODEGROUP_MEMORY_DETAIL displays statistics about memory usage of the logical cluster that the current database belongs to in the unit of MB.

Table 15-137 GS_TOTAL_NODEGROUP_MEMORY_DETAIL columns

Name	Type	Description
ngname	text	Name of a logical cluster

Name	Type	Description
memorytype	text	Memory type. Its value can be: • **ng_total_memory**: total memory of the logical cluster • **ng_used_memory**: memory usage of the logical cluster • **ng_estimate_memory**: estimated memory usage of the logical cluster • **ng_foreignrp_memsize**: total memory of the external resource pool of the logical cluster • **ng_foreignrp_memsize**: memory usage of the external resource pool of the logical cluster • **ng_foreignrp_peaksize**: peak memory usage of the external resource pool of the logical cluster • **ng_foreignrp_mempct**: percentage of the external resource pool of the logical cluster to the total memory of the logical cluster • **ng_foreignrp_estmsize**: estimated memory usage of the external resource pool of the logical cluster
memorymbytes	integer	Size of allocated memory-typed memory

15.3.78 GS_USER_MONITOR

GS_USER_MONITOR displays all users' job running and resource usage information. This view can be queried only on CNs. This view is supported only by clusters of 8.2.1.100 and later versions.

Table 15-138 GS_USER_MONITOR columns

Column	Type	Description
usename	name	Username
rpname	name	Name of the resource pool associated with the user
nodegroup	name	Name of the logical cluster the resource pool belongs to. The default value is **installation**.
session_count	bigint	Number of sessions initiated by the user, including idle and active sessions
active_count	bigint	Number of active sessions initiated by the user, that is, the number of sessions that are performing queries.
global_wait	bigint	Number of jobs that are queued because the number of concurrent jobs on a single CN exceeds the value of **max_active_statements**.

Column	Type	Description
fast_run	bigint	Number of jobs that are running on the fast lane of the resource pool among all jobs executed by the user.
fast_wait	bigint	Number of jobs queued in the fast lane of the resource pool among all jobs executed by the user.
slow_run	bigint	Number of jobs that are running on the slow lane of the resource pool among all jobs executed by the user.
slow_wait	bigint	Number of jobs queued in the slow lane of the resource pool among all jobs executed by the user.
used_mem	bigint	Average memory used by a user on all DNs, in MB.
estimate_mem	bigint	Total estimated memory used by running jobs, in MB.
used_cpu	double precision	Average number of CPU cores used by a user on all DNs. If a single node contains multiple DNs, the number of CPU cores used by a user on the node must be multiplied by the number of DNs.
read_speed	bigint	Average logical I/O read rate of a user on all DNs, in KB/s.
write_speed	bigint	Average logical I/O write rate of a user on all DNs, in KB/s.
send_speed	bigint	Average data sending rate of a user on all DNs, in KB/s.
recv_speed	bigint	Average data receiving rate of a user on all DNs, in KB/s.
used_space	bigint	Used space of user permanent tables, in KB.
space_limit	bigint	Maximum space that can be used by user permanent tables, in KB. The value **-1** indicates that the space size is not limited.
used_temp_space	bigint	Used space of user temporary tables, in KB.
temp_space_limit	bigint	Maximum space that can be used by user temporary tables, in KB. The value **-1** indicates that the space size is not limited.
used_spill_space	bigint	Used space for flushing intermediate result sets, in KB.
spill_space_limit	bigint	Maximum space that can be used for flushing intermediate result sets, in KB. The value **-1** indicates that the space size is not limited.

15.3.79 GS_USER_TRANSACTION

GS_USER_TRANSACTION provides transaction information about users on a single CN. The database records the number of times that each user commits and rolls back transactions and the response time of transaction commitment and rollback, in microseconds.

Table 15-139 GS_USER_TRANSACTION columns

Name	Type	Description
usename	name	Username
commit_counter	bigint	Number of the commit times
rollback_counter	bigint	Number of rollbacks
resp_min	bigint	Minimum response time
resp_max	bigint	Maximum response time
resp_avg	bigint	Average response time
resp_total	bigint	Total response time

15.3.80 GS_VIEW_DEPENDENCY

GS_VIEW_DEPENDENCY allows you to query the direct dependencies of all views visible to the current user.

Table 15-140 GS_VIEW_DEPENDENCY columns

Column	Type	Description
objschema	name	View space name
objname	name	View name
refobjschema	name	Name of the space where the dependent object resides
refobjname	name	Name of a dependent object
relobjkind	char	Type of a dependent object • r: table • v: view

15.3.81 GS_VIEW_DEPENDENCY_PATH

GS_VIEW_DEPENDENCY_PATH allows you to query the direct dependencies of all views visible to the current user. If the base table on which the view depends exists and the dependency between views at different levels is normal, you can use this view to query the dependency between views at different levels starting from the base table.

Table 15-141 GS_VIEW_DEPENDENCY_PATH columns

Column	Type	Description
objschema	name	View space name
objname	name	View name
refobjschema	name	Name of the space where the dependent object resides
refobjname	name	Name of a dependent object
path	text	Dependency path

15.3.82 GS_VIEW_INVALID

GS_VIEW_INVALID queries all unavailable views visible to the current user. If the base table, function, or synonym that the view depends on is abnormal, the **validtype** column of the view is displayed as "invalid".

Table 15-142 GS_VIEW_INVALID columns

Column	Type	Description
oid	oid	OID of the view
schemaname	name	View space name
viewname	name	Name of the view
viewowner	name	Owner of the view
definition	text	Definition of the view
validtype	text	View validity flag

15.3.83 GS_WAIT_EVENTS

GS_WAIT_EVENTS displays statistics about waiting status and events on the current node.

The values of statistical columns in this view are accumulated only when the **enable_track_wait_event** GUC parameter is set to **on**. If

enable_track_wait_event is set to **off** during statistics measurement, the statistics will no longer be accumulated, but the existing values are not affected. If **enable_track_wait_event** is **off**, 0 row is returned when this view is queried.

Table 15-143 GS_WAIT_EVENTS columns

Name	Type	Description
nodename	name	Node name
type	text	Event type, which can be **STATUS**, **LOCK_EVENT**, **LWLOCK_EVENT**, or **IO_EVENT**
event	text	Event name. For details, see **PG_THREAD_WAIT_STATUS**.
wait	bigint	Number of times an event occurs. This column and all the columns below are values accumulated during process running.
failed_wait	bigint	Number of waiting failures. In the current version, this column is used only for counting timeout errors and waiting failures of locks such as **LOCK** and **LWLOCK**.
total_wait_time	bigint	Total duration of the event
avg_wait_time	bigint	Average duration of the event
max_wait_time	bigint	Maximum wait time of the event
min_wait_time	bigint	Minimum wait time of the event

In the current version, for events whose **type** is **LOCK_EVENT**, **LWLOCK_EVENT**, or **IO_EVENT**, the display scope of **GS_WAIT_EVENTS** is the same as that of the corresponding events in the **PG_THREAD_WAIT_STATUS** view.

For events whose **type** is **STATUS**, **GS_WAIT_EVENTS** displays the following waiting status columns. For details, see the **PG_THREAD_WAIT_STATUS** view.

- acquire lwlock
- acquire lock
- wait io
- wait pooler get conn
- wait pooler abort conn
- wait pooler clean conn
- wait transaction sync
- wait wal sync
- wait data sync

- wait producer ready
- create index
- analyze
- vacuum
- vacuum full
- gtm connect
- gtm begin trans
- gtm commit trans
- gtm rollback trans
- gtm create sequence
- gtm alter sequence
- gtm get sequence val
- gtm set sequence val
- gtm drop sequence
- gtm rename sequence

15.3.84 GS_WLM_OPERARAOR_INFO

This view displays the execution information about operators in the query statements that have been executed on the current CN. The information comes from the system catalog **dbms_om**. **gs_wlm_operator_info**.

15.3.85 GS_WLM_OPERATOR_HISTORY

GS_WLM_OPERATOR_HISTORY displays the records of operators in jobs that have been executed by the current user on the current CN.

This view is used to query data from the GaussDB(DWS). Data in the GaussDB(DWS) is cleared periodically. If the GUC parameter **enable_resource_record** is set to **on**, records in the view will be dumped to the system catalog **GS_WLM_OPERATOR_INFO** every 3 minutes and deleted from the view. If **enable_resource_record** is set to **off**, the records will be deleted from the view after the retention period expires. The recorded data is the same as that described in **Table 15-5**.

15.3.86 GS_WLM_OPERATOR_STATISTICS

GS_WLM_OPERATOR_STATISTICS displays the operators of the jobs that are being executed by the current user.

Table 15-144 GS_WLM_OPERATOR_STATISTICS columns

Name	Type	Description
queryid	bigint	Internal query_id used for statement execution
pid	bigint	ID of the backend thread
plan_node_id	integer	plan_node_id of the execution plan of a query

Name	Type	Description
plan_node_name	text	Name of the operator corresponding to **plan_node_id**. The maximum length of the operator name is 127 characters (excluding format characters such as spaces).
start_time	timestamp with time zone	Time when the operator starts to be executed for the first time.
duration	bigint	Total execution time of the operator from the start to the end, in milliseconds.
status	text	Execution status of the current operator. The value can be **waiting**, **running**, or **finished**.
query_dop	integer	DOP of the current operator
estimated_rows	bigint	Number of rows estimated by the optimizer. If the number of returned estimated rows exceeds int64_max, int64_max is displayed.
tuple_processed	bigint	Total number of elements returned by the current operator on all DNs. If the estimated number of returned rows exceeds int64_max, int64_max is displayed.
min_peak_memory	integer	Minimum peak memory used by the current operator on all DNs. The unit is MB.
max_peak_memory	integer	Maximum peak memory used by the current operator on all DNs. The unit is MB.
average_peak_memory	integer	Average peak memory used by the current operator on all DNs. The unit is MB.
memory_skew_percent	integer	Memory usage skew of the current operator among DNs
min_spill_size	integer	Minimum logical spilled data among all DNs when a spill occurs, in MB. The default value is **0**.
max_spill_size	integer	Maximum logical spilled data among all DNs when a spill occurs, in MB. The default value is **0**.
average_spill_size	integer	Average logical spilled data among all DNs when a spill occurs, in MB. The default value is **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. The unit is ms.

Name	Type	Description
max_cpu_time	bigint	Maximum execution time of the operator on all DNs. The unit is ms.
total_cpu_time	bigint	Total execution time of the operator on all DNs. The unit is ms.
cpu_skew_percent	integer	Skew of the execution time among DNs.
warning	text	Warning. The following warnings are displayed: 1. Sort/SetOp/HashAgg/HashJoin spill 2. Spill file size large than 256MB 3. Broadcast size large than 100MB 4. Early spill 5. Spill times is greater than 3 6. Spill on memory adaptive 7. Hash table conflict

15.3.87 GS_WLM_SESSION_INFO

This view displays the execution information about the query statements that have been executed on the current CN. The information comes from the system catalog **dbms_om**. **gs_wlm_session_info**.

15.3.88 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 view is used to query data from GaussDB(DWS). The view returns the data queried from the **GS_WLM_SESSION_INFO** table within 3 minutes only if the GUC parameter **enable_resource_track** is set to **on**.

Table 15-145 GS_WLM_SESSION_HISTORY columns

Name	Type	Description
datid	oid	OID of the database this backend is connected to
dbname	text	Name of the database the backend is connected to
schemaname	text	Schema name
nodename	text	Name of the CN where the statement is run
username	text	User name used for connecting to the backend

Name	Type	Description
application_name	text	Name of the application that is connected to the backend
client_addr	inet	IP address of the client connected to this backend. 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 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, or **-1** if a Unix socket is used
query_band	text	Job type, which is specified by the **query_band** parameter. The default value is a null string.
block_time	bigint	Duration that a statement is blocked before being executed, including the statement parsing and optimization duration. The unit is ms.
start_time	timestamp with time zone	Time when the statement starts to be run
finish_time	timestamp with time zone	Time when the statement execution ends
duration	bigint	Execution time of a statement. The unit is ms.
estimate_total_time	bigint	Estimated execution time of a statement. The unit is ms.
status	text	Final statement execution status. Its value can be **finished** (normal) or **aborted** (abnormal). The statement status here is the execution status of the database server. If the statement is successfully executed on the database server but an error is reported in the result set, the statement status is **finished**.
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

Name	Type	Description
estimate_memory	integer	Estimated memory used by a statement on a single instance. The unit is MB. This column takes effect only when the GUC parameter **enable_dynamic_workload** is set to **on**.
min_peak_memory	integer	Minimum memory peak of a statement across all DNs. The unit is MB.
max_peak_memory	integer	Maximum memory peak of a statement across all DNs. The unit is MB.
average_peak_memory	integer	Average memory usage during statement execution. The unit is MB.
memory_skew_percent	integer	Memory usage skew of a statement among DNs.
spill_info	text	Statement spill information on all DNs. **None** indicates that the statement has not been spilled to disks on any DNs. **All** indicates that the statement has been spilled to disks on every DN. **[*a*:*b*]** indicates that 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. The unit is MB. The default value is **0**.
max_spill_size	integer	Maximum spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
average_spill_size	integer	Average spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
spill_skew_percent	integer	DN spill skew when a spill occurs
min_dn_time	bigint	Minimum execution time of a statement across all DNs. The unit is ms.
max_dn_time	bigint	Maximum execution time of a statement across all DNs. The unit is ms.
average_dn_time	bigint	Average execution time of a statement across all DNs. The unit is ms.
dntime_skew_percent	integer	Execution time skew of a statement among DNs.
min_cpu_time	bigint	Minimum CPU time of a statement across all DNs. The unit is ms.

Name	Type	Description
max_cpu_time	bigint	Maximum CPU time of a statement across all DNs. The unit is ms.
total_cpu_time	bigint	Total CPU time of a statement across all DNs. The unit is ms.
cpu_skew_percent	integer	CPU time skew of a statement among DNs.
min_peak_iops	integer	Minimum IOPS peak of a 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 a 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 a 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 SQL self-diagnosis tuning are displayed: 1. Spill file size large than 256MB 2. Broadcast size large than 100MB 3. Early spill 4. Spill times is greater than 3 5. Spill on memory adaptive 6. Hash table conflict
queryid	bigint	Internal query ID used for statement execution
query	text	Statement to be executed. A maximum of 64 KB of strings can be retained.

Name	Type	Description
query_plan	text	Execution plan of a statement. Specification restrictions: 1. Execution plans are displayed only for DML statements. 2. In 8.2.1.100 and later versions, the number of data binding times is added to the execution plans of Parse Bind Execute (PBE) statements to facilitate statement analysis. The number of data binding times is displayed in the format of **PBE bind times:** *Times*.
node_group	text	Logical cluster of the user running the statement
pid	bigint	PID of the backend thread of the statement
lane	text	Fast/Slow lane where the statement is executed
unique_sql_id	bigint	ID of the normalized unique SQL.
session_id	text	Unique identifier of a session in the database system. Its format is **session_start_time.tid.node_name**.
min_read_bytes	bigint	Minimum I/O read bytes of a statement across all DNs. The unit is byte.
max_read_bytes	bigint	Maximum I/O read bytes of a statement across all DNs. The unit is byte.
average_read_bytes	bigint	Average I/O read bytes of a statement across all DNs.
min_write_bytes	bigint	Minimum I/O write bytes of a statement across all DNs.
max_write_bytes	bigint	Maximum I/O write bytes of a statement across all DNs.
average_write_bytes	bigint	Average I/O write bytes of a statement across all DNs.
recv_pkg	bigint	Total number of communication packages received by a statement across all DNs.
send_pkg	bigint	Total number of communication packages sent by a statement across all DNs.
recv_bytes	bigint	Total received data of the statement stream, in byte.

Name	Type	Description
send_bytes	bigint	Total sent data of the statement stream, in byte.
stmt_type	text	Query type corresponding to the statement.
except_info	text	Information about the exception rule triggered by the statement.
parse_time	bigint	Total parsing time before statements are queued (including lexical syntax parsing, optimization rewriting, and plan generation time). The unit is ms. This field is supported only by 8.3.0.100 and later versions.

15.3.89 GS_WLM_SESSION_STATISTICS

GS_WLM_SESSION_STATISTICS displays load management information about jobs being executed by the current user on the current CN.

Table 15-146 GS_WLM_SESSION_STATISTICS columns

Name	Type	Description
datid	oid	OID of the database this backend is connected to
dbname	name	Name of the database the backend is connected to
schemaname	text	Schema name
nodename	text	Name of the CN where the statement is executed
username	name	User name 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 this backend. 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 will only be non-null for IP connections, and only when **log_hostname** is enabled.

Name	Type	Description
client_port	integer	TCP port number that the client uses for communication with this backend, or **-1** if a Unix socket is used
query_band	text	Job type, which is specified by the GUC parameter **query_band** parameter. The default value is a null string.
pid	bigint	Process ID of the backend
block_time	bigint	Block time before the statement is executed. The unit is ms.
start_time	timestamp with time zone	Time when the statement starts to be executed
parse_time	bigint	SQL Parsing Unit: millisecond
duration	bigint	For how long a statement has been executing. The unit is ms.
estimate_total_time	bigint	Estimated execution time of a statement. The unit is ms.
estimate_left_time	bigint	Estimated remaining time of statement execution. The unit is ms.
enqueue	text	Workload management resource status
resource_pool	name	Resource pool used by the user
control_group	text	Cgroup used by the statement
estimate_memory	integer	Estimated memory used by a statement on a single instance. The unit is MB. This column takes effect only when the GUC parameter **enable_dynamic_workload** is set to **on**.
min_peak_memory	integer	Minimum memory peak of a statement across all DNs. The unit is MB.
max_peak_memory	integer	Maximum memory peak of a statement across all DNs. The unit is MB.
average_peak_memory	integer	Average memory usage during statement execution. The unit is MB.
memory_skew_percent	integer	Memory usage skew of a statement among DNs.

Name	Type	Description
spill_info	text	Statement spill information on all DNs. **None** indicates that the statement has not been spilled to disks on any DNs. **All** indicates that the statement has been spilled to disks on every DN. **[*a*:*b*]** indicates that 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. The unit is MB. The default value is **0**.
max_spill_size	integer	Maximum spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
average_spill_size	integer	Average spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
spill_skew_percent	integer	DN spill skew when a spill occurs
min_dn_time	bigint	Minimum execution time of a statement across all DNs. The unit is ms.
max_dn_time	bigint	Maximum execution time of a statement across all DNs. The unit is ms.
average_dn_time	bigint	Average execution time of a statement across all DNs. The unit is ms.
dntime_skew_percent	integer	Execution time skew of a statement among DNs.
min_cpu_time	bigint	Minimum CPU time of a statement across all DNs. The unit is ms.
max_cpu_time	bigint	Maximum CPU time of a statement across all DNs. The unit is ms.
total_cpu_time	bigint	Total CPU time of a statement across all DNs. The unit is ms.
cpu_skew_percent	integer	CPU time skew of a statement among DNs.
min_peak_iops	integer	Minimum IOPS peak of a statement across all DNs. It is counted by ones in a column-store table and by ten thousands in a row-store table.

Name	Type	Description
max_peak_iops	integer	Maximum IOPS peak of a 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 a 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.
min_read_speed	integer	Minimum I/O read rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
max_read_speed	integer	Maximum I/O read rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
average_read_speed	integer	Average I/O read rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
min_write_speed	integer	Minimum I/O write rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
max_write_speed	integer	Maximum I/O write rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
average_write_speed	integer	Average I/O write rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
recv_pkg	bigint	Total number of communication packages received by a statement across all DNs.
send_pkg	bigint	Total number of communication packages sent by a statement across all DNs.
recv_bytes	bigint	Total received data of the statement stream, in byte.
send_bytes	bigint	Total sent data of the statement stream, in byte.

Name	Type	Description
warning	text	Warning. The following warnings and warnings related to SQL self-diagnosis tuning are displayed: 1. Spill file size large than 256MB 2. Broadcast size large than 100MB 3. Early spill 4. Spill times is greater than 3 5. Spill on memory adaptive 6. Hash table conflict
unique_sql_id	bigint	ID of the normalized unique SQL.
queryid	bigint	Internal query ID used for statement execution
query	text	Statement that is being executed
query_plan	text	Execution plan of a statement Specification restrictions: 1. Execution plans are displayed only for DML statements. 2. In 8.2.1.100 and later versions, the number of data binding times is added to the execution plans of Parse Bind Execute (PBE) statements to facilitate statement analysis. The number of data binding times is displayed in the format of **PBE bind times:** *Times*.
node_group	text	Logical cluster of the user running the statement
stmt_type	text	Query type corresponding to the statement.
except_info	text	Information about the exception rule triggered by the statement.
parse_time	bigint	Total parsing time before statements are queued (including lexical syntax parsing, optimization rewriting, and plan generation time). The unit is ms. This field is supported only by 8.3.0.100 and later versions.

15.3.90 GS_WLM_SQL_ALLOW

GS_WLM_SQL_ALLOW displays the configured resource management SQL whitelist, including the default SQL whitelist and the SQL whitelist configured using the GUC parameter **wlm_sql_allow_list**.

15.3.91 GS_WORKLOAD_SQL_COUNT

GS_WORKLOAD_SQL_COUNT displays statistics on the number of SQL statements executed in workload Cgroups on the current node, including the number of **SELECT**, **UPDATE**, **INSERT**, and **DELETE** statements and the number of DDL, DML, and DCL statements.

Table 15-147 GS_WORKLOAD_SQL_COUNT columns

Name	Type	Description
workload	name	Workload Cgroup 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

15.3.92 GS_WORKLOAD_SQL_ELAPSE_TIME

GS_WORKLOAD_SQL_ELAPSE_TIME displays statistics on the response time of SQL statements in workload Cgroups on the current node, including the maximum, minimum, average, and total response time of **SELECT**, **UPDATE**, **INSERT**, and **DELETE** statements. The unit is microsecond.

Table 15-148 GS_WORKLOAD_SQL_ELAPSE_TIME columns

Name	Type	Description
workload	name	Workload Cgroup name
total_select_elapse	bigint	Total response time of **SELECT** statements
max_select_elapse	bigint	Maximum response time of **SELECT** statements

Name	Type	Description
min_select_elapse	bigint	Minimum response time of **SELECT** statements
avg_select_elapse	bigint	Average response time of **SELECT** statements
total_update_elapse	bigint	Total response time of **UPDATE** statements
max_update_elapse	bigint	Maximum response time of **UPDATE** statements
min_update_elapse	bigint	Minimum response time of **UPDATE** statements
avg_update_elapse	bigint	Average response time of **UPDATE** statements
total_insert_elapse	bigint	Total response time of **INSERT** statements
max_insert_elapse	bigint	Maximum response time of **INSERT** statements
min_insert_elapse	bigint	Minimum response time of **INSERT** statements
avg_insert_elapse	bigint	Average response time of **INSERT** statements
total_delete_elapse	bigint	Total response time of **DELETE** statements
max_delete_elapse	bigint	Maximum response time of **DELETE** statements
min_delete_elapse	bigint	Minimum response time of **DELETE** statements
avg_delete_elapse	bigint	Average response time of **DELETE** statements

15.3.93 GS_WORKLOAD_TRANSACTION

GS_WORKLOAD_TRANSACTION provides transaction information about workload cgroups on a single CN. The database records the number of times that each workload Cgroup commits and rolls back transactions and the response time of transaction commitment and rollback, in microseconds.

Table 15-149 GS_WORKLOAD_TRANSACTION columns

Name	Type	Description
workload	name	Workload Cgroup name
commit_counter	bigint	Number of the commit times
rollback_counter	bigint	Number of rollbacks
resp_min	bigint	Minimum response time
resp_max	bigint	Maximum response time
resp_avg	bigint	Average response time
resp_total	bigint	Total response time

15.3.94 MPP_TABLES

MPP_TABLES displays information about tables in **PGXC_CLASS**.

Table 15-150 MPP_TABLES columns

Name	Type	Description
schemaname	name	Name of the schema that contains the table
tablename	name	Name of a table
tableowner	name	Owner of the table
tablespace	name	Tablespace where the table is located.
pgroup	name	Name of a node cluster.
nodeoids	oidvector_extend	List of distributed table node OIDs

15.3.95 PG_AVAILABLE_EXTENSION_VERSIONS

PG_AVAILABLE_EXTENSION_VERSIONS displays the extension versions of certain database features.

Table 15-151 PG_AVAILABLE_EXTENSION_VERSIONS columns

Name	Type	Description
name	name	Extension name
version	text	Version name

Name	Type	Description
installed	boolean	The value is **true** if the version of this extension is currently installed.
superuser	boolean	The value is **true** if only system administrators are allowed to install this extension.
relocatable	boolean	The value is **true** if an extension can be relocated to another schema.
schema	name	Name of the schema that the extension must be installed into. The value is null if the extension is partially or fully relocatable.
requires	name[]	Names of prerequisite extensions. The value is null if there are no prerequisite extensions.
comment	text	Comment string from the extension's control file

15.3.96 PG_AVAILABLE_EXTENSIONS

PG_AVAILABLE_EXTENSIONS displays the extended information about certain database features.

Table 15-152 PG_AVAILABLE_EXTENSIONS columns

Name	Type	Description
name	name	Extension name
default_version	text	Name of default version. The value is **NULL** if none is specified.
installed_version	text	Currently installed version of the extension. The value is **NULL** if no version is installed.
comment	text	Comment string from the extension's control file

15.3.97 PG_BULKLOAD_STATISTICS

On any normal node in a cluster, **PG_BULKLOAD_STATISTICS** displays the execution status of the import and export services. Each import or export service corresponds to a record. This view is accessible only to users with system administrators rights.

Table 15-153 PG_BULKLOAD_STATISTICS columns

Name	Type	Description
node_name	text	Node name
db_name	text	Database name
query_id	bigint	Query ID. It is equivalent to **debug_query_id**.
tid	bigint	ID of the current thread
lwtid	integer	Lightweight thread ID
session_id	bigint	GDS session ID
direction	text	Service type. The options are **gds to file**, **gds from file**, **gds to pipe**, **gds from pipe**, **copy from**, and **copy to**.
query	text	Query statement
address	text	Location of the foreign table used for data import and export
query_start	timestamp with time zone	Start time of data import or export
total_bytes	bigint	Total size of data to be processed This parameter is specified only when a GDS common file is to be imported and the record in the row comes from a CN. Otherwise, left this parameter unspecified.
phase	text	Execution phase of the current service import and export. The options are **INITIALIZING**, **TRANSFER_DATA**, and **RELEASE_RESOURCE**.
done_lines	bigint	Number of lines that have been transferred
done_bytes	bigint	Number of bytes that have been transferred

15.3.98 PG_COMM_CLIENT_INFO

PG_COMM_CLIENT_INFO stores the client connection information of a single node. (You can query this view on a DN to view the information about the connection between the CN and DN.)

Table 15-154 PG_COMM_CLIENT_INFO columns

Name	Type	Description
node_name	text	Current node name.
app	text	Client application name
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	It 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	If the connection is a logical connection, **sid** is displayed. If **-1** is displayed, the current connection is a physical connection.

15.3.99 PG_COMM_DELAY

PG_COMM_DELAY displays the communication library delay status for a single DN.

Table 15-155 PG_COMM_DELAY columns

Name	Type	Description
node_name	text	Node name
remote_name	text	Name of the node with the maximum latency in connecting to the peer end.
remote_host	text	IP address of the peer.
stream_num	integer	Number of logical stream connections used by the current physical connection.
min_delay	integer	Minimum delay of the current physical connection. The unit is microsecond.
average	integer	Average delay of the current physical connection. The unit is microsecond.
max_delay	integer	Maximum delay of the current physical connection. The unit is microsecond. **NOTE** If its value is **-1**, the latency detection has timed out. In this case, re-establish the connection between nodes and then perform the query.

15.3.100 PG_COMM_STATUS

PG_COMM_STATUS displays the communication library status for a single DN.

Table 15-156 PG_COMM_STATUS columns

Name	Type	Description
node_name	text	Specifies the node name.
rxpck/s	integer	Receiving rate of the communication library on a node. The unit is byte/s.
txpck/s	integer	Sending rate of the communication library on a node. The unit is byte/s.
rxkB/s	bigint	Receiving rate of the communication library on a node. The unit is KB/s.
txkB/s	bigint	Sending rate of the communication library on a node. The unit is KB/s.
buffer	bigint	Size of the buffer of the Cmailbox.
memKB(libcomm)	bigint	Communication memory size of the **libcomm** process, in KB.
memKB(libpq)	bigint	Communication memory size of the **libpq** process, in KB.
%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.

15.3.101 PG_COMM_RECV_STREAM

PG_COMM_RECV_STREAM displays the receiving stream status of all the communication libraries for a single DN.

Table 15-157 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	Current status of the stream • **UNKNOWN**: The logical connection is unknown. • **READY**: The logical connection is ready. • **RUN**: The logical connection receives packets normally. • **HOLD**: The logical connection is waiting to receive packets. • **CLOSED**: The logical connection is closed. • **TO_CLOSED**: The logical connection is to be closed. • **WRITING**: Data is being written.
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. The unit is byte.
time	bigint	Current life cycle service duration of the stream. The unit is ms.
speed	bigint	Average receiving rate of the stream. The unit is byte/s.
quota	bigint	Current communication quota value of the stream. The unit is Byte.
buff_usize	bigint	Current size of the data cache of the stream. The unit is byte.

15.3.102 PG_COMM_SEND_STREAM

PG_COMM_SEND_STREAM displays the sending stream status of all the communication libraries for a single DN.

Table 15-158 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
state	text	Current status of the stream • **UNKNOWN**: The logical connection is unknown. • **READY**: The logical connection is ready. • **RUN**: The logical connection sends packets normally. • **HOLD**: The logical connection is waiting to send packets. • **CLOSED**: The logical connection is closed. • **TO_CLOSED**: The logical connection is to be closed. • **WRITING**: Data is being written.
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. The unit is Byte.

Name	Type	Description
time	bigint	Current life cycle service duration of the stream. The unit is ms.
speed	bigint	Average sending rate of the stream. The unit is Byte/s.
quota	bigint	Current communication quota value of the stream. The unit is Byte.
wait_quota	bigint	Extra time generated when the stream waits the quota value. The unit is ms.

15.3.103 PG_COMM_QUERY_SPEED

PG_COMM_QUERY_SPEED displays traffic information about all queries on a single node.

Table 15-159 PG_COMM_QUERY_SPEED columns

Name	Type	Description
node_name	text	Node name
query_id	bigint	**debug_query_id** corresponding to the stream
rxkB/s	bigint	Receiving rate of the query stream (unit: byte/s)
txkB/s	bigint	Sending rate of the query stream (unit: byte/s)
rxkB	bigint	Total received data of the query stream (unit: byte)
txkB	bigint	Total sent data of the query stream (unit: byte)
rxpck/s	bigint	Packet receiving rate of the query (unit: packets/s)
txpck/s	bigint	Packet sending rate of the query (unit: packets/s)
rxpck	bigint	Total number of received packets of the query
txpck	bigint	Total number of sent packets of the query

15.3.104 PG_CONTROL_GROUP_CONFIG

PG_CONTROL_GROUP_CONFIG displays the Cgroup configuration information in the system.

Table 15-160 PG_CONTROL_GROUP_CONFIG columns

Name	Type	Description
pg_control_group_config	text	Configuration information of the cgroup

15.3.105 PG_CURSORS

PG_CURSORS displays the cursors that are currently available.

Table 15-161 PG_CURSORS columns

Name	Type	Description
name	text	Cursor name
statement	text	Query statement when the cursor is declared to change
is_holdable	boolean	Whether the cursor is holdable (that is, it can be accessed after the transaction that declared the cursor has committed). If it is, its value is **true**.
is_binary	boolean	Whether the cursor was declared BINARY. If it was, its value is **true**.
is_scrollable	boolean	Whether the cursor is scrollable (that is, it allows rows to be retrieved in a nonsequential manner). If it is, its value is **true**.
creation_time	timestamp with time zone	Timestamp at which the cursor is declared

15.3.106 PG_EXT_STATS

PG_EXT_STATS displays extension statistics stored in the **PG_STATISTIC_EXT** table. The extension statistics means multiple columns of statistics.

Table 15-162 PG_EXT_STATS columns

Name	Type	Reference	Description
schemaname	name	**PG_NAMESPACE**.nspname	Name of the schema that contains a table

Name	Type	Reference	Description
tablename	name	PG_CLASS.relname	Name of a table
attname	int2vector	PG_STATISTIC_EXT.stakey	Indicates the columns to be combined for collecting statistics.
inherited	boolean	-	Includes inherited sub-columns if the value is **true**; otherwise, indicates the column in a specified table.
null_frac	real	-	Percentage of column combinations that are null to all records
avg_width	integer	-	Average width of column combinations. The unit is byte.
n_distinct	real	-	• Estimated number of distinct values in a column combination if the value is greater than 0 • Negative of the number of distinct values divided by the number of rows if the value is less than 0 • The number of distinct values is unknown if the value is **0**. **NOTE** The negated form is used when ANALYZE believes that the number of distinct values is likely to increase as the table grows. 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.

Name	Type	Reference	Description
n_dndistinct	real	-	Number of unique not-null data values in the **dn1** column combination • Exact number of distinct values if the value is greater than 0 • 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**. • 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 combination. If this combination does not have the most common values, **most_common_vals_null** 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**)

15.3.107 PG_GET_INVALID_BACKENDS

PG_GET_INVALID_BACKENDS displays the information about backend threads on the CN that are connected to the current standby DN.

Table 15-163 PG_GET_INVALID_BACKENDS columns

Name	Type	Description
pid	bigint	Thread ID
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 performed by the backend thread

15.3.108 PG_GET_SENDERS_CATCHUP_TIME

PG_GET_SENDERS_CATCHUP_TIME displays the catchup information of the currently active primary/standby instance sending thread on a single DN.

Table 15-164 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 a catchup task
catchup_type	text	Catchup task type, full or incremental
catchup_bcm_filename	text	BCM file executed by the current catchup task

Name	Type	Description
catchup_bcm_finished	integer	Number of BCM files completed by a catchup task
catchup_bcm_total	integer	Total number of BCM files to be operated by a catchup task
catchup_percent	text	Completion percentage of a catchup task
catchup_remaining_time	text	Estimated remaining time of a catchup task

15.3.109 PG_GROUP

PG_GROUP displays the database role authentication and the relationship between roles.

Table 15-165 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

15.3.110 PG_INDEXES

PG_INDEXES displays access to useful information about each index in the database.

Table 15-166 PG_INDEXES columns

Name	Type	Reference	Description
schemaname	name	PG_NAMESPACE.nspname	Name of the schema that contains tables and indexes
tablename	name	PG_CLASS.relname	Name of the table for which the index serves
indexname	name	PG_CLASS.relname	Index name
tablespace	name	PG_TABLESPACE.spcname	Name of the tablespace that contains the index

Name	Type	Reference	Description
indexdef	text	-	Index definition (a reconstructed **CREATE INDEX** command)

Example

Query the index information about a specified table.

```
SELECT * FROM pg_indexes WHERE tablename = 'mytable';
 schemaname | tablename |   indexname    | tablespace |                                indexdef
------------+-----------+----------------+------------
+-------------------------------------------------------------------------------
 public     | mytable   | idx_mytable_id |            | CREATE INDEX idx_mytable_id ON mytable USING btree
(id) TABLESPACE pg_default
(1 row)
```

Query information about indexes of all tables in a specified schema in the current database.

```
SELECT tablename, indexname, indexdef FROM pg_indexes WHERE schemaname = 'public' ORDER BY
tablename,indexname;
 tablename |     indexname      |                                          indexdef
-----------+--------------------
+-----------------------------------------------------------------------------------------------------
 books     | books_pkey         | CREATE UNIQUE INDEX books_pkey ON books USING btree (id) TABLESPACE
pg_default
 books     | idx_books_tags_gin | CREATE INDEX idx_books_tags_gin ON books USING gin (tags)
TABLESPACE pg_default
 customer  | c_custkey_key      | CREATE UNIQUE INDEX c_custkey_key ON customer USING btree
(c_custkey, c_name) TABLESPACE pg_default
 mytable   | idx_mytable_id     | CREATE INDEX idx_mytable_id ON mytable USING btree (id) TABLESPACE
pg_default
 test1     | idx_test_id        | CREATE INDEX idx_test_id ON test1 USING btree (id) TABLESPACE pg_default
 v0        | v0_pkey            | CREATE UNIQUE INDEX v0_pkey ON v0 USING btree (c) TABLESPACE pg_default
(6 rows)
```

15.3.111 PG_JOB

PG_JOB displays detailed information about scheduled tasks created by users.

The **PG_JOB** view replaces the **PG_JOB** system catalog in earlier versions and provides forward compatibility with earlier versions. The original **PG_JOB** system catalog is changed to the **PG_JOBS** system catalog. For details about **PG_JOBS**, see **PG_JOBS**.

Table 15-167 PG_JOB columns

Name	Type	Description
job_id	bigint	Job ID
current_postgres_pid	bigint	If the current job has been executed, the PostgreSQL thread ID of this job is recorded. The default value is **-1**, indicating that the task is not executed or has been executed.
log_user	name	User name of the job creator

Name	Type	Description
priv_user	name	User name of the job executor
dbname	name	Name of the database where the job is executed
node_name	name	CN node on which the job will be created and executed
job_status	text	Status of the current job. The value range is **r**, **s**, **f**, **d**, **p**, **w**, or **l**. The default value is **s**. The indications are as follows: ● r=running ● s=successfully finished ● f=job failed ● d=disable ● p=pending ● w=waiting ● l=launching **NOTE** ● Note: When you disable a scheduled task (by setting **job_queue_processes** to **0**), the thread monitor the job execution is not started, and the **job_status** will not be updated. You can ignore the **job_status**. ● Only when the scheduled task function is enabled (that is, when **job_queue_processes** is not **0**), the system updates the value of **job_status** based on the real-time job status. ● The execution status **p**, **w**, or **l** only in cluster 8.3.0.100 or later.
start_date	timestamp without time zone	Start time of the first job execution, precise to millisecond
next_run_date	timestamp without time zone	Scheduled time of the next job execution, accurate to millisecond
failure_count	smallint	Number of consecutive failures.
interval	text	Job execution interval
last_start_date	timestamp without time zone	Start time of the last job execution, accurate to millisecond
last_end_date	timestamp without time zone	End time of the last job execution, accurate to millisecond

Name	Type	Description
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 namespace where a job is running
what	text	Job content

15.3.112 PG_JOB_PROC

The **PG_JOB_PROC** view replaces the **PG_JOB_PROC** system catalog in earlier versions and provides forward compatibility with earlier versions. The original **PG_JOB_PROC** and **PG_JOB** system catalogs are merged into the **PG_JOBS** system catalog in the current version. For details about the **PG_JOBS** system catalog, see **PG_JOBS**.

Table 15-168 PG_JOB_PROC columns

Name	Type	Description
job_id	bigint	Job ID
what	text	Job content

15.3.113 PG_JOB_SINGLE

PG_JOB_SINGLE displays job information about the current node.

Table 15-169 PG_JOB_SINGLE columns

Name	Type	Description
job_id	bigint	Job ID
current_postgres_pid	bigint	If the current job has been executed, the PostgreSQL thread ID of this job is recorded. The default value is **-1**, indicating that the task is not executed or has been executed.
log_user	name	User name of the job creator
priv_user	name	User name of the job executor

Name	Type	Description
dbname	name	Name of the database where the job is executed
node_name	name	CN node on which the job will be created and executed
job_status	text	Status of the current job. The value range is **r**, **s**, **f**, **d**, **p**, **w**, or **l**. The default value is **s**. The indications are as follows: ● r=running ● s=successfully finished ● f=job failed ● d=disable ● p=pending ● w=waiting ● l=launching **NOTE** ● Note: When you disable a scheduled task (by setting **job_queue_processes** to **0**), the thread monitor the job execution is not started, and the **job_status** will not be updated. You can ignore the **job_status**. ● Only when the scheduled task function is enabled (that is, when **job_queue_processes** is not **0**), the system updates the value of **job_status** based on the real-time job status. ● The execution status **p**, **w**, or **l** only in cluster 8.3.0.100 or later.
start_date	timestamp without time zone	Start time of the first job execution, precise to millisecond
next_run_date	timestamp without time zone	Scheduled time of the next job execution, accurate to millisecond
failure_count	smallint	Number of consecutive failures.
interval	text	Job execution interval
last_start_date	timestamp without time zone	Start time of the last job execution, accurate to millisecond
last_end_date	timestamp without time zone	End time of the last job execution, accurate to millisecond

Name	Type	Description
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 namespace where a job is running
what	text	Job content

15.3.114 PG_LIFECYCLE_DATA_DISTRIBUTE

PG_LIFECYCLE_DATA_DISTRIBUTE displays the distribution of cold and hot data in a multi-temperature table of OBS.

Table 15-170 PG_LIFECYCLE_DATA_DISTRIBUTE columns

Name	Type	Description
schemaname	name	Schema name
tablename	name	Current table name
nodename	name	Node name
hotpartition	text	Hot partition on the DN
coldpartition	text	Cold partition on the DN
switchablepartition	text	Switchable partition on the DN
hotdatasize	text	Data size of the hot partition on the DN
colddatasize	text	Data size of the cold partition on the DN
switchabledatasize	text	Data size of the switchable partition on the DN

15.3.115 PG_LOCKS

PG_LOCKS displays information about the locks held by open transactions.

Table 15-171 PG_LOCKS columns

Name	Type	Reference	Description
locktype	text	-	Type of the locked object: relation, extend, page, tuple, transactionid, virtualxid, object, userlock, and advisory
database	oid	PG_DATABASE.oid	OID of the database in which the locked target exists • The OID is **0** if the target is a shared object. • The OID is **NULL** if the locked target is a transaction.
relation	oid	PG_CLASS.oid	OID of the relationship targeted by the lock. The value is **NULL** if the object is neither a relationship nor part of a relationship.
page	integer	-	Page number targeted by the lock within the relationship. If the object is neither a relation page nor row page, the value is **NULL**.
tuple	smallint	-	Row number targeted by the lock within the page. If the object is not a row, the value is **NULL**.
virtualxid	text	-	Virtual ID of the transaction targeted by the lock. If the object is not a virtual transaction ID, the value is **NULL**.
transactionid	xid	-	ID of the transaction targeted by the lock. If the object is not a transaction ID, the value is **NULL**.
classid	oid	PG_CLASS.oid	OID of the system table that contains the object. If the object is not a general database object, the value is **NULL**.
objid	oid	-	OID of the lock target within its system table. If the target is not a general database object, the value is **NULL**.
objsubid	smallint	-	Column number for a column in the table. The value is **0** if the target is some other object type. If the object is not a general database object, the value is **NULL**.

Name	Type	Reference	Description
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. This is **NULL** if the lock is held by a prepared transaction.
mode	text	-	Lock mode held or desired by this thread For more information about lock modes, see**LOCK**.
granted	boolean	-	• The value is **true** if the lock is a held lock. • The value is **false** if the lock is an awaited lock.
fastpath	boolean	-	Whether the lock is obtained through **fast-path** (**true**) or main lock table (**false**)

15.3.116 PG_NODE_ENV

PG_NODE_ENVO displays the environmental variable information about the current node.

Table 15-172 PG_NODE_ENV columns

Name	Type	Description
node_name	text	Name of the current node
host	text	Host name of the current node
process	integer	Process ID of the current node
port	integer	Port ID of the current node
installpath	text	Installation directory of current node
datapath	text	Data directory of the current node
log_directory	text	Log directory of the current node

15.3.117 PG_OS_THREADS

PG_OS_THREADS displays the status information about all the threads under the current node.

Table 15-173 PG_OS_THREADS columns

Name	Type	Description
node_name	text	Name of the current node
pid	bigint	Thread number 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

15.3.118 PG_POOLER_STATUS

PG_POOLER_STATUS displays the cache connection status in the pooler. **PG_POOLER_STATUS** can only query on the CN, and displays the connection cache information about the pooler module.

Table 15-174 PG_POOLER_STATUS columns

Name	Type	Description
database	text	Database name
user_name	text	User name
tid	bigint	ID of a thread 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 in use • **t** (true): indicates that the connection is in use. • **f** (false): indicates that the connection is not in use.
fdsock	bigint	Peer socket.
remote_pid	bigint	Peer thread ID.
session_params	text	GUC session parameter delivered by the connection.

Example

View information about the connection pool **pooler**:

```
select database,user_name,node_name,in_use,count(*) from pg_pooler_status group by 1, 2, 3 ,4 order by 5
desc limit 50;
 database | user_name |  node_name   | in_use | count
----------+-----------+--------------+--------+-------
 mydbdemo | user3     | cn_5001      | f      |     2
 mydbdemo | user3     | dn_6005_6006 | t      |     2
 mydbdemo | user3     | dn_6001_6002 | t      |     2
 mydbdemo | user3     | dn_6003_6004 | f      |     2
 mydbdemo | user3     | dn_6003_6004 | t      |     2
 mydbdemo | user3     | dn_6005_6006 | f      |     2
 mydbdemo | user3     | dn_6001_6002 | f      |     2
 mydbdemo | user3     | cn_5002      | f      |     2
 gaussdb  | user3     | dn_6003_6004 | f      |     1
 mydbdemo | user3     | cn_5001      | t      |     1
 music    | user2     | dn_6003_6004 | f      |     1
 music    | user2     | dn_6005_6006 | f      |     1
 gaussdb  | user1     | dn_6005_6006 | f      |     1
(13 rows)
```

15.3.119 PG_PREPARED_STATEMENTS

PG_PREPARED_STATEMENTS displays all prepared statements that are available in the current session.

Table 15-175 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 casting the regtype value to oid.
from_sql	boolean	How a prepared statement was created • **true**: The prepared statement was created through the PREPARE statement. • **false** The statement was prepared through the frontend/backend protocol.

15.3.120 PG_PREPARED_XACTS

PG_PREPARED_XACTS displays information about transactions that are currently prepared for two-phase commit.

Table 15-176 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	PG_AUTHID.rolname	Name of the user that executes the transaction
database	name	PG_DATABASE.datname	Name of the database in which the transaction is executed

15.3.121 PG_PUBLICATION_TABLES

PG_PUBLICATION_TABLES displays the mapping between a publication and its published tables. Unlike the underlying system catalog **PG_PUBLICATION_REL**, this view expands the publications defined as **FOR ALL TABLES** and **FOR ALL TABLES IN SCHEMA**, in which each publishable table has a row. This view is supported only by clusters of version 8.2.0.100 or later.

Table 15-177 PG_PUBLICATION_TABLES columns

Name	Type	Description
pubname	name	Publication name
schemaname	name	Name of the schema of a table
tablename	name	Table name

Examples

Query all published tables.

```
SELECT * FROM PG_PUBLICATION_TABLES;
 pubname | schemaname | tablename
```



```
---------+------------+-----------
 mypub   | public     | t1
 mypub   | public     | t2
(2 rows)
```

15.3.122 PG_QUERYBAND_ACTION

PG_QUERYBAND_ACTION displays information about the object associated with **query_band** and the **query_band** query order.

Table 15-178 PG_QUERYBAND_ACTION columns

Name	Type	Description
qband	text	**query_band** key-value pairs
respool_id	oid	OID of the resource pool associated with **query_band**
respool	text	Name of the resource pool associated with **query_band**
priority	text	Intra-queue priority associated with **query_band**
qborder	integer	**query_band** query order

15.3.123 PG_REPLICATION_SLOTS

PG_REPLICATION_SLOTS displays the replication node information.

Table 15-179 PG_REPLICATION_SLOTS columns

Name	Type	Description
slot_name	text	Name of a replication node
plugin	name	Name of the output plug-in of the logical replication slot
slot_type	text	Type of a replication node
datoid	oid	OID of the database on the replication node
database	name	Name of the database on the replication node
active	boolean	Whether the replication node is active
xmin	xid	Transaction ID of the replication node
catalog_xmin	text	ID of the earliest-decoded transaction corresponding to the logical replication slot
restart_lsn	text	Xlog file information on the replication node

Name	Type	Description
dummy_standby	boolean	Whether the replication node is the dummy standby node

15.3.124 PG_ROLES

PG_ROLES displays information about database roles.

Table 15-180 PG_ROLES columns

Name	Type	Reference	Description
rolname	name	-	Role name
rolsuper	boolean	-	Whether the role is the initial system administrator with the highest permission
rolinherit	boolean	-	Whether the role inherits permissions for this type of roles
rolcreaterole	boolean	-	Whether the role can create other roles
rolcreatedb	boolean	-	Whether the role can create databases
rolcatupdate	boolean	-	Whether the role can update system tables directly. Only the initial system administrator whose usesysid is 10 has this permission. It is not available for other users.
rolcanlogin	boolean	-	Whether the role can log in to the database
rolreplication	boolean	-	Whether the role can be replicated
rolauditadmin	boolean	-	Whether the role is an audit system administrator
rolsystemadmin	boolean	-	Whether the role is a system administrator
rolconnlimit	integer	-	Sets the maximum number of concurrent connections this role can make if this role can log in. -1 indicates no limit.
rolpassword	text	-	Not the password (always reads as ********)

Name	Type	Reference	Description
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
rolparentid	oid	PG_AUTHID.rolparentid	OID of a group user to which the user belongs
roltabspace	text	-	The storage space of the user permanent table.
roltempspace	text	-	The storage space of the user temporary table.
rolspillspace	text	-	The operator disk flushing space of the user.
rolconfig	text[]	-	Session defaults for runtime configuration variables
oid	oid	PG_AUTHID.oid	ID of the role
roluseft	boolean	PG_AUTHID.roluseft	Whether the role can perform operations on foreign tables
nodegroup	name	-	Name of the logical cluster associated with the role. If no logical cluster is associated, this column is left empty.

15.3.125 PG_RULES

PG_RULES displays information about rewrite rules.

Table 15-181 PG_RULES columns

Name	Type	Description
schemaname	name	Name of the schema that contains the table
tablename	name	Name of the table the rule is for
rulename	name	Rule name

Name	Type	Description
definition	text	Rule definition (a reconstructed creation command)

15.3.126 PG_RUNNING_XACTS

PG_RUNNING_XACTS displays information about running transactions on the current node.

Table 15-182 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 or **0**: starting)
node	text	Node name
xmin	xid	Minimum transaction ID **xmin** on the node
vacuum	boolean	Whether the current transaction is lazy vacuum
timeline	bigint	Number of database restarts
prepare_xid	xid	Transaction ID in the **prepared** status. If the status is not **prepared**, the value is **0**.
pid	bigint	Thread ID corresponding to the transaction
next_xid	xid	Transaction ID sent from a CN to a DN

15.3.127 PG_SECLABELS

PG_SECLABELS displays information about security labels.

Table 15-183 PG_SECLABEL columns

Name	Type	Reference	Description
objoid	oid	Any OID column	OID of the object this security label pertains to
classoid	oid	PG_CLASS.oid	OID of the system table that contains the object

Name	Type	Reference	Description
objsubid	integer	-	For a security label on a table column, this is the column number (the **objoid** and **classoid** refer to the table itself). For all other object types, this column is **0**.
objtype	text	-	Type of the object to which this label applies
objnamespace	oid	PG_NAMESPACE.oid	OID of the namespace for this object, if applicable; otherwise NULL.
objname	text	-	Name of the object to which the label applies
provider	text	PG_SECLABEL.provider	Label provider associated with this label
label	text	PG_SECLABEL.label	Security label applied to this object

15.3.128 PG_SESSION_WLMSTAT

PG_SESSION_WLMSTAT displays the corresponding load management information about the task currently executed by the user.

Table 15-184 PG_SESSION_WLMSTAT columns

Column	Type	Description
datid	oid	OID of the database this backend is connected to
datname	name	Name of the database the backend is connected to
threadid	bigint	ID of the backend thread
processid	integer	Thread PID of the backend
usesysid	oid	OID of the user who logged into 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

Column	Type	Description
attribute	text	Statement attributes • **Ordinary**: default attribute of a statement before it is parsed by the database • **Simple**: simple statements • **Complicated**: complicated statements • **Internal**: internal statement of the database
block_time	bigint	Pending duration of the statements by now (unit: s)
elapsed_time	bigint	Actual execution duration of the statements by now (unit: s)
total_cpu_time	bigint	Total CPU usage duration of the statement on the DN in the last period (unit: s)
cpu_skew_percent	integer	CPU usage inclination ratio of the statement on the DN in the last period
statement_mem	integer	Estimated memory required for statement execution. This column is reserved.
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 a statement, including: • **pending** • **running** • **finished** (If **enqueue** is set to **StoredProc** or **Transaction**, this state indicates that only some of the jobs in the statement have been executed. This state persists until the finish of this statement.) • **aborted**: terminated unexpectedly • **active**: normal status except for those above • **unknown**: unknown status

Column	Type	Description
enqueue	text	Current queuing status of the statements, including: • **Global**: global queuing. • **Respool**: resource pool queuing. • **CentralQueue**: queuing on the CCN • **Transaction**: being in a transaction block • **StoredProc**: being in a stored procedure • **None**: not in a queue • **Forced None**: being forcibly executed (transaction block statement or stored procedure statement are) because the statement waiting time exceeds the specified value
resource_pool	name	Current resource pool where the statements are located.
query	text	Text of this backend's most recent query If **state** is **active**, this column shows the executing query. In all other states, it shows the last query that was executed.
isplana	bool	In logical cluster mode, indicates whether a statement occupies the resources of other logical clusters. The default value is **f**, indicating that resources of other logical clusters are not occupied.
node_group	text	Logical cluster of the user running the statement
lane	text	Fast or slow lane for statement queries. • fast: fast lane • slow: slow lane • none: not controlled

15.3.129 PG_SESSION_IOSTAT

PG_SESSION_IOSTAT has been discarded in version 8.1.2 and is reserved for compatibility with earlier versions. This view is invalid in the current version. You can use **PGXC_WLM_SESSION_STATISTICS** to view load management information about jobs being executed on all CNs.

Table 15-185 PG_SESSION_IOSTAT columns

Name	Type	Description
query_id	bigint	Job ID

Name	Type	Description
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

15.3.130 PG_SETTINGS

PG_SETTINGS displays information about parameters of the running database.

Table 15-186 PG_SETTINGS columns

Name	Type	Description
name	text	Parameter name
setting	text	Current value of the parameter
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. It can be **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 data, the value of this column is null.
max_val	text	Maximum value of the parameter. If the parameter type is not numeric data, the value of this column is null.

Name	Type	Description
enumvals	text[]	Valid values of an enum-typed 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.

15.3.131 PG_SHADOW

PG_SHADOW displays properties of all roles that are marked as **rolcanlogin** in **PG_AUTHID**.

This view is not readable to all users because it contains passwords. **PG_USER** is a publicly readable view on **PG_SHADOW** that blanks out the password column.

Table 15-187 PG_SHADOW columns

Name	Type	Reference	Description
usename	name	**PG_AUTHID**.rolname	User name
usesysid	oid	**PG_AUTHID**.oid	ID of a user
usecreatedb	boolean	-	Indicates that the user can create databases.
usesuper	boolean	-	Indicates that the user is an administrator.
usecatupd	boolean	-	Indicates that the user can update system catalogs. Even the system administrator cannot do this unless this column is **true**.

Name	Type	Reference	Description
userepl	boolean	-	User can initiate streaming replication and put the system in and out of backup mode.
passwd	text	-	Password (possibly encrypted); null if none. See **PG_AUTHID** for details about how encrypted passwords are stored.
valbegin	timestamp with time zone	-	Account validity start time; null if no start time
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	-	The storage space of the permanent table.
tempspacelimit	text	-	The storage space of the temporary table.
spillspacelimit	text	-	The operator disk flushing space.
useconfig	text[ ]	-	Session defaults for runtime configuration variables

15.3.132 PG_SHARED_MEMORY_DETAIL

PG_SHARED_MEMORY_DETAIL displays usage information about all the shared memory contexts.

Table 15-188 PG_SHARED_MEMORY_DETAIL columns

Name	Type	Description
contextname	text	Name of the context in the memory
level	smallint	Hierarchy of the memory context
parent	text	Context of the parent memory

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

15.3.133 PG_STATS

PG_STATS displays the single-column statistics stored in the **pg_statistic** table.

Table 15-189 PG_STATS columns

Name	Type	Reference	Description
schemaname	name	**PG_NAMESPACE**.nspname	Name of the schema that contains the table
tablename	name	**PG_CLASS**.relname	Name of the table
attname	name	**PG_ATTRIBUTE**.attname	Column name
inherited	boolean	-	Includes inherited sub-columns if the value is **true**; otherwise, 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

Name	Type	Reference	Description
n_distinct	real	-	• Estimated number of distinct values in the column if the value is greater than 0 • Negative of the number of distinct values divided by the number of rows if the value is less than 0 The negated form is used when ANALYZE believes that the number of distinct values is likely to increase as the table grows. The positive form is used when the column seems to have a fixed number of possible values. For example, **-1** indicates a unique column in which the number of distinct values is the same as the number of rows.
n_dndistinct	real	-	Number of unique non-null data values in the **dn1** column • Exact number of distinct values if the value is greater than 0 • 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**.) • 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. If this combination does not have the most common values, it will be **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**)

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	-	Specifies a list of non-null element values most often appearing.
most_common_elem_freqs	real[]	-	Specifies a list of the frequencies of the most common element values.
elem_count_histogram	real[]	-	Histogram of the counts of distinct non-null element values.

15.3.134 PG_STAT_ACTIVITY

PG_STAT_ACTIVITY displays information about the current user's queries. If you have the rights of an administrator or the preset role, you can view all information about user queries.

Table 15-190 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
pid	bigint	Backend thread ID

Name	Type	Description
lwtid	integer	Lightweight thread ID
usesysid	oid	OID of the user logging in to the backend
usename	name	OID of the user logging 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 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 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, or **-1** if a Unix socket is used
backend_start	timestamp with time zone	Startup time of the backend process, that is, the time when the client connects to the server.
xact_start	timestamp with time zone	Time when the current transaction was started, or **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 for the last status change
waiting	boolean	The value is **t** if the backend is waiting for a lock or node. Otherwise, the value is **f**.

Name	Type	Description
enqueue	text	Queuing status of a statement. Its value can be: • **waiting in global queue**: The statement is queuing in the global concurrent queue. The number of concurrent statements exceeds the value of **max_active_statements** configured for a single CN. • **waiting in respool queue**: The statement is queuing in the resource pool and the concurrency of simple jobs is limited. The main reason is that the concurrency of simple jobs exceeds the upper limit **max_dop** of the fast track. • **waiting in ccn queue**: The job is in the CCN queue, which may be global memory queuing, slow lane memory queuing, or concurrent queuing. The scenarios are: 1. The available global memory exceeds the upper limit, the job is queuing in the global memory queue. 2. Concurrent requests on the slow lane in the resource pool exceed the upper limit, which is specified by **active_statements**. 3. The slow lane memory of the resource pool exceeds the upper limit, that is, the estimated memory of concurrent jobs in the resource pool exceeds the upper limit specified by **mem_percent**. • Empty or **no waiting queue**: The statement is running.

Name	Type	Description
state	text	Current overall state of this backend. Its value can be: • **active**: The backend is executing queries. • **idle**: The backend is waiting for new client commands. • **idle in transaction**: The backend is in a transaction, but there is no statement being executed in the transaction. • **idle in transaction** (aborted): The backend is in a transaction, but there are statements failed in the transaction. • **fastpath function call**: The backend is executing a fast-path function. • **disabled**: This state is reported if **track_activities** is disabled in this backend. **NOTE** Common users can view only their own session status. The state information of other accounts is empty.
resource_pool	name	Resource pool used by the user
stmt_type	text	Statement type
query_id	bigint	ID of a query
query	text	Text of the most recent query in this backend If **state** is **active**, this column shows the running 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**)

15.3.135 PG_STAT_ALL_INDEXES

PG_STAT_ALL_INDEXES displays statistics about all accesses to a specific index in the current database.

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 15-191 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 this index is in
relname	name	Name of the table for this index
indexrelname	name	Name of this index
idx_scan	bigint	Number of index scans initiated on this index
idx_tup_read	bigint	Number of index entries returned by scans on this index
idx_tup_fetch	bigint	Number of live table rows fetched by simple index scans using this index

15.3.136 PG_STAT_ALL_TABLES

PG_STAT_ALL_TABLES displays statistics about accesses to tables in the current database, including TOAST tables.

Table 15-192 PG_STAT_ALL_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Name of the table
seq_scan	bigint	Number of sequential scans started on the table
seq_tup_read	bigint	Number of rows that have live data fetched by sequential scans
idx_scan	bigint	Number of index scans
idx_tup_fetch	bigint	Number of rows that have live data fetched by index scans
n_tup_ins	bigint	Number of rows inserted

Name	Type	Description
n_tup_upd	bigint	Number of rows updated
n_tup_del	bigint	Number of rows deleted
n_tup_hot_upd	bigint	Number of rows updated by **HOT** (no separate index update is 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 (excluding **VACUUM FULL**)
last_autovacuum	timestamp with time zone	Last time at which this table was automatically vacuumed
last_analyze	timestamp with time zone	Last time at which this table was analyzed
last_autoanalyze	timestamp with time zone	Last time at which this table was automatically vacuumed
vacuum_count	bigint	Number of vacuum operations (excluding **VACUUM FULL**)
autovacuum_count	bigint	Number of autovacuum operations
analyze_count	bigint	Number of analyze operations
autoanalyze_count	bigint	Number of autoanalyze operations
last_data_changed	timestamp with time zone	Last time at which this table was updated (by **INSERT**/**UPDATE**/**DELETE** or **EXCHANGE**/**TRUNCATE**/**DROP** *partition*). This column is recorded only on the local CN.

Example

Query the last data change time in the **table_test** table:

```
SELECT last_data_changed FROM PG_STAT_ALL_TABLES WHERE relname ='table_test';
      last_data_changed
-------------------------------
 2024-03-27 10:28:16.277136+08
(1 row)
```


15.3.137 PG_STAT_BAD_BLOCK

PG_STAT_BAD_BLOCK displays statistics about page or CU verification failures after a node is started.

Table 15-193 PG_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 occurrence
last_time	timestamp with time zone	Time of the latest occurrence

15.3.138 PG_STAT_BGWRITER

PG_STAT_BGWRITER displays statistics about the background writer process's activity.

Table 15-194 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

Name	Type	Description
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 that a backend has to execute **fsync**
buffers_alloc	bigint	Number of buffers allocated
stats_reset	timestamp with time zone	Time at which these statistics were reset

15.3.139 PG_STAT_DATABASE

PG_STAT_DATABASE displays the status and statistics of each database on the current node.

Table 15-195 PG_STAT_DATABASE columns

Name	Type	Description
datid	oid	Database OID
datname	name	Database name
numbackends	integer	Number of backends currently connected to this database on the current node. This is the only column in this view that reflects the current state value. All columns return the accumulated value since the last reset.
xact_commit	bigint	Number of transactions in this database that have been committed on the current node
xact_rollback	bigint	Number of transactions in this database that have been rolled back on the current node
blks_read	bigint	Number of disk blocks read in this database on the current node
blks_hit	bigint	Number of disk blocks found in the buffer cache on the current node, that is, the number of blocks hit in the cache. (This only includes hits in the GaussDB(DWS) buffer cache, not in the file system cache.)

Name	Type	Description
tup_returned	bigint	Number of rows returned by queries in this database on the current node
tup_fetched	bigint	Number of rows fetched by queries in this database on the current node
tup_inserted	bigint	Number of rows inserted in this database on the current node
tup_updated	bigint	Number of rows updated in this database on the current node
tup_deleted	bigint	Number of rows deleted from this database on the current node
conflicts	bigint	Number of queries canceled due to database recovery conflicts on the current node (conflicts occurring only on the standby server). For details, see PG_STAT_DATABASE_CONFLICTS.
temp_files	bigint	Number of temporary files created by this database on the current node. 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	Size of temporary files written to this database on the current node. 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 in this database on the current node
blk_read_time	double precision	Time spent reading data file blocks by backends in this database on the current node, in milliseconds
blk_write_time	double precision	Time spent writing into data file blocks by backends in this database on the current node, in milliseconds
stats_reset	timestamp with time zone	Time when the database statistics are reset on the current node

15.3.140 PG_STAT_DATABASE_CONFLICTS

PG_STAT_DATABASE_CONFLICTS displays statistics about database conflicts.

Table 15-196 PG_STAT_DATABASE_CONFLICTS columns

Name	Type	Description
datid	oid	Database OID
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

15.3.141 PG_STAT_GET_MEM_MBYTES_RESERVED

PG_STAT_GET_MEM_MBYTES_RESERVED displays the current activity information of a thread stored in memory. You need to specify the thread ID (pid in **PG_STAT_ACTIVITY**) for query. If the thread ID is set to **0**, the current thread ID is used. For example:

```
SELECT pg_stat_get_mem_mbytes_reserved(0);
```

Table 15-197 PG_STAT_GET_MEM_MBYTES_RESERVED columns

Parameter	Description
ConnectInfo	Connection information
ParctlManager	Concurrency management information
GeneralParams	Basic parameter information
GeneralParams RPDATA	Basic resource pool information
ExceptionManager	Exception management information
CollectInfo	Collection information
GeneralInfo	Basic information
ParctlState	Concurrency status information
CPU INFO	CPU information
ControlGroup	Cgroup information
IOSTATE	I/O status information

15.3.142 PG_STAT_USER_FUNCTIONS

PG_STAT_USER_FUNCTIONS displays user-defined function status information in the namespace. (The language of the function is non-internal language.)

Table 15-198 PG_STAT_USER_FUNCTIONS columns

Name	Type	Description
funcid	oid	Function OID
schemaname	name	Schema name
funcname	name	Name of the function
calls	bigint	Number of times this 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 itself, excluding other functions called by it

15.3.143 PG_STAT_USER_INDEXES

PG_STAT_USER_INDEXES displays information about the index status of user-defined ordinary tables and TOAST tables.

Table 15-199 PG_STAT_USER_INDEXES columns

Name	Type	Description
relid	oid	Table OID for the index
indexrelid	oid	OID of this index
schemaname	name	Name of the schema this index is in
relname	name	Name of the table for this index
indexrelname	name	Name of this index
idx_scan	bigint	Number of index scans
idx_tup_read	bigint	Number of index entries returned by scans on this index
idx_tup_fetch	bigint	Number of rows that have live data fetched by index scans

15.3.144 PG_STAT_USER_TABLES

PG_STAT_USER_TABLES displays status information about user-defined ordinary tables and TOAST tables in all namespaces.

Table 15-200 PG_STAT_USER_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Name of a table
seq_scan	bigint	Number of sequential scans started on the table
seq_tup_read	bigint	Number of rows that have live data fetched by sequential scans
idx_scan	bigint	Number of index scans
idx_tup_fetch	bigint	Number of rows that have live data 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 updated by **HOT** (no separate index update is 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 (excluding **VACUUM FULL**)
last_autovacuum	timestamp with time zone	Time of the last **AUTOVACUUM**
last_analyze	timestamp with time zone	Last time at which this table was analyzed
last_autoanalyze	timestamp with time zone	Time of the last **AUTOANALYZE**
vacuum_count	bigint	Number of vacuum operations (excluding **VACUUM FULL**)

Name	Type	Description
autovacuum_count	bigint	Number of autovacuum operations
analyze_count	bigint	Number of analyze operations
autoanalyze_count	bigint	Number of autoanalyze operations

15.3.145 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 15-201 PG_STAT_REPLICATION columns

Name	Type	Description
pid	bigint	PID of the thread
usesysid	oid	User system ID
usename	name	Username
application_name	text	Application name
client_addr	inet	Client address
client_hostname	text	Client name
client_port	integer	Client port number
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
receiver_flush_location	text	Location where the receiver flushes logs
receiver_replay_location	text	Location where the receiver replays logs

Name	Type	Description
sync_priority	integer	Priority of synchronous duplication (**0** indicates asynchronization)
sync_state	text	Synchronization state (asynchronous duplication, synchronous duplication, or potential synchronization)

15.3.146 PG_STAT_SYS_INDEXES

PG_STAT_SYS_INDEXES displays the index status information about all the system catalogs in the **pg_catalog** and **information_schema** schemas.

Table 15-202 PG_STAT_SYS_INDEXES columns

Name	Type	Description
relid	oid	Table OID for the index
indexrelid	oid	Index OID
schemaname	name	Schema name for the index
relname	name	Table name for the index
indexrelname	name	Index name
idx_scan	bigint	Number of index scans
idx_tup_read	bigint	Number of index entries returned by scans on this index
idx_tup_fetch	bigint	Number of rows that have live data fetched by index scans

15.3.147 PG_STAT_SYS_TABLES

PG_STAT_SYS_TABLES displays the statistics about the system catalogs of all the namespaces in **pg_catalog** and **information_schema** schemas.

Table 15-203 PG_STAT_SYS_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Name of a table

Name	Type	Description
seq_scan	bigint	Number of sequential scans started on the table
seq_tup_read	bigint	Number of rows that have live data fetched by sequential scans
idx_scan	bigint	Number of index scans
idx_tup_fetch	bigint	Number of rows that have live data 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 updated by **HOT** (no separate index update is 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 (excluding **VACUUM FULL**)
last_autovacuum	timestamp with time zone	Last time at which this table was automatically vacuumed
last_analyze	timestamp with time zone	Last time at which this table was analyzed
last_autoanalyze	timestamp with time zone	Last time at which this table was automatically analyzed
vacuum_count	bigint	Number of vacuum operations (excluding **VACUUM FULL**)
autovacuum_count	bigint	Number of autovacuum operations
analyze_count	bigint	Number of analyze operations
autoanalyze_count	bigint	Number of autoanalyze operations

15.3.148 PG_STAT_XACT_ALL_TABLES

PG_STAT_XACT_ALL_TABLES displays the transaction status information about all ordinary tables and TOAST tables in the namespaces.

Table 15-204 PG_STAT_XACT_ALL_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Name of a table
seq_scan	bigint	Number of sequential scans started on the table
seq_tup_read	bigint	Number of live rows fetched by sequential scans
idx_scan	bigint	Number of index scans started 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 with HOT updates (no separate index update is required).

15.3.149 PG_STAT_XACT_SYS_TABLES

PG_STAT_XACT_SYS_TABLES displays the transaction status information of the system catalog in the namespace.

Table 15-205 PG_STAT_XACT_SYS_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Table name
seq_scan	bigint	Number of sequential scans started on the table
seq_tup_read	bigint	Number of live rows fetched by sequential scans
idx_scan	bigint	Number of index scans started 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

Name	Type	Description
n_tup_del	bigint	Number of rows deleted
n_tup_hot_upd	bigint	Number of rows with HOT updates (no separate index update is required).

15.3.150 PG_STAT_XACT_USER_FUNCTIONS

PG_STAT_XACT_USER_FUNCTIONS displays statistics about function execution.

Table 15-206 PG_STAT_XACT_USER_FUNCTIONS columns

Name	Type	Description
funcid	oid	Function OID
schemaname	name	Schema name
funcname	name	Name of the function
calls	bigint	Number of times this 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 itself, excluding other functions called by it

15.3.151 PG_STAT_XACT_USER_TABLES

PG_STAT_XACT_USER_TABLES displays the transaction status information of the user table in the namespace.

Table 15-207 PG_STAT_XACT_USER_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Name of a table
seq_scan	bigint	Number of sequential scans started on the table
seq_tup_read	bigint	Number of live rows fetched by sequential scans
idx_scan	bigint	Number of index scans started on the table

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 with HOT updates (no separate index update is required).

15.3.152 PG_STATIO_ALL_INDEXES

PG_STATIO_ALL_INDEXES displays I/O statistics of all indexes in the current database.

Table 15-208 PG_STATIO_ALL_INDEXES columns

Name	Type	Description
relid	oid	OID of the index table
indexrelid	oid	OID of this index
schemaname	name	Name of the schema this index is in
relname	name	Name of the table for this index
indexrelname	name	Name of this index
idx_blks_read	bigint	Number of disk blocks read from the index
idx_blks_hit	bigint	Number of buffer hits in this index

15.3.153 PG_STATIO_ALL_SEQUENCES

PG_STATIO_ALL_SEQUENCES displays the sequence information in the current database and the I/O statistics of a specified sequence.

Table 15-209 PG_STATIO_ALL_SEQUENCES columns

Name	Type	Description
relid	oid	OID of this sequence
schemaname	name	Name of the schema this sequence is in
relname	name	Name of this sequence
blks_read	bigint	Number of disk blocks read from the sequence

Name	Type	Description
blks_hit	bigint	Number of buffer hits in this sequence

15.3.154 PG_STATIO_ALL_TABLES

PG_STATIO_ALL_TABLES displays I/O statistics about all tables (including TOAST tables) in the current database.

Table 15-210 PG_STATIO_ALL_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Name of a table
heap_blks_read	bigint	Number of disks read from this table
heap_blks_hit	bigint	Number of buffer hits in this table
idx_blks_read	bigint	Number of disk blocks read from the index in this table
idx_blks_hit	bigint	Number of buffer hits in all indexes on this table
toast_blks_read	bigint	Number of disk blocks read from the TOAST table (if any) in this table
toast_blks_hit	bigint	Number of buffer hits in the TOAST table (if any) in this table
tidx_blks_read	bigint	Number of disk blocks read from the TOAST table index (if any) in this table
tidx_blks_hit	bigint	Number of buffer hits in the TOAST table index (if any) in this table

15.3.155 PG_STATIO_SYS_INDEXES

PG_STATIO_SYS_INDEXES displays the I/O status information about all system catalog indexes in the namespace.

Table 15-211 PG_STATIO_SYS_INDEXES columns

Name	Type	Description
relid	oid	Table OID for the index
indexrelid	oid	Index OID
schemaname	name	Schema name for the index
relname	name	Table name for the index
indexrelname	name	Index name
idx_blks_read	bigint	Number of disk blocks read from this index
idx_blks_hit	bigint	Number of buffer hits in this index

15.3.156 PG_STATIO_SYS_SEQUENCES

PG_STATIO_SYS_SEQUENCES displays the I/O status information about all the system sequences in the namespace.

Table 15-212 PG_STATIO_SYS_SEQUENCES columns

Name	Type	Description
relid	oid	OID of this sequence
schemaname	name	Name of the schema this sequence is in
relname	name	Name of this sequence
blks_read	bigint	Number of disk blocks read from the sequence
blks_hit	bigint	Number of buffer hits in this sequence

15.3.157 PG_STATIO_SYS_TABLES

PG_STATIO_SYS_TABLES displays the I/O status information about all the system catalogs in the namespace.

Table 15-213 PG_STATIO_SYS_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Name of a table

Name	Type	Description
heap_blks_read	bigint	Number of disk blocks read from this table
heap_blks_hit	bigint	Number of buffer hits in this table
idx_blks_read	bigint	Number of disk blocks read from the index in this table
idx_blks_hit	bigint	Number of buffer hits in all indexes on this table
toast_blks_read	bigint	Number of disk blocks read from the TOAST table (if any) in this table
toast_blks_hit	bigint	Number of buffer hits in the TOAST table (if any) in this table
tidx_blks_read	bigint	Number of disk blocks read from the TOAST table index (if any) in this table
tidx_blks_hit	bigint	Number of buffer hits in the TOAST table index (if any) in this table

15.3.158 PG_STATIO_USER_INDEXES

PG_STATIO_USER_INDEXES displays the I/O status information about all the user relationship table indexes in the namespace.

Table 15-214 PG_STATIO_USER_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 this index is in
relname	name	Name of the table for this index
indexrelname	name	Name of this index
idx_blks_read	bigint	Number of disk blocks read from the index
idx_blks_hit	bigint	Number of buffer hits in this index

15.3.159 PG_STATIO_USER_SEQUENCES

PG_STATIO_USER_SEQUENCES displays the I/O status information about all the user relation table sequences in the namespace.

Table 15-215 PG_STATIO_USER_SEQUENCES columns

Name	Type	Description
relid	oid	OID of this sequence
schemaname	name	Name of the schema this sequence is in
relname	name	Name of this sequence
blks_read	bigint	Number of disk blocks read from the sequence
blks_hit	bigint	Cache hits in the sequence

15.3.160 PG_STATIO_USER_TABLES

PG_STATIO_USER_TABLES displays the I/O status information about all the user relation tables in the namespace.

Table 15-216 PG_STATIO_USER_TABLES columns

Name	Type	Description
relid	oid	Table OID
schemaname	name	Schema name of the table
relname	name	Name of a table
heap_blks_read	bigint	Number of disk blocks read from this table
heap_blks_hit	bigint	Number of buffer hits in this table
idx_blks_read	bigint	Number of disk blocks read from the index in this table
idx_blks_hit	bigint	Number of buffer hits in all indexes on this table
toast_blks_read	bigint	Number of disk blocks read from the TOAST table (if any) in this table
toast_blks_hit	bigint	Number of buffer hits in the TOAST table (if any) in this table
tidx_blks_read	bigint	Number of disk blocks read from the TOAST table index (if any) in this table
tidx_blks_hit	bigint	Number of buffer hits in the TOAST table index (if any) in this table

15.3.161 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.

Table 15-217 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
lwtid	integer	Lightweight thread ID of the current thread
ptid	integer	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 15-218**.
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.

The waiting statuses in the **wait_status** column are as follows:

Table 15-218 Waiting status 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
wait cmd	Waiting for network communication packet read to complete
wait pooler get conn	Waiting for pooler to obtain the connection

Value	Description
wait pooler abort conn	Waiting for pooler to terminate the connection
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 the data from a connected node. The thread is waiting for the 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: • **begin**: The transaction is being started. • **commit**: The transaction is being committed. • **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 log 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
wait data sync queue	Waiting for putting the data pages that are in the row storage or the CU in the column storage into the synchronization queue

Value	Description
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 steam plan ends
nodegroup destroy	Waiting for destroying the stream node group when the steam plan ends
wait active statement	Waiting for job execution under resource and load control.
wait global queue	Waiting for job execution. The job is queuing in the global queue.
wait respool queue	Waiting for job execution. The job is queuing in the resource pool.
wait ccn queue	Waiting for job execution. The job is queuing on the central coordinator node (CCN).
gtm connect	Waiting for connecting to GTM.
gtm get gxid	Wait for obtaining xids 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 create sequence	Waiting for GTM to create a sequence.
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.

Value	Description
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. • **build hash**: The **HashJoin** operator is creating a hash table. • **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. • **build hash**: The **HashAgg** operator is creating a hash table. • **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. • **build hash**: The **HashSetop** operator is creating a hash table. • **write file**: The **HashSetop** operator is writing data to disks.
Sort | Sort - write file	The **Sort** operator is being executed. **write file** indicates that the **Sort** operator is writing data to disks.

Value	Description
Material | Material - write file	The **Material** operator is being executed. **write file** indicates that the **Material** operator is writing data to disks.
wait sync consumer next step	The consumer (receive end) synchronously waits for the next iteration.
wait sync producer next step	The producer (transmit end) synchronously waits for the next iteration.
wait agent release	The current agent is being released (supported by 8.1.2 and later versions).
wait stream task	The stream thread is waiting for being reused (supported by 8.1.2 and later versions).

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 15-219 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

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
MultiXactGenLock	Used to allocate a unique MultiXact ID in serial mode
MultiXactOffsetControl-Lock	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 already exists
BtreeVacuumLock	Used to prevent **VACUUM** from clearing pages that are being used by B-tree indexes
AutovacuumLock	Used to access the autovacuum worker array in serial mode
AutovacuumScheduleLock	Used to distribute tables requiring **VACUUM** in serial mode
SyncScanLock	Used to determine the start position of a relfilenode during heap scanning
NodeTableLock	Used to protect a shared structure that stores CN and DN 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
AsyncCtlLock	Used to prevent concurrent access to or concurrent modification on the sharing notification status

wait_event	Description
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
SerializableFinishedList-Lock	Used to prevent concurrent read/write or concurrent write/write on a shared linked list for completed serial transactions
SerializablePredicateLock-ListLock	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
CStoreCUCacheSweep-Lock	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
DfsConnectorCacheLock	Used to protect a global hash table where HDFS connection handles are cached
dummyServerInfoCache-Lock	Used to protect a global hash table where the information about computing Node Group connections is cached
ExtensionConnectorLi-bLock	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
DfsUserLoginLock	Used to protect a global linked table where HDFS user information is stored
DfsSpaceCacheLock	Used to ensure that the IDs of files to be imported to an HDFS table increase monotonically

wait_event	Description
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
ReplicationSlotControl-Lock	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 the I/O information of the current DN
WorkloadCGroupHash-Lock	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
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, *GAUSSHOME*.

wait_event	Description
LLVMDumpIRLock	Used to export the assembly language for dynamically generating functions
LLVMParseIRLock	Used to compile and parse a finished IR function from the IR file at the start position of a query
RPNumberLock	Used by a DN on a computing Node Group to count the number of threads for a task where plans are being executed
ClusterRPLock	Used to control concurrent access on cluster load data maintained in a CCN of the cluster
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	It is used to protect a common lock structure.
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

The following table describes the corresponding wait events when **wait_status** is **wait io**.

Table 15-220 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, mainly 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, mainly 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 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.
LockFileAddToDataDir-Read	Reads the **postmaster.pid** file.
LockFileAddToDataDir-Sync	Flushes the **postmaster.pid** file to a disk.
LockFileAddToDataDir-Write	Writes the PID information into the **postmaster.pid** file.
LockFileCreateRead	Read the LockFile file **%s.lock**.
LockFileCreateSync	Flushes the LockFile file **%s.lock** to a disk.

wait_event	Description
LockFileCreateWRITE	Writes the 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.
ReplicationSlotRestore-Sync	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 submission and restoration.
TwophaseFileSync	Flushes the **pg_twophase** file to a disk, mainly during two-phase transaction submission and restoration.
TwophaseFileWrite	Writes the **pg_twophase** file, mainly during two-phase transaction submission and restoration.

wait_event	Description
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 15-221 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.
virtualxid	Adds a lock to a virtual transaction ID.
object	Adds a lock to an object.

wait_event	Description
cstore_freespace	Adds a lock to idle column-store space.
userlock	Adds a lock to a user.
advisory	Adds an advisory lock.

15.3.162 PG_TABLES

PG_TABLES displays access to each table in the database.

Table 15-222 PG_TABLES columns

Name	Type	Reference	Description
schemaname	name	**PG_NAMESPACE**.nspname	Name of the schema that contains the table
tablename	name	**PG_CLASS**.relname	Name of the table
tableowner	name	pg_get_userbyid(**PG_CLASS**.relowner)	Owner of the table
tablespace	name	**PG_TABLESPACE**.spcname	Tablespace that contains the table. The default value is null
hasindexes	boolean	**PG_CLASS**.relhasindex	Whether the table has (or recently had) an index. If it does, its value is **true**. Otherwise, its value is **false**.
hasrules	boolean	**PG_CLASS**.relhasrules	Whether the table has rules. If it does, its value is **true**. Otherwise, its value is **false**.
hastriggers	boolean	**PG_CLASS**.RELHASTRIGGERS	Whether the table has triggers. If it does, its value is **true**. Otherwise, its value is **false**.
tablecreator	name	pg_get_userbyid(**PG_OBJECT**.creator)	Table creator. If the creator has been deleted, no value is returned.
created	timestamp with time zone	**PG_OBJECT**.ctime	Time when the table was created.

Name	Type	Reference	Description
last_ddl_time	timestamp with time zone	PG_OBJECT.mtime	Last time when the cluster was modified.

Example

Query all tables in a specified schema.

```
SELECT tablename FROM PG_TABLES WHERE schemaname = 'myschema';
   tablename
----------------
 inventory
 product
 sales_info
 test1
 mytable
 product_info
 customer_info
 newproducts
 customer_t1
(9 rows)
```

15.3.163 PG_TDE_INFO

PG_TDE_INFO displays the encryption information about the current cluster.

Table 15-223 PG_TDE_INFO columns

Name	Type	Description
is_encrypt	text	Whether the cluster is an encryption cluster • **f**: Non-encryption cluster • **t**: Encryption cluster
g_tde_algo	text	Encryption algorithm • SM4-CTR-128 • AES-CTR-128
remain	text	Reserved columns

Examples

Check whether the current cluster is encrypted, and check the encryption algorithm (if any) used by the current cluster.

```
SELECT * FROM PG_TDE_INFO;
 is_encrypt | g_tde_algo  | remain
------------+-------------+--------
 f          | AES-CTR-128 | remain
(1 row)
```


15.3.164 PG_TIMEZONE_ABBREVS

PG_TIMEZONE_ABBREVS displays all time zone abbreviations that can be recognized by the input routines.

Table 15-224 PG_TIMEZONE_ABBREVS columns

Name	Type	Description
abbrev	text	Time zone abbreviation
utc_offset	interval	Offset from UTC
is_dst	boolean	Whether the abbreviation indicates a daylight saving time (DST) zone. If it does, its value is **true**. Otherwise, its value is **false**.

15.3.165 PG_TIMEZONE_NAMES

PG_TIMEZONE_NAMES displays all time zone names that can be recognized by **SET TIMEZONE**, along with their associated abbreviations, UTC offsets, and daylight saving time statuses.

Table 15-225 PG_TIMEZONE_NAMES columns

Name	Type	Description
name	text	Name of the time zone
abbrev	text	Time zone name abbreviation
utc_offset	interval	Offset from UTC
is_dst	boolean	Whether DST is used. If it is, its value is **true**. Otherwise, its value is **false**.

15.3.166 PG_TOTAL_MEMORY_DETAIL

PG_TOTAL_MEMORY_DETAIL displays the memory usage of a certain node in the database.

Table 15-226 PG_TOTAL_MEMORY_DETAIL columns

Name	Type	Description
nodename	text	Node name

Name	Type	Description
memorytype	text	It can be set to any of the following values: • **max_process_memory**: memory used by a GaussDB(DWS) cluster instance • **process_used_memory**: memory used by a GaussDB(DWS) process • **max_dynamic_memory**: maximum dynamic memory • **dynamic_used_memory**: used dynamic memory • **dynamic_peak_memory**: dynamic peak value of the memory • **dynamic_used_shrctx**: maximum dynamic shared memory context • **dynamic_peak_shrctx**: dynamic peak value of the shared memory context • **max_shared_memory**: maximum shared memory • **shared_used_memory**: used shared memory • **max_cstore_memory**: maximum memory allowed for column store • **cstore_used_memory**: memory used for column store • **max_sctpcomm_memory**: maximum memory allowed for the communication library • **sctpcomm_used_memory**: memory used for the communication library • **sctpcomm_peak_memory**: memory peak of the communication library • **max_topsql_memory**: maximum memory that can be used by Top SQL to record historical job monitoring information • **topsql_used_memory**: memory used by Top SQL to record historical job monitoring information • **topsql_peak_memory**: memory peak of Top SQL to record historical job monitoring information • **other_used_memory**: other used memory • **gpu_max_dynamic_memory**: maximum GPU memory

Name	Type	Description
		• **gpu_dynamic_used_memory**: sum of the available GPU memory and temporary GPU memory • **gpu_dynamic_peak_memory**: maximum memory used for GPU • **pooler_conn_memory**: memory used for pooler connections • **pooler_freeconn_memory**: memory used for idle pooler connections • **storage_compress_memory**: memory used for column-store compression and decompression • **udf_reserved_memory**: memory reserved for the **UDF Worker** process • **mmap_used_memory**: memory used for **mmap**
memorymbytes	integer	Size of the used memory (MB)

15.3.167 PG_TOTAL_SCHEMA_INFO

PG_TOTAL_SCHEMA_INFO displays the storage usage of all schemas in each database. This view is valid only if use_workload_manager is set to **on**.

Column	Type	Description
schemaid	oid	Schema OID
schemaname	text	Schema name
databaseid	oid	Database OID
databasename	name	Database name
usedspace	bigint	Size of the permanent table storage space used by the schema, in bytes.
permspace	bigint	Upper limit of the permanent table storage space of the schema, in bytes.

15.3.168 PG_TOTAL_USER_RESOURCE_INFO

PG_TOTAL_USER_RESOURCE_INFO displays the resource usage of all users. Only administrators can query this view. This view is valid only if use_workload_manager is set to **on**.

Table 15-227 PG_TOTAL_USER_RESOURCE_INFO columns

Name	Type	Description
username	name	Username
used_memory	integer	Memory used by a user, in MB. • On a DN, it indicates the memory used by users on the current DN. • On a CN, it indicates the total memory used by users on all DNs.
total_memory	integer	Memory used by the resource pool, in MB. **0** indicates that the maximum available memory is not limited and depends on the maximum available memory of the database (**max_dynamic_memory**). The calculation formula is as follows: total_memory = max_dynamic_memory * parent_percent * user_percent On a CN, it indicates the total maximum available memory on all DNs.
used_cpu	double precision	Number of CPU cores in use. Only the CPU usage of complex jobs in the non-default resource pool is collected, and the value is the CPU usage of the related cgroup.
total_cpu	integer	Total number of CPU cores of the Cgroup associated with a user on the node
used_space	bigint	Used permanent table storage space (unit: KB)
total_space	bigint	Available storage space (unit: KB). **-1** indicates that the storage space is not limited.
used_temp_space	bigint	Used temporary table storage space (unit: KB)
total_temp_space	bigint	Available temporary table storage space (unit: KB). **-1** indicates that the storage space is not limited.
used_spill_space	bigint	Size of the used operator flushing space, in KB

Name	Type	Description
total_spill_space	bigint	Size of the available operator flushing space, in KB. The value **-1** indicates that the operator flushing space is not limited.
read_kbytes	bigint	On a CN, it indicates the total number of bytes logically read by a user on all DNs in the last 5 seconds, in KB. On a DN, it indicates the total number of bytes logically read by a user from the instance startup time to the current time, in KB.
write_kbytes	bigint	On a CN, it indicates the total number of bytes logically written by a user on all DNs in the last 5 seconds, in KB. On a DN, it indicates the total number of bytes logically written by a user from the instance startup time to the current time, in KB.
read_counts	bigint	On a CN, it indicates the total number of logical reads performed by a user on all DNs in the last 5 seconds. On a DN, it indicates the total number of logical reads performed by a user from the instance startup time to the current time.
write_counts	bigint	On a CN, it indicates the total number of logical writes performed by a user on all DNs in the last 5 seconds. On a DN, it indicates the total number of logical writes performed by a user from the instance startup time to the current time.
read_speed	double precision	On a CN, it indicates the sum of average logical read rates of a user on all DNs in the last 5 seconds, in KB/s. On a DN, it indicates the average logical read rate of a user on the DN in the last 5 seconds, in KB/s.
write_speed	double precision	On a CN, it indicates the sum of average logical write rates of a user on all DNs in the last 5 seconds, in KB/s. On a DN, it indicates the average logical write rate of a user on the DN in the last 5 seconds, in KB/s.

Name	Type	Description
send_speed	double precision	On a CN, it indicates the sum of the average network sending rates of a user on all DNs in the last 5 seconds, in KB/s. On a DN, it indicates the average network sending rate of a user on the DN in the last 5 seconds, in KB/s.
recv_speed	double precision	On a CN, it indicates the sum of the average network receiving rates of a user on all DNs in the last 5 seconds, in KB/s. On a DN, it indicates the average network receiving rate of a user on the DN in the last 5 seconds, in KB/s.

15.3.169 PG_USER

PG_USER displays information about users who can access the database.

Table 15-228 PG_USER columns

Name	Type	Description
usename	name	User name
usesysid	oid	ID of this user
usecreatedb	boolean	Whether the user has the permission to create databases
usesuper	boolean	whether the user is the initial system administrator with the highest rights.
usecatupd	boolean	whether the user can directly update system tables. Only the initial system administrator whose usesysid is 10 has this permission. It is not available for other users.
userepl	boolean	Whether the user has the permission to duplicate data streams
passwd	text	Encrypted user password. The value is displayed as ********.
valbegin	timestamp with time zone	Account validity start time; null if no start time
valuntil	timestamp with time zone	Password expiry time; null if no expiration

Name	Type	Description
respool	name	Resource pool where the user is in
parent	oid	Parent user OID
spacelimit	text	The storage space of the permanent table.
tempspacelimit	text	The storage space of the temporary table.
spillspacelimit	text	The operator disk flushing space.
useconfig	text[]	Session defaults for run-time configuration variables
nodegroup	name	Name of the logical cluster associated with the user. If no logical cluster is associated, this column is left blank.

Example

Query the current database user list.

```
SELECT usename  FROM pg_user;
  usename
-----------
 dbadmin
 u1
 u2
 u3
(4 rows)
```

15.3.170 PG_USER_MAPPINGS

PG_USER_MAPPINGS displays information about user mappings.

This is essentially a publicly readable view of **PG_USER_MAPPING** that leaves out the options column if the user has no rights to use it.

Table 15-229 PG_USER_MAPPINGS columns

Name	Type	Reference	Description
umid	oid	**PG_USER_MAPPING**.oid	OID of the user mapping
srvid	oid	**PG_FOREIGN_SERVER**.oid	OID of the foreign server that contains this mapping
srvname	name	**PG_FOREIGN_SERVER**.srvname	Name of the foreign server
umuser	oid	**PG_AUTHID**.oid	OID of the local role being mapped, 0 if the user mapping is public

Name	Type	Reference	Description
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, its value is keyword=value strings. Otherwise, its value is null.

15.3.171 PG_VIEWS

PG_VIEWS displays basic information about each view in the database.

Table 15-230 PG_VIEWS columns

Name	Type	Reference	Description
schemaname	name	**PG_NAMESPACE**.nspname	Name of the schema that contains the view
viewname	name	**PG_CLASS**.relname	View name
viewowner	name	**PG_AUTHID**.Erolname	Owner of the view
definition	text	-	Definition of the view

Example

Query all the views in a specified schema.

```
SELECT * FROM pg_views WHERE schemaname = 'myschema';
 schemaname | viewname | viewowner |                                 definition
------------+----------+-----------+-----------------------------------------------------------------------------------------
 myschema   | myview   | dbadmin   | SELECT  * FROM pg_tablespace WHERE (pg_tablespace.spcname =
'pg_default'::name);
 myschema   | v1       | dbadmin   | SELECT  * FROM t1 WHERE (t1.c1 > 200);
(2 rows)
```

15.3.172 PG_WLM_STATISTICS

PG_WLM_STATISTICS displays information about workload management after the task is complete or the exception has been handled. This view has been discarded in 8.1.2. You can use **PGXC_WLM_SESSION_INFO** to view load management records of completed jobs executed on all CNs.

Table 15-231 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 • **pending**: The statement is waiting to be executed. • **running**: The statement is being executed. • **finished**: The execution is finished normally. • **abort**: The execution is unexpectedly terminated.
action	text	Actions when statements are executed for exception handling • **abort** indicates terminating the operation. • **adjust** indicates executing the Cgroup adjustment operations. Currently, you can only perform the demotion operation. • **finish** indicates that the operation is normally finished.
queryid	bigint	Internal query ID used for statement execution
threadid	bigint	ID of the backend thread

15.3.173 PGXC_BULKLOAD_PROGRESS

PGXC_BULKLOAD_PROGRESS displays the progress of the service import. Only GDS common files can be imported. This view is accessible only to users with system administrators rights.

Table 15-232 PGXC_BULKLOAD_PROGRESS columns

Name	Type	Description
session_id	bigint	GDS session ID
query_id	bigint	Query ID. It is equivalent to **debug_query_id**.
query	text	Query statement
progress	text	Progress percentage

15.3.174 PGXC_BULKLOAD_STATISTICS

PGXC_BULKLOAD_STATISTICS displays real-time statistics about service execution, such as GDS, COPY, and \COPY, on a CN. This view summarizes the real-time execution status of import and export services that are being executed on each node in the current cluster. In this way, you can monitor the real-time progress of import and export services and locate performance problems.

Columns in **PGXC_BULKLOAD_STATISTICS** are the same as those in **PG_BULKLOAD_STATISTICS**. This is because **PGXC_BULKLOAD_STATISTICS** is essentially the summary result of querying **PG_BULKLOAD_STATISTICS** on each node in the cluster.

This view is accessible only to users with system administrators rights.

Table 15-233 PGXC_BULKLOAD_STATISTICS columns

Name	Type	Description
node_name	text	Node name
db_name	text	Database name
query_id	bigint	Query ID. It is equivalent to **debug_query_id**.
tid	bigint	ID of the current thread
lwtid	integer	Lightweight thread ID
session_id	bigint	GDS session ID
direction	text	Service type. The options are **gds to file**, **gds from file**, **gds to pipe**, **gds from pipe**, **copy from**, and **copy to**.
query	text	Query statement
address	text	Location of the foreign table used for data import and export

query_start	timestamp with time zone	Start time of data import or export
total_bytes	bigint	Total size of data to be processed This parameter is specified only when a GDS common file is to be imported and the record in the row comes from a CN. Otherwise, left this parameter unspecified.
phase	text	Current phase. The options are **INITIALIZING**, **TRANSFER_DATA**, and **RELEASE_RESOURCE**.
done_lines	bigint	Number of lines that have been transferred
done_bytes	bigint	Number of bytes that have been transferred

15.3.175 PGXC_COLUMN_TABLE_IO_STAT

PGXC_COLUMN_TABLE_IO_STAT provides I/O statistics of all column-store tables of the database on all CNs and DNs in the cluster. Except the **nodename** column of the name type added in front of each row, the names, types, and sequences of other columns are the same as those in the **GS_COLUMN_TABLE_IO_STAT** view. For details about the columns, see **GS_COLUMN_TABLE_IO_STAT**.

15.3.176 PGXC_COMM_CLIENT_INFO

PGXC_COMM_CLIENT_INFO stores the client connection information of all nodes. (You can query this view on a DN to view the information about the connection between the CN and DN.)

Table 15-234 PGXC_COMM_CLIENT_INFO columns

Name	Type	Description
node_name	text	Current node name.
app	text	Client application name
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	It is displayed if the connection is a physical connection.
remote_ip	text	Peer node IP address.

Name	Type	Description
remote_port	text	Peer node port.
logic_id	integer	If the connection is a logical connection, **sid** is displayed. If **-1** is displayed, the current connection is a physical connection.

15.3.177 PGXC_COMM_DELAY

PGXC_COMM_STATUS displays the communication library delay status for all the DNs.

Table 15-235 PGXC_COMM_DELAY columns

Name	Type	Description
node_name	text	Node name
remote_name	text	Name of the peer node with the maximum connection latency.
remote_host	text	IP address of the peer
stream_num	integer	Number of logical stream connections used by the current physical connection
min_delay	integer	Minimum delay of the current physical connection. The unit is microsecond.
average	integer	Average delay of the current physical connection. The unit is microsecond.
max_delay	integer	Maximum delay of the current physical connection. The unit is microsecond. **NOTE** If its value is **-1**, the latency detection has timed out. In this case, re-establish the connection between nodes and then perform the query.

15.3.178 PGXC_COMM_RECV_STREAM

PG_COMM_RECV_STREAM displays the receiving stream status of the communication libraries for all the DNs.

Table 15-236 PGXC_COMM_RECV_STREAM columns

Name	Type	Description
node_name	text	Node name

Name	Type	Description
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	Current status of the stream • **UNKNOWN**: The logical connection is unknown. • **READY**: The logical connection is ready. • **RUN**: The logical connection receives packets normally. • **HOLD**: The logical connection is waiting to receive packets. • **CLOSED**: The logical connection is closed. • **TO_CLOSED**: The logical connection is to be closed. • **WRITING**: Data is being written.
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. The unit is byte.
time	bigint	Current life cycle service duration of the stream. The unit is ms.
speed	bigint	Average receiving rate of the stream. The unit is byte/s.
quota	bigint	Current communication quota value of the stream. The unit is Byte.
buff_usize	bigint	Current size of the data cache of the stream. The unit is byte.

15.3.179 PGXC_COMM_SEND_STREAM

PGXC_COMM_SEND_STREAM displays the sending stream status of the communication libraries for all the DNs.

Table 15-237 PGXC_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	Current status of the stream. • **UNKNOWN**: The logical connection is unknown. • **READY**: The logical connection is ready. • **RUN**: The logical connection sends packets normally. • **HOLD**: The logical connection is waiting to send packets. • **CLOSED**: The logical connection is closed. • **TO_CLOSED**: The logical connection is to be closed. • **WRITING**: Data is being written.
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. The unit is Byte.
time	bigint	Current life cycle service duration of the stream. The unit is ms.
speed	bigint	Average sending rate of the stream. The unit is Byte/s.

Name	Type	Description
quota	bigint	Current communication quota value of the stream. The unit is Byte.
wait_quota	bigint	Extra time generated when the stream waits the quota value. The unit is ms.

15.3.180 PGXC_COMM_STATUS

PGXC_COMM_STATUS displays the communication library status for all the DNs.

Table 15-238 PGXC_COMM_STATUS columns

Name	Type	Description
node_name	text	Node name
rxpck/s	integer	Receiving rate of the communication library on a node. The unit is byte/s.
txpck/s	integer	Sending rate of the communication library on a node. The unit is byte/s.
rxkB/s	bigint	Receiving rate of the communication library on a node. The unit is KB/s.
txkB/s	bigint	Sending rate of the communication library on a node. The unit is KB/s.
buffer	bigint	Size of the buffer of the Cmailbox.
memKB(libcomm)	bigint	Communication memory size of the **libcomm** process, in KB.
memKB(libpq)	bigint	Communication memory size of the **libpq** process, in KB.
%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.

15.3.181 PGXC_COMM_QUERY_SPEED

PGXC_COMM_QUERY_SPEED displays traffic information about all queries on all nodes.

Table 15-239 PGXC_COMM_QUERY_SPEED columns

Name	Type	Description
node_name	text	Node name
query_id	bigint	**debug_query_id** corresponding to the stream
rxkB/s	bigint	Receiving rate of the query stream (unit: byte/s)
txkB/s	bigint	Sending rate of the query stream (unit: byte/s)
rxkB	bigint	Total received data of the query stream (unit: byte)
txkB	bigint	Total sent data of the query stream (unit: byte)
rxpck/s	bigint	Packet receiving rate of the query (unit: packets/s)
txpck/s	bigint	Packet sending rate of the query (Unit: packets/s)
rxpck	bigint	Total number of received packets of the query
txpck	bigint	Total number of sent packets of the query

15.3.182 PGXC_DEADLOCK

PGXC_DEADLOCK displays lock wait information generated due to distributed deadlocks.

Currently, **PGXC_DEADLOCK** collects only lock wait information about locks whose **locktype** is **relation**, **partition**, **page**, **tuple**, or **transactionid**.

Table 15-240 PGXC_DEADLOCK columns

Name	Type	Description
locktype	text	Type of the locked object
nodename	name	Name of the node where the locked object resides

Name	Type	Description
dbname	name	Name of the database where the locked object resides. The value is **NULL** if the locked object is a transaction.
nspname	name	Name of the namespace of the locked object
relname	name	Name of the relation targeted by the lock. The value is **NULL** if the object is not a relation or part of a relation.
partname	name	Name of the partition targeted by the lock. The value is **NULL** if the locked object is not a partition.
page	integer	Number of the page targeted by the lock. The value is **NULL** if the locked object is neither a page nor a tuple.
tuple	smallint	Number of the tuple targeted by the lock. The value is **NULL** if the locked object is not a tuple.
transactionid	xid	ID of the transaction targeted by the lock. The value is **NULL** if the locked object is not a transaction.
waitusername	name	Name of the user who waits for the lock
waitgxid	xid	ID of the transaction that waits for the lock
waitxactstart	timestamp with time zone	Start time of the transaction that waits for the lock
waitqueryid	bigint	Latest query ID of the thread that waits for the lock
waitquery	text	Latest query statement of the thread that waits for the lock
waitpid	bigint	ID of the thread that waits for the lock
waitmode	text	Mode of the waited lock
holdusername	name	Name of the user who holds the lock
holdgxid	xid	ID of the transaction that holds the lock
holdxactstart	timestamp with time zone	Start time of the transaction that holds the lock
holdqueryid	bigint	Latest query ID of the thread that holds the lock

Name	Type	Description
holdquery	text	Latest query statement of the thread that holds the lock
holdpid	bigint	ID of the thread that holds the lock
holdmode	text	Mode of the held lock

15.3.183 PGXC_GET_STAT_ALL_TABLES

PGXC_GET_STAT_ALL_TABLES displays information about insertion, update, and deletion operations on tables and the dirty page rate of tables.

Before running **VACUUM FULL** on a system catalog with a high dirty page rate, ensure that no user is performing operations on it.

You are advised to run **VACUUM FULL** to tables (excluding system catalogs) whose dirty page rate exceeds 80% or run it based on service scenarios.

NOTE

For clusters of 8.2.0.100 or later, **PGXC_STAT_TABLE_DIRTY** is recommended for querying the dirty page rate.

Table 15-241 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

Examples

Use the view **PGXC_GET_STAT_ALL_TABLES** to query the tables whose dirty page rate is greater than 30%.

```
SELECT * FROM PGXC_GET_STAT_ALL_TABLES WHERE dirty_page_rate>30;
 relid |        relname         | schemaname | n_tup_ins | n_tup_upd | n_tup_del | n_live_tup | n_dead_tup |
```



```
dirty_page_rate
-------+-------------------------+------------+-----------+-----------+-----------+------------+------------
+-----------------
  2840 | pg_toast_2619           | pg_toast   |      7415 |         0 |      7415 |          0 |        291 |          88.00
  9001 | pgxc_class              | pg_catalog |     56331 |         3 |     56285 |         54 |        143 |          72.59
 53860 | reason                  | dbadmin    |         9 |        19 |         0 |          9 |         19 |          67.86
  9025 | pg_object               | pg_catalog |    112858 |   1179707 |    112619 |        246 |        429 |
63.56
  9015 | pgxc_node               | pg_catalog |        15 |        24 |         0 |         15 |         24 |          61.54
  2606 | pg_constraint           | pg_catalog |        78 |         0 |        42 |         36 |         42 |          53.85
  1260 | pg_authid               | pg_catalog |         6 |         6 |         0 |          6 |          6 |          50.00
(7 rows)
```

15.3.184 PGXC_GET_STAT_ALL_PARTITIONS

PGXC_GET_STAT_ALL_PARTITIONS displays information about insertion, update, and deletion operations on partitions of partitioned tables and the dirty page rate of tables.

The statistics of this view depend on the **ANALYZE** operation. To obtain the most accurate information, perform the **ANALYZE** operation on the partitioned table first.

NOTE

For clusters of 8.2.0.100 or later, **PGXC_STAT_TABLE_DIRTY** is recommended for querying the dirty page rate.

Table 15-242 PGXC_GET_STAT_ALL_PARTITIONS columns

Name	Type	Description
relid	oid	Table OID
partid	oid	Partition OID
schename	name	Schema name of a table
relname	name	Table name
partname	name	Partition name
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
page_dirty_rate	numeric(5,2)	Dirty page rate (%) of a table

15.3.185 PGXC_GET_TABLE_SKEWNESS

PGXC_GET_TABLE_SKEWNESS displays the data skew on tables in the current database. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view.

Table 15-243 PGXC_GET_TABLE_SKEWNESS columns

Name	Type	Description
schemaname	name	Schema name of a table
tablename	name	Name of a table
totalsize	numeric	Total size of a 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(10,3)	Ratio of the maximum table size on a single DN to to **avgsize**
minratio	numeric(10,3)	Ratio of the minimum table size on a single DN to **avgsize**
skewsize	bigint	Table skew rate (the maximum table size on a single DN minus the minimum table size on a single DN)
skewratio	numeric(10,3)	Table skew rate (skewsize/avgsize)
skewstddev	numeric(1000, 0)	Standard deviation of table distribution (For two tables of the same size, a larger deviation indicates a more severe skew.)

15.3.186 PGXC_WLM_TABLE_DISTRIBUTION_SKEWNESS

PGXC_WLM_TABLE_DISTRIBUTION_SKEWNESS displays data skews of tables in the current database. You can quickly query the storage space skew of all tables in the current database on each node. This view is supported only by clusters of version 8.2.1 or later.

The formula for calculating the skew rate is as follows: Skew rate (SKEW_PERCENT) = (Maximum value – Average value) x 100/Maximum value

Table 15-244 PGXC_WLM_TABLE_DISTRIBUTION_SKEWNESS columns

Column	Type	Description
schema_name	name	Name of the schema where a table is
table_name	name	Table name
total_size	numeric	Total storage space of a table on all nodes, in bytes
avg_size	numeric(1000,0)	Average storage space of a table on each node, in bytes
max_percent	numeric	Percentage (%) of the maximum storage space of a table on each node to the total storage space
min_percent	numeric	Percentage (%) of the minimum storage space of a table on each node to the total storage space
skew_percent	numeric	Skew rate (%) of a table

NOTE

- To use this view to query the storage distribution information of a specified table, you must have the **SELECT** permission on the table.
- This function is based on the physical file storage space recorded in the **PG_RELFILENODE_SIZE** system catalog. Ensure that the GUC parameters **use_workload_manager** and **enable_perm_space** are enabled.
- When you analyze the disk space skew of each table in a database in a large cluster with a large amount of data, the **PGXC_WLM_TABLE_DISTRIBUTION_SKEWNESS** view delivers better query performance than the **gs_table_distribution()** function and the **PGXC_GET_TABLE_SKEWNESS** view. You are advised to use the **PGXC_WLM_TABLE_DISTRIBUTION_SKEWNESS** view to query the table skew status overview, and then use the **gs_table_distribution(schemaname text, tablename text)** function to obtain the disk space distribution of a specified table on each node.

Example

You can use the **PGXC_WLM_TABLE_DISTRIBUTION_SKEWNESS** view to query the table skew status overview, and then use the **gs_table_distribution(schemaname text, tablename text)** function to obtain the disk space distribution of a specified table on each node.

Step 1 Use the **PGXC_WLM_TABLE_DISTRIBUTION_SKEWNESS** view to query the table skew status overview.

```
tpcds_col=# select * from pgxc_wlm_table_distribution_skewness;
```

The query result is as follows:


```
tpcds_col=# select * from pgxc_wlm_table_distribution_skewness;
    schema_name     |                  table_name                  | total_size  |  avg_size  | max_percent | min_percent | skew_percent
--------------------+----------------------------------------------+-------------+------------+-------------+-------------+--------------
 pg_catalog         | pg_namespace_oid_index                       |       98304 |      16384 |       16.67 |       16.67 |         0.00
 public             | customer_demographics                        |     4595712 |    1531904 |       33.33 |       33.33 |         0.00
 pg_catalog         | pg_type_oid_index                            |      245760 |      40960 |       16.67 |       16.67 |         0.00
 pg_catalog         | pg_partition                                 |       49152 |       8192 |       16.67 |       16.67 |         0.00
 pg_catalog         | pg_user_mapping_user_server_index            |       49152 |       8192 |       16.67 |       16.67 |         0.00
 pg_catalog         | pg_attrdef                                   |      294912 |      49152 |       16.67 |       16.67 |         0.00
 pg_catalog         | pg_global_temp_parent_nsp_index              |       49152 |       8192 |       16.67 |       16.67 |         0.00
 pg_catalog         | pg_namespace_nspname_index                   |       98304 |      16384 |       16.67 |       16.67 |         0.00
 pg_catalog         | pg_synonym_name_nsp_index                    |       49152 |       8192 |       16.67 |       16.67 |         0.00
 pg_catalog         | pg_proc_proname_args_nsp_index               |     2015232 |     335872 |       16.67 |       16.67 |         0.00
 public             | dbgen_version                                |       32768 |      10923 |      100.00 |        0.00 |        66.67
 pg_catalog         | pg_amop_opr_fam_index                        |      294912 |      49152 |       16.67 |       16.67 |         0.00
 pg_catalog         | pg_global_temp                               |           0 |          0 |        0.00 |        0.00 |         0.00
 pg_catalog         | pg_workload_group_name_index                 |           0 |          0 |        0.00 |        0.00 |         0.00
 public             | date_dim                                     |     7159808 |    2386603 |       34.10 |       32.95 |         2.24
 pg_catalog         | pg_operator_oid_index                        |      245760 |      40960 |       16.67 |       16.67 |         0.00
```

The data skew of the **dbgen_version** table is severe.

Step 2 Use the **gs_table_distribution(schemaname text, tablename text)** function to query the disk space distribution of the **dbgen_version** table on each node.

```
tpcds_col=# select * from gs_table_distribution('public','dbgen_version');
```

The query result is as follows:

```
tpcds_col=# select * from gs_table_distribution('public','dbgen_version');
 schemaname |   tablename    | relkind | relpersistence |   nodename    | dnsize | sessionid
------------+----------------+---------+----------------+---------------+--------+-----------
 public     | dbgen_version | r       | p              | dn_6001_6002 |      0 |
 public     | dbgen_version | r       | p              | dn_6005_6006 |  32768 |
 public     | dbgen_version | r       | p              | dn_6003_6004 |      0 |
(3 rows)
```

According to the preceding information, data skew occurs in the disk space occupied by the table on DNs. Most data is stored on **dn_6005_6006**.

----End

15.3.187 PGXC_GTM_SNAPSHOT_STATUS

PGXC_GTM_SNAPSHOT_STATUS displays transaction information on the current GTM.

Table 15-245 PGXC_GTM_SNAPSHOT_STATUS columns

Name	Type	Description
xmin	xid	Minimum ID of the running transactions
xmax	xid	ID of the transaction next to the executed transaction with the maximum ID
csn	integer	Sequence number of the transaction to be committed
oldestxmin	xid	Minimum ID of the executed transactions
xcnt	integer	Number of the running transactions
running_xids	text	IDs of the running transactions

15.3.188 PGXC_INSTANCE_TIME

PGXC_INSTANCE_TIME displays the running time of processes on each node in the cluster and the time consumed in each execution phase. Except the **node_name** column, the other columns are the same as those in the **PV_INSTANCE_TIME** view. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view.

15.3.189 PGXC_LOCKWAIT_DETAIL

PGXC_LOCKWAIT_DETAIL displays detailed information about the lock wait hierarchy on each node in a cluster. If a node has multiple lock wait levels, the entire lock waiting hierarchy is displayed in sequence.

This view is supported only by clusters of version 8.1.3.200 or later.

Table 15-246 PGXC_LOCKWAIT_DETAIL columns

Name	Type	Description
level	integer	Level in the lock wait hierarchy. The value starts with 1 and increases by 1 when there is a wait relationship.
node_name	name	Node name, corresponding to the **node_name** column in the **pgxc_node** table.
lock_wait_hierarchy	text	Lock wait hierarchy , in the format of *Node name: Process ID->Waiting process ID->Waiting process ID->...*
lock_type	text	Type of the locked object
database	oid	OID of the database where the locked target is
relation	oid	OID of the locked object relationship
page	integer	Page index in a relationship
tuple	smallint	Row number of a page.
virtual_xid	text	Virtual ID of a transaction
transaction_id	xid	Transaction ID
class_id	oid	OID of the system catalog that contains the object
obj_id	oid	OID of the object in its system catalog
obj_subid	smallint	Column number of a table
virtual_transaction	text	Virtual ID of the transaction holding or awaiting this lock
pid	bigint	ID of the thread holding or awaiting this lock

Name	Type	Description
mode	text	Lock level
granted	boolean	Indicates whether a lock is held.
fastpath	boolean	Indicates whether to obtain a lock using FASTPATH.
wait_for_pid	bigint	ID of the thread where a lock conflict occurs.
conflict_mode	text	Level of the conflicted lock held by the thread where it is
query_id	bigint	ID of a query statement.
query	text	Query statement
application_name	text	Name of the application connected to the backend
backend_start	timestamp with time zone	Startup time of the backend process, that is, the time when the client connects to the server
xact_start	timestamp with time zone	Start time of the current transaction
query_start	timestamp with time zone	Start time of the active query
state	text	Overall state of the backend

Example

Step 1 Connect to the DN, start a transaction, and run the following command:

```
begin;select * from t1;
```

Step 2 Connect to the CN in another window and truncate table **t1**.

```
truncate t1;
```

In this case, truncation is blocked.

Step 3 Open another window to connect to the CN and run the **select * from pgxc_lockwait_detail;** command.

```
SELECT * FROM PGXC_LOCKWAIT_DETAIL;
level | node_name |             lock_wait_hierarchy              | lock_type | database |  relation  | page | tuple |
virtual_xid | transaction_id | class_id | obj_id | obj_subid | virtual_transaction |       p
id       |        mode         | granted | fastpath |  wait_for_pid   |  conflict_mode  |     query_id
|                  query                   | application_name |         backend_start         |
xact_start          |         query_start          |        state
-------+-----------+----------------------------------------------+-----------+----------+------------+------+-------
+-------------+----------------+----------+--------+-----------+---------------------+--------
---------+---------------------+---------+----------+-----------------+-----------------+------------------
+-----------------------------------------------+-----------------+------------------------------+--
----------------------------+------------------------------+--------------------
```

```
1 | datanode1 | datanode1:140378619314976                  | relation |    16049 | 2147484411 |      |
|            |        673638 |          |        |          | 19/297             | 1403786
19314976 | AccessExclusiveLock | f       | f       | 140378619263840 | AccessShareLock | 73183493945504391
| TRUNCATE t1                  | coordinator1     | 2023-03-13 12:13:52.530602+08 | 2
023-03-13 14:52:16.1456+08    | 2023-03-13 14:52:16.148693+08 | active
2 | datanode1 | datanode1:140378619314976 -> 140378619263840 | relation |    16049 | 2147484411 |
|      |            |              |         |        |          | 23/16067           | 1403786
19263840 | AccessShareLock     | t       | f       |              |               |               0 | begin;select * from t1;
| gsql            | 2023-03-13 14:19:26.325602+08 | 2
023-03-13 14:52:12.042741+08 | 2023-03-13 14:52:12.042741+08 | idle in transaction
(2 rows)
```

----End

15.3.190 PGXC_INSTR_UNIQUE_SQL

PGXC_INSTR_UNIQUE_SQL displays the complete Unique SQL statistics of all CN nodes in the cluster.

Only the system administrator can access this view. For details about the field, see **GS_INSTR_UNIQUE_SQL**.

15.3.191 PGXC_LOCK_CONFLICTS

PGXC_LOCK_CONFLICTS displays information about conflicting locks in the cluster.

When a lock is waiting for another lock or another lock is waiting for this one, a lock conflict occurs.

Currently, **PGXC_LOCK_CONFLICTS** collects only information about locks whose **locktype** is **relation**, **partition**, **page**, **tuple**, or **transactionid**.

Table 15-247 PGXC_LOCK_CONFLICTS columns

Name	Type	Description
locktype	text	Type of the locked object
nodename	name	Name of the node where the locked object resides
dbname	name	Name of the database where the locked object resides. The value is **NULL** if the locked object is a transaction.
nspname	name	Name of the namespace of the locked object
relname	name	Name of the relation targeted by the lock. The value is **NULL** if the object is not a relation or part of a relation.
partname	name	Name of the partition targeted by the lock. The value is **NULL** if the locked object is not a partition.
page	integer	Number of the page targeted by the lock. The value is **NULL** if the locked object is neither a page nor a tuple.

Name	Type	Description
tuple	smallint	Number of the tuple targeted by the lock. The value is **NULL** if the locked object is not a tuple.
transactionid	xid	ID of the transaction targeted by the lock. The value is **NULL** if the locked object is not a transaction.
username	name	Name of the user who applies for the lock
gxid	xid	ID of the transaction that applies for the lock
xactstart	timestamp with time zone	Start time of the transaction that applies for the lock
queryid	bigint	Latest query ID of the thread that applies for the lock
query	text	Latest query statement of the thread that applies for the lock
pid	bigint	ID of the thread that applies for the lock
mode	text	Lock mode
granted	boolean	• **TRUE** if the lock has been held • **FALSE** if the lock is still waiting for another lock

15.3.192 PGXC_NODE_ENV

PGXC_NODE_ENV displays the environmental variables information about all nodes in a cluster.

Table 15-248 PGXC_NODE_ENV columns

Name	Type	Description
node_name	text	Names of all nodes in the cluster
host	text	Host names of all nodes in the cluster
process	integer	Process IDs of all nodes in the cluster
port	integer	Port numbers of all nodes in the cluster
installpath	text	Installation directory of all nodes in the cluster
datapath	text	Data directory of all nodes in the cluster
log_directory	text	Log directory of all nodes in the cluster

15.3.193 PGXC_NODE_STAT_RESET_TIME

PGXC_NODE_STAT_RESET_TIME displays the time when statistics of each node in the cluster are reset. All columns except **node_name** are the same as those in the **GS_NODE_STAT_RESET_TIME** view. This view is accessible only to users with system administrators rights.

15.3.194 PGXC_OS_RUN_INFO

PGXC_OS_RUN_INFO displays the OS running status of each node in the cluster. All columns except **node_name** are the same as those in the **PV_OS_RUN_INFO** view. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view.

15.3.195 PGXC_OS_THREADS

PGXC_OS_THREADS displays thread status information under all normal nodes in the current cluster.

Table 15-249 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 normal node processes in the current cluster
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

15.3.196 PGXC_POOLER_STATUS

PGXC_POOLER_STATUS displays the pooler cache connection status of each CN in the current cluster. This view can be queried only on CNs to display the connection cache information of the pooler module on all CNs. The **PGXC_POOLER_STATUS** view is supported only by clusters of versions 8.2.1.300 or later.

Table 15-250 PGXC_POOLER_STATUS columns

Column	Type	Description
coorname	text	CN node name
database	text	Database name
user_name	text	Username

Column	Type	Description
tid	bigint	ID of a thread 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 in use • **t** (true): indicates that the connection is in use. • **f** (false): indicates that the connection is not in use.
fdsock	bigint	Peer socket
remote_pid	bigint	Peer thread ID
session_params	text	GUC session parameter delivered by the connection

15.3.197 PGXC_PREPARED_XACTS

PGXC_PREPARED_XACTS displays the two-phase transactions in the **prepared** phase.

Table 15-251 PGXC_PREPARED_XACTS columns

Name	Type	Description
pgxc_prepared_xact	text	Two-phase transactions in **prepared** phase

15.3.198 PGXC_REDO_STAT

PGXC_REDO_STAT displays statistics on redoing Xlogs of each node in the cluster. All columns except **node_name** are the same as those in the **PV_REDO_STAT** view. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view.

15.3.199 PGXC_REL_IOSTAT

PGXC_REL_IOSTAT displays statistics on disk read and write of each node in the cluster. All columns except **node_name** are the same as those in the **GS_REL_IOSTAT** view. This view is accessible only to users with system administrators rights.

15.3.200 PGXC_REPLICATION_SLOTS

PGXC_REPLICATION_SLOTS displays the replication information of DNs in the cluster. All columns except **node_name** are the same as those in the

PG_REPLICATION_SLOTS view. This view is accessible only to users with system administrators rights.

15.3.201 PGXC_RESPOOL_RUNTIME_INFO

PGXC_RESPOOL_RUNTIME_INFO displays the running information about all resource pool jobs on all CNs.

Table 15-252 PGXC_RESPOOL_RUNTIME_INFO columns

Name	Type	Description
nodename	name	CN name
nodegroup	name	Name of the logical cluster of the resource pool. The default value is **installation**
rpname	name	Resource pool name
ref_count	int	Number of jobs referenced by resource pools. The number is counted regardless of whether a job is controlled by a resource pool.
fast_run	int	Number of running jobs in the fast lane of the resource pool
fast_wait	int	Number of jobs queued in the fast lane of the resource pool
slow_run	int	Number of running jobs in the slow lane of the resource pool
slow_wait	int	Number of jobs queued in the slow lane of the resource pool

15.3.202 PGXC_RESPOOL_RESOURCE_INFO

PGXC_RESPOOL_RESOURCE_INFO displays the real-time monitoring information about the resource pools on all instances.

NOTE

- On a DN, it only displays the monitoring information of the logical cluster that the DN belongs to.
- Cluster 8.2.0 and later versions provide the negative memory feedback mechanism. The CCN can decrease the estimated memory usage of statements based on their actual memory usage on DNs, improving resource utilization by reducing overestimation. However, the estimated memory usage on CNs remains unchanged. If the CCN allows more jobs to run, the total estimated memory usage in the resource pool monitoring view may exceed the memory upper limit of the resource pool.
- Only the operators occupying large memory are under statement memory control. The memory, thread initialization costs, and expression costs of the operators with small memory usage are not controlled. So the value of **used_mem** of the resource pool may exceed the value of **mem_limit** to a limited extent.

Table 15-253 PGXC_RESPOOL_RESOURCE_INFO columns

Name	Type	Description
nodename	name	Instance name, including CNs and DNs.
nodegroup	name	Name of the logical cluster of the resource pool. The default value is **installation**.
rpname	name	Resource pool name.
cgroup	name	Name of the Cgroup associated with the resource pool.
ref_count	int	Number of jobs referenced by the resource pool. The number is counted regardless of whether the jobs are controlled by the resource pool. This parameter is valid only on CNs.
fast_run	int	Number of running jobs in the fast lane of the resource pool. This parameter is valid only on CNs.
fast_wait	int	Number of jobs queued in the fast lane of the resource pool. This parameter is valid only on CNs.
fast_limit	int	Limit on the number of concurrent jobs in the fast lane in a resource pool. This parameter is valid only on CNs.
slow_run	int	Number of running jobs in the slow lane of the resource pool. This parameter is valid only on CNs.
slow_wait	int	Number of jobs queued in the slow lane of the resource pool. This parameter is valid only on CNs.
slow_limit	int	Limit on the number of concurrent jobs in the slow lane in a resource pool. This parameter is valid only on CNs.
used_cpu	double	Average number of CPUs used by the resource pool in a 5s monitoring period. The value is accurate to two decimal places. • On a DN, it indicates the number of CPUs used by the resource pool on the current DN. • On a CN, it indicates the total CPU usage of resource pools on all DNs.

Name	Type	Description
cpu_limit	int	It indicates the upper limit of available CPUs for resource pools. If the CPU share is limited, this parameter indicates the available CPUs for GaussDB(DWS). If the CPU limit is specified, this parameter indicates the available CPUs for associated Cgroups. ● On a DN, it indicates the upper limit of available CPUs for the resource pool on the current DN. ● On a CN, it indicates the total upper limit of available CPUs for resource pools on all DNs.
used_mem	int	Memory size used by the resource pool (unit: MB) ● On a DN, it indicates the memory usage of the resource pool on the current DN. ● On a CN, it indicates the total memory usage of resource pools on all DNs.
estimate_mem	int	Estimated memory used by the jobs running in the resource pools on the current CN. This parameter is valid only on CNs.
mem_limit	int	Upper limit of available memory for the resource pool (unit: MB). ● On a DN, it indicates the upper limit of available memory for the resource pool on the current DN. ● On a CN, it indicates the total upper limit of available memory for resource pools on all DNs.
read_kbytes	bigint	Number of logical read bytes in the resource pool within a 5s monitoring period (unit: KB). ● On a DN, it indicates the number of logical read bytes in the resource pool on the current DN. ● On a CN, it indicates the total logical read bytes of resource pools on all DNs.
write_kbytes	bigint	Number of logical write bytes in the resource pool within a 5s monitoring period (unit: KB). ● On a DN, it indicates the number of logical write bytes in the resource pool on the current DN. ● On a CN, it indicates the total logical write bytes of resource pools on all DNs.

Name	Type	Description
read_counts	bigint	Number of logical reads in the resource pool within a 5s monitoring period. ● On a DN, it indicates the number of logical reads in the resource pool on the current DN. ● On a CN, it indicates the total number of logical reads in resource pools on all DNs.
write_counts	bigint	Number of logical writes in the resource pool within a 5s monitoring period. ● On a DN, it indicates the number of logical writes in the resource pool on the current DN. ● On a CN, it indicates the total number of logical writes in resource pools on all DNs.
read_speed	double	Average logical read rate of a resource pool in a 5-second monitoring period, in KB/s ● On a DN, it indicates the logical read rate of the resource pool on the current DN. ● On a CN, it indicates the overall logical read rate of resource pools on all DNs.
write_speed	double	Average logical write rate of a resource pool in a 5-second monitoring period, in KB/s ● On a DN, it indicates the logical write rate of the resource pool on the current DN. ● On a CN, it indicates the overall logical write rate of resource pools on all DNs.
send_speed	double	Average network sending rate of a resource pool in a 5-second monitoring period, in KB/s ● On a DN, it indicates the network sending rate of the resource pool on the current DN. ● On a CN, it indicates the sum of the network sending rates of the resource pool on all DNs.
recv_speed	double	Average network sending rate of a resource pool in a 5-second monitoring period, in KB/s ● On a DN, it indicates the network sending rate of the resource pool on the current DN. ● On a CN, it indicates the sum of the network sending rates of the resource pool on all DNs.

15.3.203 PGXC_RESPOOL_RESOURCE_HISTORY

PGXC_RESPOOL_RESOURCE_HISTORY is used to query historical monitoring information about resource pools on all instances.

Table 15-254 PGXC_RESPOOL_RESOURCE_HISTORY columns

Name	Type	Description
nodename	name	Instance name, including CNs and DNs
timestamp	timestamp	Time when resource pool monitoring information is persistently stored
nodegroup	name	Name of the logical cluster the resource pool belongs to. The default cluster is **installation**.
rpname	name	Resource pool name
cgroup	name	Name of the Cgroup associated with the resource pool
ref_count	int	Number of jobs referenced by the resource pool. The number is counted regardless of whether the jobs are controlled by the resource pool. This parameter is valid only on CNs.
fast_run	int	Number of running jobs in the fast lane of the resource pool. This parameter is valid only on CNs.
fast_wait	int	Number of jobs queued in the fast lane of the resource pool. This parameter is valid only on CNs.
fast_limit	int	Limit on the number of concurrent jobs in the fast lane in a resource pool. This parameter is valid only on CNs.
slow_run	int	Number of running jobs in the slow lane of the resource pool. This parameter is valid only on CNs.
slow_wait	int	Number of jobs queued in the slow lane of the resource pool. This parameter is valid only on CNs.
slow_limit	int	Limit on the number of concurrent jobs in the slow lane in a resource pool. This parameter is valid only on CNs.

Name	Type	Description
used_cpu	double	Average number of CPUs used by the resource pool in a 5s monitoring period. The value is accurate to two decimal places. • On a DN, it indicates the number of CPUs used by the resource pool on the current DN. • On a CN, it indicates the total CPU usage of resource pools on all DNs.
cpu_limit	int	It indicates the upper limit of available CPUs for resource pools. If the CPU share is limited, this parameter indicates the available CPUs for GaussDB(DWS). If the CPU limit is specified, this parameter indicates the available CPUs for associated Cgroups. • On a DN, it indicates the upper limit of available CPUs for the resource pool on the current DN. • On a CN, it indicates the total upper limit of available CPUs for resource pools on all DNs.
used_mem	int	Memory used by the resource pool, in MB • On a DN, it indicates the memory usage of the resource pool on the current DN. • On a CN, it indicates the total memory usage of resource pools on all DNs.
estimate_mem	int	Estimated memory used by the jobs running in the resource pools on the current CN. This parameter is valid only on CNs.
mem_limit	int	Upper limit of available memory for the resource pool, in MB • On a DN, it indicates the upper limit of available memory for the resource pool on the current DN. • On a CN, it indicates the total upper limit of available memory for resource pools on all DNs.
read_kbytes	bigint	Number of logical read bytes in the resource pool within a 5s monitoring period, in KB • On a DN, it indicates the number of logical read bytes in the resource pool on the current DN. • On a CN, it indicates the total logical read bytes of resource pools on all DNs.

Name	Type	Description
write_kbytes	bigint	Number of logical write bytes in the resource pool within a 5s monitoring period, in KB • On a DN, it indicates the number of logical write bytes in the resource pool on the current DN. • On a CN, it indicates the total logical write bytes of resource pools on all DNs.
read_counts	bigint	Number of logical reads in the resource pool within a 5s monitoring period • On a DN, it indicates the number of logical reads in the resource pool on the current DN. • On a CN, it indicates the total number of logical reads in resource pools on all DNs.
write_counts	bigint	Number of logical writes in the resource pool within a 5s monitoring period. • On a DN, it indicates the number of logical writes in the resource pool on the current DN. • On a CN, it indicates the total number of logical writes in resource pools on all DNs.
read_speed	double	Average logical read rate of a resource pool in a 5-second monitoring period, in KB/s • On a DN, it indicates the logical read rate of the resource pool on the current DN. • On a CN, it indicates the overall logical read rate of resource pools on all DNs.
write_speed	double	Average logical write rate of a resource pool in a 5-second monitoring period, in KB/s • On a DN, it indicates the logical write rate of the resource pool on the current DN. • On a CN, it indicates the overall logical write rate of resource pools on all DNs.
send_speed	double	Average network sending rate of a resource pool in a 5-second monitoring period, in KB/s • On a DN, it indicates the network sending rate of the resource pool on the current DN. • On a CN, it indicates the sum of the network sending rates of the resource pool on all DNs.

Name	Type	Description
recv_speed	double	Average network receiving rate of a resource pool in a 5-second monitoring period, in KB/s • On a DN, it indicates the network receiving rate of the resource pool on the current DN. • On a CN, it indicates the sum of the network receiving rates of the resource pool on all DNs.

15.3.204 PGXC_ROW_TABLE_IO_STAT

PGXC_ROW_TABLE_IO_STAT provides I/O statistics of all row-store tables of the database on all CNs and DNs in the cluster. Except the **nodename** column of the name type added in front of each row, the names, types, and sequences of other columns are the same as those in the **GS_ROW_TABLE_IO_STAT** view. For details about the columns, see **GS_ROW_TABLE_IO_STAT**.

15.3.205 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 in **PG_RUNNING_XACTS**.

Table 15-255 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 or **0**: starting)
node	text	Node name
xmin	xid	Minimum transaction ID **xmin** on the node
vacuum	boolean	Whether the current transaction is lazy vacuum
timeline	bigint	Number of database restarts
prepare_xid	xid	Transaction ID in **prepared** state. If the status is not **prepared**, the value is **0**.
pid	bigint	Thread ID corresponding to the transaction
next_xid	xid	Transaction ID sent from a CN to a DN

15.3.206 PGXC_SETTINGS

PGXC_SETTINGS displays the database running status of each node in the cluster. All columns except **node_name** are the same as those in the **PG_SETTINGS** view. This view is accessible only to users with system administrators rights.

15.3.207 PGXC_SESSION_WLMSTAT

PGXC_SESSION_WLMSTAT displays load management information about ongoing jobs executed on each CN in the current cluster.

Table 15-256 PGXC_SESSION_WLMSTAT columns

Name	Type	Description
nodename	name	Node name
datid	oid	OID of the database the backend is connected to
datname	name	Name of the database the backend is connected to
threadid	bigint	Thread ID of the backend
processid	integer	PID of a backend thread
usesysid	oid	OID of the user who logged into the backend
appname	text	Name of the application that is connected to the backend
username	name	Name of the user logged in to the backend
priority	bigint	Priority of Cgroup where the statement is located
attribute	text	Statement attributes • **Ordinary**: default attribute of a statement before it is parsed by the database • **Simple**: simple statements • **Complicated**: complicated statements • **Internal**: internal statement of the database
block_time	bigint	Pending duration of the statements by now (unit: s)
elapsed_time	bigint	Actual execution duration of the statements by now (unit: s)
total_cpu_time	bigint	Total CPU usage duration of the statement on the DN in the last period (unit: s)
cpu_skew_percent	integer	CPU usage inclination ratio of the statement on the DN in the last period
statement_mem	integer	Estimated memory required for statement execution. This column is reserved.

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 a statement, including: • **pending** • **running**: The statement is being executed. • **finished**: The execution is finished normally. (If **enqueue** is set to **StoredProc** or **Transaction**, this state indicates that only some of the jobs in the statement have been executed. This state persists until the finish of this statement.) • **aborted**: terminated unexpectedly • **active**: normal status except for those above • **unknown**: unknown status
enqueue	text	Current queuing status of the statements, including: • **Global**: global queuing. • **Respool**: resource pool queuing. • **CentralQueue**: queuing on the CCN • **Transaction**: being in a transaction block • **StoredProc**: being in a stored procedure • **None**: not in a queue • **Forced None**: being forcibly executed (transaction block statement or stored procedure statement are) because the statement waiting time exceeds the specified value
resource_pool	name	Current resource pool where the statements are located.
query	text	Text of this backend's most recent query If **state** is **active**, this column shows the executing query. In all other states, it shows the last query that was executed.
isplana	bool	In logical cluster mode, indicates whether a statement occupies the resources of other logical clusters. The default value is **f**, indicating that resources of other logical clusters are not occupied.

Name	Type	Description
node_group	text	Logical cluster of the user running the statement
lane	text	Fast or slow lane for statement queries. • **fast**: fast lane • **slow**: slow lane • **none**: not controlled

15.3.208 PGXC_STAT_ACTIVITY

PGXC_STAT_ACTIVITY displays information about the query performed by the current user on all the CNs in the current cluster.

Table 15-257 PGXC_STAT_ACTIVITY columns

Name	Type	Description
coorname	text	Name of the CN in the current cluster
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	ID of the backend thread
lwtid	integer	Lightweight thread ID of the backend thread
usesysid	oid	OID of the user logging in to the backend
usename	name	Name of the user logging 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 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 will only be non-null for IP connections, and only when **log_hostname** is enabled.

Name	Type	Description
client_port	integer	TCP port number that the client uses for communication with this backend, or **-1** if a Unix socket is used
backend_start	timestamp with time zone	Startup time of the backend process, that is, the time when the client connects to the server
xact_start	timestamp with time zone	Time when the current transaction was started, or **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 time when the last query was started if **state** is not **active**
state_change	timestamp with time zone	Time for the last status change
waiting	boolean	The value is **t** if the backend is waiting for a lock or node. Otherwise, the value is **f**.

Name	Type	Description
enqueue	text	Queuing status of a statement. Its value can be: • **waiting in global queue**: The statement is in the global concurrent queues. • **waiting in respool queue**: The statement is queuing in the resource pool. The scenarios are as follows: 1. When dynamic load balancing is enabled, the number of simple jobs exceeds the upper limit (**max_dop**) of concurrent jobs on the fast lane. 2. When dynamic load balancing is disabled, the number of simple jobs exceeds the upper limit (**max_dop**) of concurrent jobs on the fast lane or the number of complex jobs exceeds the upper limit of concurrent jobs on the slow lane. • **waiting in ccn queue**: The job is in the CCN queue, which may be global memory queuing, slow lane memory queuing, or concurrent queuing. • Empty or **no waiting queue**: The statement is running.

Name	Type	Description
state	text	Overall state of the backend. Its value can be: • **active**: The backend is executing a query. • **idle**: The backend is waiting for a new client command. • **idle in transaction**: The backend is in a transaction, but there is no statement being executed in the transaction. • **idle in transaction (aborted)**: The backend is in a transaction, but there are statements failed in the transaction. • **fastpath function call**: The backend is executing a **fast-path** function. • **disabled**: This state is reported if **track_activities** is disabled in this backend. **NOTE** Only system administrators can view the session status of their accounts. The state information of other accounts is empty.
resource_pool	name	Resource pool used by the user
stmt_type	text	Type of a user statement
query_id	bigint	ID of a query
query	text	Text of this backend's most recent query If the **state** is **active**, this column shows the executing 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**).

Example

Run the following command to view blocked query statements.

```
SELECT datname,usename,state,query FROM PGXC_STAT_ACTIVITY WHERE waiting = true;
```

Check the working status of the snapshot thread.


```
SELECT application_name,backend_start,state_change,state,query FROM PGXC_STAT_ACTIVITY WHERE
application_name='WDRSnapshot';
```

View the running query statements.

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

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**.

```
SELECT COUNT(*) FROM PGXC_STAT_ACTIVITY WHERE DATNAME='postgres';
 count
-------
     1
(1 row)
```

15.3.209 PGXC_STAT_BAD_BLOCK

PGXC_STAT_BAD_BLOCK displays statistics about page or CU verification failures after all nodes in a cluster are started.

Table 15-258 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 occurrence
last_time	timestamp with time zone	Time of the latest occurrence

15.3.210 PGXC_STAT_BGWRITER

PGXC_STAT_BGWRITER displays statistics on the background writer of each node in the cluster. All columns except **node_name** are the same as those in the **PG_STAT_BGWRITER** view. This view is accessible only to users with system administrators rights.

15.3.211 PGXC_STAT_DATABASE

PGXC_STAT_DATABASE displays the database status and statistics of each node in the cluster. All columns except **node_name** are the same as those in the **PG_STAT_DATABASE** view. This view is accessible only to users with system administrators rights.

15.3.212 PGXC_STAT_OBJECT

PGXC_STAT_OBJECT displays statistics and autovacuum efficiency information about tables of all instances in a cluster. This system view is supported only by clusters of version 8.2.1 or later.

Table 15-259 PGXC_STAT_OBJECT columns

Name	Type	Reference	Description
nodename	name	-	Node name
datname	name	-	Name of the database where the table is located.
relnamespace	name	-	Name of the schema where the table is located.
relname	name	-	Table name.
partname	name	-	Partition name of the partitioned table
databaseid	oid	**PG_DATABASE**.oid	OID of a database.
relid	oid	**PG_CLASS**.oid	OID of a table. It is the OID of the primary table for a partitioned table.
partid	oid	**PG_PARTITION**.oid	Partition OID. For an ordinary table, the value of this column is **0**.
numscans	bigint	-	Number of times that sequential scans are started.
tuples_returned	bigint	-	Number of visible tuples fetched by sequential scans.
tuples_fetched	bigint	-	Number of visible tuples fetched.
tuples_inserted	bigint	-	Number of inserted records.
tuples_updated	bigint	-	Number of updated records.

Name	Type	Reference	Description
tuples_deleted	bigint	-	Number of deleted records.
tuples_hot_updated	bigint	-	Number of HOT updates.
n_live_tuples	bigint	-	Number of visible tuples.
last_autovacuum_begin_n_dead_tuple	bigint	-	Number of tuples deleted before Autovacuum is executed.
n_dead_tuples	bigint	-	Number of tuples deleted after Autovacuum is successful.
changes_since_analyze	bigint	-	Last data modification time after Analyze.
blocks_fetched	bigint	-	Number of selected pages.
blocks_hit	bigint	-	Number of scanned pages.
cu_mem_hit	bigint	-	Number of CU memory hits.
cu_hdd_sync	bigint	-	Times that CUs are synchronously read from disks.
cu_hdd_asyn	bigint	-	Times that CUs are asynchronously read from disks.
data_changed_timestamp	timestamp with time zone	-	Last data modification time.
data_access_timestamp	timestamp with time zone	-	Last access time of a table.
analyze_timestamp	timestamp with time zone	-	Last Analyze time.
analyze_count	bigint	-	Total number of Analyze times.
autovac_analyze_timestamp	timestamp with time zone	-	Last Autoanalyze time.
autovac_analyze_count	bigint	-	Total number of Autoanalyze times.
vacuum_timestamp	timestamp with time zone	-	Time of the latest Vacuum.

Name	Type	Reference	Description
vacuum_count	bigint	-	Total number of Vacuum times.
autovac_vacuum_timestamp	timestamp with time zone	-	Last Autovacuum time.
autovac_vacuum_count	bigint	-	Total number of Autovacuum times.
autovacuum_success_count	bigint	-	Total number of successful Autovacuum operations.
last_autovacuum_time_cost	bigint	-	Time spent on the latest successful Autovacuum, in microseconds.
avg_autovacuum_time_cost	bigint	-	Average execution time of successful Autovacuum operations. Unit: μs.
last_autovacuum_failed_count	bigint	-	Total number of autovacuum failures since the last successful Autovacuum.
last_autovacuum_trigger	smallint	-	Triggering mode of the latest autovacuum, which helps maintenance personnel determine the Vacuum status.
last_autovacuum_oldestxmin	bigint	-	**oldestxmin** after the latest successful Autovacuum execution. If the table-level **oldestxmin** feature is enabled, this field records the value of **oldestxmin** used by the latest **(AUTO)VACUUM** of the table.
last_autovacuum_scan_pages	bigint	-	Number of pages last scanned by autovacuum (only for row-store tables).
last_autovacuum_dirty_pages	bigint	-	Number of pages last modified by Autovacuum (only for row-store tables).
last_autovacuum_clear_deadtuples	bigint	-	Number of dead tuples last cleared by Autovacuum (only for row-store tables)
sum_autovacuum_scan_pages	bigint	-	Total number of pages scanned by Autovacuum since database initialization (only for row-store tables).

Name	Type	Reference	Description
sum_autovacuum_dirty_pages	bigint	-	Number of pages modified by Autovacuum since database initialization (only for row-store tables).
sum_autovacuum_clear_deadtuples	bigint	-	Total number of dead tuples cleared by Autovacuum since database initialization (only for row-store tables).
last_autovacuum_begin_cu_size	bigint	-	Size of the CU file before the latest Autovacuum operation (only for column-store tables).
last_autovacuum_cu_size	bigint	-	Size of the CU file after the latest Autovacuum (only for column-store tables).
last_autovacuum_rewrite_size	bigint	-	Size of the column-store file last rewritten by autovacuum (only for column-store tables).
last_autovacuum_clear_size	bigint	-	Size of the column-store file last cleared by Autovacuum (only for column-store tables).
last_autovacuum_clear_cbtree_tuples	bigint	-	Number of cbtree tuples last cleared by Autovacuum (only for column-store tables).
sum_autovacuum_rewrite_size	bigint	-	Total size of column-store files rewritten by Autovacuum since database initialization (only for column-store tables).
sum_autovacuum_clear_size	bigint	-	Total size of column-store files cleared by Autovacuum since database initialization (only for column-store tables).
sum_autovacuum_clear_cbtree_tuples	bigint	-	Total number of cbtree tuples cleared by Autovacuum since database initialization (only for column-store tables).
last_autovacuum_csn	bigint	-	If the table-level **oldestxmin** feature is enabled, this field records the CSN value corresponding to the latest **oldestxmin** value used by the table **(AUTO)VACUUM**.

Name	Type	Reference	Description
last_reference_timestamp	timestamp with time zone	-	Last access time of a table. (This field is supported only by cluster versions 8.3.0 and later.) This parameter corresponds to the latest time between **data_changed_time_stamp** (last modification time) and **data_access_timestamp** (last access time) in **PG_STAT_OBJECT**.
extra1	bigint	-	Reserved field 1.
extra2	bigint	-	Reserved field 2.
extra3	bigint	-	Reserved field 3.
extra4	bigint	-	Reserved field 4.

15.3.213 PGXC_STAT_REPLICATION

PGXC_STAT_REPLICATION displays the log synchronization status of each node in the cluster. All columns except **node_name** are the same as those in the **PG_STAT_REPLICATION** view. Only users with system administrator permissions can access this view.

15.3.214 PGXC_STAT_TABLE_DIRTY

PGXC_STAT_TABLE_DIRTY displays statistics about all the tables on all the CNs and DNs in the current cluster, and the dirty page rate of tables on a single CN or DN. This view is supported only by clusters of version 8.1.3 or later.

NOTE

The statistics of this view depend on the **ANALYZE** operation. To obtain the most accurate information, perform the **ANALYZE** operation on the table first.

Table 15-260 PGXC_STAT_TABLE_DIRTY columns

Name	Type	Description
nodename	text	Node name
schema	name	Schema name of the table
tablename	name	Table name
partname	name	Partition name of the partitioned table

Name	Type	Description
last_vacuum	timestampwith time zone	Time of the last manual **VACUUM**
last_autovacuum	timestampwith time zone	Time of the last **AUTOVACUUM**
last_analyze	timestampwith time zone	Time of the last manual **ANALYZE**
last_antoanalyze	timestampwith time zone	Time of the last **AUTOANALYZE**
vacuum_count	bigint	Number of times **VACUUM** operations
autovacuum_count	bigint	Number of **AUTOVACUUM** operations
analyze_count	bigint	Number of **ANALYZE** operations
autoanalyze_count	bigint	Number of **AUTOANALYZE_COUNT** operations
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 with HOT updates
n_tup_change	bigint	Number of changed rows after **ANALYZE**
n_live_tup	bigint	Estimated number of live rows
n_dead_tup	bigint	Estimated number of dead rows
dirty_rate	bigint	Dirty page rate of a single CN or DN
last_data_changed	timestampwith time zone	Time when a table was last modified

Suggestion

- Before running **VACUUM FULL** on a system catalog with a high dirty page rate, ensure that no user is performing operations on it.
- You are advised to run **VACUUM FULL** to tables (excluding system catalogs) whose dirty page rate exceeds 80% or run it based on service scenarios.

Scenarios

1. Query the overall dirty page rate of all the user tables in a database.

```
select
   t1.schema,
   t1.tablename,
   t1.total_ins,
   t1.total_upd,
   t1.total_del,
   t1. total_tup_hot_upd,
   t1.total_change,
   t1.total_live,
   t1.total_dead,
   t1.total_dirty_rate,
   t1.max_dirty,
   t2.max_node,
   t1.min_dirty,
   t2.min_node
from
   (select
      a.schema,
      a.tablename,
      sum(a.n_tup_ins) as total_ins,
      sum(a.n_tup_upd) as total_upd,
      sum(a.n_tup_del) as total_del,
      sum(a.n_tup_hot_upd) as total_tup_hot_upd,
      sum(a.n_tup_change) as total_change,
      sum(a.n_live_tup) as total_live,
      sum(a.n_dead_tup) as total_dead,
      Round((total_dead / (total_dead + total_live + 0.0001) * 100),2) AS total_dirty_rate,
      max(a.dirty_rate) as max_dirty,
      min(a.dirty_rate) as min_dirty
   from pg_catalog.pgxc_stat_table_dirty a where a.partname is null and a.schema not in
('pg_toast','cstore','gs_logical_cluster','sys','dbms_om','information_schema','pg_catalog','dbms_output','
dbms_random','utl_raw','utl_raw dbms_sql','dbms_lob') group by a.tablename, a.schema
   ) t1,
   (select distinct
   tablename, schema,
   first_value(nodename) over(partition by tablename, schema order by dirty_rate) as min_node,
   first_value(nodename) over(partition by tablename, schema order by dirty_rate desc) as max_node
   from (select * from pg_catalog.pgxc_stat_table_dirty)) t2
where t1.tablename = t2.tablename and t1.schema = t2.schema;
```

2. Query the overall dirty page rate of all the tables (user tables and system catalogs) in a database.

```
select
   t1.schema,
   t1.tablename,
   t1.total_ins,
   t1.total_upd,
   t1.total_del,
   t1. total_tup_hot_upd,
   t1.total_change,
   t1.total_live,
   t1.total_dead,
   t1.total_dirty_rate,
   t1.max_dirty,
   t2.max_node,
   t1.min_dirty,
   t2.min_node
from
   (select
      a.schema,
      a.tablename,
      sum(a.n_tup_ins) as total_ins,
      sum(a.n_tup_upd) as total_upd,
      sum(a.n_tup_del) as total_del,
      sum(a.n_tup_hot_upd) as total_tup_hot_upd,
      sum(a.n_tup_change) as total_change,
```

```
    sum(a.n_live_tup) as total_live,
    sum(a.n_dead_tup) as total_dead,
    Round((total_dead / (total_dead + total_live + 0.0001) * 100),2) AS total_dirty_rate,
    max(a.dirty_rate) as max_dirty,
    min(a.dirty_rate) as min_dirty
  from pg_catalog.pgxc_stat_table_dirty a where a.partname is null group by a.tablename, a.schema
  ) t1,
  (select distinct
  tablename, schema,
  first_value(nodename) over(partition by tablename, schema order by dirty_rate) as min_node,
  first_value(nodename) over(partition by tablename, schema order by dirty_rate desc) as max_node
  from (select * from pg_catalog.pgxc_stat_table_dirty)) t2
where t1.tablename = t2.tablename and t1.schema = t2.schema;
```

3. Query all system catalogs in a database.

```
select * from pgxc_stat_table_dirty where schema in
('pg_toast','cstore','gs_logical_cluster','sys','dbms_om','information_schema','pg_catalog','dbms_output','
dbms_random','utl_raw','utl_raw dbms_sql','dbms_lob');
```

15.3.215 PGXC_STAT_WAL

PGXC_STAT_WAL displays the WAL logs and data page traffic information of the current query. This view is supported only by clusters 8.2.0 and later versions.

Table 15-261 PGXC_STAT_WAL columns

Name	Type	Description
query_id	bigint	ID of the current query
query_start	timestamp	Start time of the query
global_wal	bigint	Total number of WAL logs generated by the current query in the cluster, in bytes
global_avg_wal_speed	bigint	Average rate of WAL log generation for the current query in the cluster, in byte/s
global_datapage	bigint	Total size of data pages generated by the current query in the cluster, in bytes
global_avg_datapage_speed	bigint	Average rate of data page generation for the current query in the cluster, in byte/s
min_wal_node	Text	Name of the instance group that generates the smallest volume of WAL logs in the current query
min_wal	bigint	Minimum WAL logs generated by a node, in bytes
max_wal_node	Text	Name of the instance group that generates the largest volume of WAL logs in the current query
max_wal	bigint	Maximum WAL logs generated by a node, in bytes
min_datapage_node	Text	Name of the instance group that generates the smallest volume of data pages in the current query

Name	Type	Description
min_data_page	bigint	Minimum data pages generated by a node, in bytes
max_datapage_node	Text	Name of the instance group that generates the largest volume of data pages in the current query
max_data_page	bigint	Maximum data pages generated by a node, in bytes
avg_wal_per_node	bigint	Average WAL logs generated by each node, in bytes
avg_datapage_per_node	bigint	Average data pages generated by each node, in bytes
query	Text	Statement that is being executed

NOTE

When row-store data is imported in batches without indexes, the Xlogs related to logical new pages are generated during data page copy. If the volume of Xlogs is greater than the default value, flow control will be triggered.

Examples

Query the statements that are being executed in the cluster, the total volumes of WAL logs and data pages generated by these statements, their average generation rates, and their distribution on DNs.

```
SELECT * FROM PGXC_STAT_WAL;
     query_id      |          query_start          | global_wal | global_avg_wal_speed | global_datapage |
global_avg_datapage_speed | min_wal_node | min_wal  | max_wal_node | max_wal  | min_datapage_node |
min_data_page | max_datapage_node | max_data_page | avg_wal_per_node |
avg_datapage_per_node |                   query
-------------------+-------------------------------+------------+----------------------+-----------------
+---------------------------+--------------+----------+--------------+----------+-------------------+---------------
+-------------------+---------------+------------------+-
----------------------+-------------------------------------------------
 72620543991351767 | 2022-11-10 16:49:47.743291+08 |    7579052 |               419000 |       284057600
|                 15740000 | datanode1    |  7579052 | datanode1    |  7579052 | datanode1         |     284057600
| datanode1         |     284057600 |          7579052 |
           284057600 | insert into mpptest3 select * from mpptest3;
 72620543991351781 | 2022-11-10 16:50:00.616697+08 |   55022176 |             10638000 |              0
|                       0 | datanode1    | 55022176 | datanode1    | 55022176 | datanode1         |             0 |
datanode1         |             0 |         55022176 |
                 0 | insert into mpptest1 select * from mpptest1;
(2 rows)
```

15.3.216 PGXC_SQL_COUNT

PGXC_SQL_COUNT displays the node-level and user-level statistics for the SQL statements of **SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO** and DDL, DML, and DCL statements of each CN in a cluster in real time, identifies query types with heavy load, and measures the capability of a cluster or a node to perform a specific type of query. You can calculate QPS based on the quantities and response time of the preceding types of SQL statements at certain time

points. For example, **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 draw cluster-user-level QPS curve graphs and determine cluster throughput, monitoring 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.

Columns in the **PGXC_SQL_COUNT** view are the same as those in the **GS_SQL_COUNT** view. For details, see **Table 15-132**.

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 increment by 1. If the pushdown is not allowed, the DN will receive an **UPDATE** or **INSERT** statement. In this case, the **update_count** or **insert_count** column will increment by 1.

15.3.217 PGXC_TABLE_CHANGE_STAT

PGXC_TABLE_CHANGE_STAT displays the changes of all tables of the database on all CNs in the cluster. Except the **nodename** column of the name type added in front of each row, the names, types, and sequences of other columns are the same as those in the **GS_TABLE_CHANGE_STAT** view. For details about the columns, see **GS_TABLE_CHANGE_STAT**.

15.3.218 PGXC_TABLE_STAT

PGXC_TABLE_STAT provides statistics of all tables of the database on all CNs and DNs in the cluster. Except the **nodename** column of the name type added in front of each row, the names, types, and sequences of other columns are the same as those in the **GS_TABLE_STAT** view. For details about the columns, see **GS_TABLE_STAT**.

15.3.219 PGXC_THREAD_WAIT_STATUS

PGXC_THREAD_WAIT_STATUS displays 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 result of the **PG_THREAD_WAIT_STATUS** view on each node in the cluster.

Table 15-262 PGXC_THREAD_WAIT_STATUS columns

Name	Type	Description
node_name	text	Current node name
db_name	text	Database name

Name	Type	Description
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
lwtid	integer	Lightweight thread ID of the current thread
ptid	integer	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 15-218**.
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.

Example:

Assume you run a statement on coordinator1, and no response is returned after a long period of time. In this case, establish another connection to coordinator1 to check the thread status on it.

```
 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 | gaussdb | gsql         | 20971544 | 140274089064208 | 22579 |       |      0 |     0 | wait node:
datanode4 |
(1 rows)
```

Furthermore, you can view the statement working status on each node in the entire cluster. In the following example, no DNs have threads blocked, and there is a huge amount of data to be read, causing slow execution.

```
select * from pgxc_thread_wait_status where query_id=20971544;
  node_name   | db_name  | thread_name  | query_id |       tid       | lwtid | ptid  | tlevel | smpid |
wait_status   |   wait_event
--------------+----------+--------------+----------+-----------------+-------+-------+--------+-------
+----------------------
 datanode1    | gaussdb | coordinator1 | 20971544 | 139902867994384 | 22735 |       |      0 |     0 | wait
node: datanode3 |
 datanode1    | gaussdb | coordinator1 | 20971544 | 139902838634256 | 22970 | 22735 |      5 |     0 |
synchronize quit     |
 datanode1    | gaussdb | coordinator1 | 20971544 | 139902607947536 | 22972 | 22735 |      5 |     1 |
synchronize quit     |
 datanode2    | gaussdb | coordinator1 | 20971544 | 140632156796688 | 22736 |       |      0 |     0 | wait
node: datanode3 |
 datanode2    | gaussdb | coordinator1 | 20971544 | 140632030967568 | 22974 | 22736 |      5 |     0 |
synchronize quit     |
 datanode2    | gaussdb | coordinator1 | 20971544 | 140632081299216 | 22975 | 22736 |      5 |     1 |
```



```
synchronize quit     |
 datanode3    | gaussdb | coordinator1 | 20971544 | 140323627988752 | 22737 |       |      0 |     0 | wait
node: datanode3 |
 datanode3    | gaussdb | coordinator1 | 20971544 | 140323523131152 | 22976 | 22737 |      5 |     0 | net
flush data       |
 datanode3    | gaussdb | coordinator1 | 20971544 | 140323548296976 | 22978 | 22737 |      5 |     1 | net
flush data
 datanode4    | gaussdb | coordinator1 | 20971544 | 140103024375568 | 22738 |       |      0 |     0 | wait
node: datanode3
 datanode4    | gaussdb | coordinator1 | 20971544 | 140102919517968 | 22979 | 22738 |      5 |     0 |
synchronize quit     |
 datanode4    | gaussdb | coordinator1 | 20971544 | 140102969849616 | 22980 | 22738 |      5 |     1 |
synchronize quit     |
 coordinator1 | gaussdb | gsql         | 20971544 | 140274089064208 | 22579 |       |      0 |     0 | wait node:
datanode4  |
(13 rows)
```

15.3.220 PGXC_TOTAL_MEMORY_DETAIL

PGXC_TOTAL_MEMORY_DETAIL displays the memory usage in the cluster. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view.

Table 15-263 PGXC_TOTAL_MEMORY_DETAIL columns

Name	Type	Description
nodename	text	Node name

Name	Type	Description
memorytype	text	Memory name, which can be set to any of the following values: • **max_process_memory**: memory used by a GaussDB(DWS) cluster instance • **process_used_memory**: memory used by a GaussDB(DWS) process • **max_dynamic_memory**: maximum dynamic memory • **dynamic_used_memory**: used dynamic memory • **dynamic_peak_memory**: dynamic peak value of the memory • **dynamic_used_shrctx**: maximum dynamic shared memory context • **dynamic_peak_shrctx**: dynamic peak value of the shared memory context • **max_shared_memory**: maximum shared memory • **shared_used_memory**: used shared memory • **max_cstore_memory**: maximum memory allowed for column store • **cstore_used_memory**: memory used for column store • **max_sctpcomm_memory**: maximum memory allowed for the communication library • **sctpcomm_used_memory**: memory used for the communication library • **sctpcomm_peak_memory**: memory peak of the communication library • **other_used_memory**: other used memory • **gpu_max_dynamic_memory**: maximum GPU memory • **gpu_dynamic_used_memory**: sum of the available GPU memory and temporary GPU memory • **gpu_dynamic_peak_memory**: maximum memory used for GPU • **pooler_conn_memory**: memory used for pooler connections • **pooler_freeconn_memory**: memory used for idle pooler connections

Name	Type	Description
		• **storage_compress_memory**: memory used for column-store compression and decompression • **udf_reserved_memory**: memory reserved for the **UDF Worker** process • **mmap_used_memory**: memory used for **mmap**
memorymbytes	integer	Size of the used memory (MB)

15.3.221 PGXC_TOTAL_SCHEMA_INFO

PGXC_TOTAL_SCHEMA_INFO displays the schema space information of all instances in the cluster, providing visibility into the schema space usage of each instance. This view can be queried only on CNs.

Table 15-264 PGXC_TOTAL_SCHEMA_INFO columns

Name	Type	Description
schemaname	text	Schema name
schemaid	oid	Schema OID
databasename	text	Database name
databaseid	oid	Database OID
nodename	text	Instance name
nodegroup	text	Name of the node group
usedspace	bigint	Size of used space
permspace	bigint	Upper limit of the space

15.3.222 PGXC_TOTAL_SCHEMA_INFO_ANALYZE

PGXC_TOTAL_SCHEMA_INFO_ANALYZE displays the overall schema space information of the cluster, including the total cluster space, average space of instances, skew ratio, maximum space of a single instance, minimum space of a single instance, and names of the instances with the maximum space and minimum space. It provides visibility into the schema space usage of the entire cluster. This view can be queried only on CNs.

Table 15-265 PGXC_TOTAL_SCHEMA_INFO_ANALYZE columns

Name	Type	Description
schemaname	text	Schema name
databasename	text	Database name
nodegroup	text	Name of the node group
total_value	bigint	Total cluster space in the current schema
avg_value	bigint	Average space of instances in the current schema
skew_percent	integer	Skew ratio
extend_info	text	Extended information, including the maximum space of a single instance, minimum space of a single instance, and names of the instances with the maximum sapce and minimum space

15.3.223 PGXC_TOTAL_USER_RESOURCE_INFO

The **PGXC_TOTAL_USER_RESOURCE_INFO** view displays real-time resource consumption information of users on all instances. This view is supported only by clusters of version 8.2.0 or later.

Table 15-266 PGXC_TOTAL_USER_RESOURCE_INFO columns

Name	Type	Description
nodename	name	Instance name, including CNs and DNs.
username	name	Username
used_memory	integer	Used memory (unit: MB) On a DN, it indicates a user's memory usage on the current DN. On a CN, it indicates a user's total memory usage on all DNs.

Name	Type	Description
total_memory	integer	Available memory (unit: MB). **0** indicates that the available memory is not limited and depends on the maximum memory available in the database. On a DN, it indicates the memory available to a user on the current DN. On a CN, it indicates the total memory available to a user on all DNs.
used_cpu	double precision	Number of CPU cores in use. Only the CPU usage of complex jobs in the non-default resource pool is collected, and the value is the CPU usage of the related cgroup. On a DN, it indicates a user's CPU core usage on the current DN. On a CN, it indicates a user's total CPU core usage on all DNs.
total_cpu	integer	Total number of CPU cores of the Cgroups associated with a user. On a DN, it indicates the CPU cores available to a user on the current DN. On a CN, it indicates the total CPU cores available to a user on all DNs.
used_space	bigint	Used permanent table storage space (unit: KB) On a DN, it indicates the size of the permanent table storage space used by a user on the current DN. On a CN, it indicates the total size of the permanent table storage space used by a user on all DNs.
total_space	bigint	Available storage space (unit: KB). **-1** indicates that the storage space is not limited. On a DN, it indicates the size of the permanent table storage space available to a user on the current DN. On a CN, it indicates the total size of the permanent table storage space available to a user on all DNs.

Name	Type	Description
used_temp_space	bigint	Used temporary table storage space (unit: KB) On a DN, it indicates the size of the temporary table storage space used by a user on the current DN. On a CN, it indicates the total size of the temporary table storage space used by a user on all DNs.
total_temp_space	bigint	Available temporary table storage space (unit: KB). **-1** indicates that the storage space is not limited. On a DN, it indicates the size of the temporary table storage space available to a user on the current DN. On a CN, it indicates the total size of the temporary table storage space available to a user on all DNs.
used_spill_space	bigint	Size of space used for operator spill to disk, in KB. On a DN, it indicates the space used by a user to spill operators to disk on the current DN. On a CN, it indicates the total space used by a user's operators spilled to disk on all DNs.
total_spill_space	bigint	Size of space available for operator spill to disk, in KB. The value **-1** indicates that the space is not limited. On a DN, it indicates the space available for a user to spill operators to disk on the current DN. On a CN, it indicates the total space available for a user to spill operators to disk on all DNs.
read_kbytes	bigint	On a CN, it indicates the total number of bytes logically read by a user on all DNs in the last 5 seconds, in KB. On a DN, it indicates the total number of bytes logically read by a user from the instance startup time to the current time, in KB.
write_kbytes	bigint	On a CN, it indicates the total number of bytes logically written by a user on all DNs in the last 5 seconds, in KB. On a DN, it indicates the total number of bytes logically written by a user from the instance startup time to the current time, in KB.

Name	Type	Description
read_counts	bigint	On a CN, it indicates the total number of logical reads performed by a user on all DNs in the last 5 seconds. On a DN, it indicates the total number of logical reads performed by a user from the instance startup time to the current time.
write_counts	bigint	On a CN, it indicates the total number of logical writes performed by a user on all DNs in the last 5 seconds. On a DN, it indicates the total number of logical writes performed by a user from the instance startup time to the current time.
read_speed	double precision	On a CN, it indicates the average logical read rate of a user on a single DN in the last 5 seconds, in KB/s. On a DN, it indicates the average logical read rate of a user on the DN in the last 5 seconds, in KB/s.
write_speed	double precision	On a CN, it indicates the average logical write rate of a user on a single DN in the last 5 seconds, in KB/s. On a DN, it indicates the average logical write rate of a user on the DN in the last 5 seconds, in KB/s.
send_speed	double precision	On a CN, it indicates the sum of the average network sending rates of a user on all DNs in the last 5 seconds, in KB/s. On a DN, it indicates the average network sending rate of a user on the DN in the last 5 seconds, in KB/s.
recv_speed	double precision	On a CN, it indicates the sum of the average network receiving rates of a user on all DNs in the last 5 seconds, in KB/s. On a DN, it indicates the average network receiving rate of a user on the DN in the last 5 seconds, in KB/s.

15.3.224 PGXC_USER_TRANSACTION

PGXC_USER_TRANSACTION provides transaction information about users on all CNs. It is accessible only to users with system administrator rights. This view is valid only if the real-time resource monitoring function is enabled, that is, if **enable_resource_track** is **on**.

Table 15-267 PGXC_USER_TRANSACTION columns

Name	Type	Description
node_name	name	Node name
usename	name	Username
commit_counter	bigint	Number of the commit times
rollback_counter	bigint	Number of rollbacks
resp_min	bigint	Minimum response time
resp_max	bigint	Maximum response time
resp_avg	bigint	Average response time
resp_total	bigint	Total response time

15.3.225 PGXC_VARIABLE_INFO

PGXC_VARIABLE_INFO displays information about transaction IDs and OIDs of all nodes in a cluster.

Table 15-268 PGXC_VARIABLE_INFO columns

Name	Type	Description
node_name	text	Node name
nextOid	oid	OID generated next time for a node
nextXid	xid	Transaction ID generated next time for a node
oldestXid	xid	Oldest transaction ID for a node
xidVacLimit	xid	Critical point that triggers forcible autovacuum
oldestXidDB	oid	OID of the database that has the minimum **datafrozenxid** on a node
lastExtendCSNLogpage	integer	Number of the last extended csnlog page
startExtendCSNLogpage	integer	Number of the page from which the csnlog extending starts
nextCommitSeqNo	integer	CSN generated next time for a node
latestCompletedXid	xid	Latest transaction ID on a node after the transaction commission or rollback

Name	Type	Description
startupMaxXid	xid	Last transaction ID before a node is powered off

15.3.226 PGXC_WAIT_DETAIL

PGXC_WAIT_DETAIL displays detailed information about the SQL waiting hierarchy of all nodes in a cluster. This view is supported only by clusters of version 8.1.3.200 or later.

Table 15-269 PGXC_WAIT_DETAIL columns

Name	Type	Description
level	integer	Level in the wait hierarchy. The value starts with 1 and increases by 1 when there is a wait relationship.
lock_wait_hierarchy	text	Wait hierarchy, in the format of *Node name:Process ID->Node name:Waiting process ID->Node name:Waiting process ID->...*
node_name	text	Node name
db_name	text	Database name
thread_name	text	Thread name
query_id	bigint	ID of a query statement
tid	bigint	Thread ID of the current thread
lwtid	integer	Lightweight thread ID of the current thread
ptid	integer	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
wait_event	text	Virtual ID of the transaction holding or awaiting this lock
exec_cn	boolean	SQL execution CN
wait_node	text	Lock level
query	text	Query statement
application_name	text	Name of the application connected to the backend

Name	Type	Description
backend_start	timestamp with time zone	Startup time of the backend process, that is, the time when the client connects to the server
xact_start	timestamp with time zone	Start time of the current transaction
query_start	timestamp with time zone	Start time of the active query
waiting	boolean	Waiting status
state	text	Overall state of the backend

Example

Step 1 Connect to the CN, start a transaction, and perform the update operation.

```
begin;update td set c2=6 where c1=1;
```

Step 2 Open another window to connect to the CN, start another transaction, and perform the update operation. (Do not update the same record concurrently.)

```
begin;update td set c2=6 where c1=7;
```

In this case, the update operation is blocked.

Step 3 Open another window to connect to the CN node and create an index.

```
create index c2_key on td(c2);
```

Step 4 Run the **select * from pgxc_wait_detail;** command.

```
SELECT * FROM PGXC_WAIT_DETAIL;
level |                lock_wait_hierarchy                | node_name | db_name  | thread_name |     query_id
|       tid       | lwtid  | ptid | tlevel | sm
pid | wait_status  | wait_event | exec_cn | wait_node |                query                | application_name |
backend_start         |          xact_st
art           |          query_start          | waiting | state
-------+-----------------------------------------------+-----------+----------+-------------+------------------
+-----------------+--------+------+--------+---
----+-------------+------------+---------+-----------+----------------------------------------+------------------
+-------------------------------+-----------------
--------------+-------------------------------+---------+--------
1 | cn_5001:139870843444360                        | cn_5001   | postgres | workload    | 73183493945299462 |
139870843444360 | 578531 |      |      0 |
0 | wait node    |           | t       |          | WLM fetch collect info from data nodes | workload         |
2023-03-13 13:56:56.611486+08 | 2023-03-14 11:54
:33.562808+08 | 2023-03-13 13:57:00.262736+08 | t       | active
1 | cn_5001:139870843654544                        | cn_5001   | postgres | gsql        | 73183493945299204 |
139870843654544 | 722259 |      |      0 |
0 | wait node    |           | t       |          | update td set c2=6 where c1=1;         | gsql             | 2023-03-14
11:52:05.176588+08 | 2023-03-14 11:52
:19.054727+08 | 2023-03-14 11:53:58.114794+08 | t       | active
1 | cn_5001:139870843655296                        | cn_5001   | postgres | gsql        | 73183493945299218 |
139870843655296 | 722301 |      |      0 |
0 | wait node    |           | t       |          | update td set c2=6 where c1=7;         | gsql             | 2023-03-14
11:52:08.084265+08 | 2023-03-14 11:52
:42.978132+08 | 2023-03-14 11:53:59.459575+08 | t       | active
1 | cn_5001:139870843656424                        | cn_5001   | postgres | gsql        | 73183493945299223 |
```



```
139870843656424 | 722344 |      |      0 |
0 | acquire lock | relation   | t       |          | create index c2_key on td(c2);          | gsql            | 2023-03-14
11:52:10.967028+08 | 2023-03-14 11:52
:53.463227+08 | 2023-03-14 11:54:00.25203+08  | t       | active
2 | cn_5001:139870843656424 -> cn_5001:139870843655296 | cn_5001   | postgres | gsql        |
73183493945299218 | 139870843655296 | 722344 |      |       |
|            |           | f       |          | update td set c2=6 where c1=7;         | gsql            | 2023-03-14
11:52:08.084265+08 | 2023-03-14 11:52
:42.978132+08 | 2023-03-14 11:53:59.459575+08 | t       | active
(5 rows)
```

----End

15.3.227 PGXC_WAIT_EVENTS

PGXC_WAIT_EVENTS displays statistics on the waiting status and events of each node in the cluster. The content is the same as that displayed in **GS_WAIT_EVENTS**. This view is accessible only to users with system administrators rights.

15.3.228 PGXC_WLM_OPERATOR_HISTORY

PGXC_WLM_OPERATOR_HISTORY displays the operator information of completed jobs executed on all CNs. This view is used to query data from GaussDB(DWS). Data in the GaussDB(DWS) database is cleared every 3 minutes.

Only the system administrator or the preset role **gs_role_read_all_stats** can access this view. For details about columns in the view, see **Table 15-5**.

15.3.229 PGXC_WLM_OPERATOR_INFO

PGXC_WLM_OPERATOR_INFO displays the operator information of completed jobs executed on CNs. The data in this view is obtained from **GS_WLM_OPERATOR_INFO**.

Only the system administrator or the preset role **gs_role_read_all_stats** can access this view. For details about columns in the view, see **Table 15-5**.

15.3.230 PGXC_WLM_OPERATOR_STATISTICS

PGXC_WLM_OPERATOR_STATISTICS displays the operator information of jobs being executed on CNs. The system administrator can query job operator information of all users in the cluster, while common users can query only their own job operator information.

For details about columns in the view, see **Table 15-144**.

15.3.231 PGXC_WLM_SESSION_INFO

PGXC_WLM_SESSION_INFO displays load management information for completed jobs executed on all CNs. The data in this view is obtained from **GS_WLM_SESSION_INFO**.

Table 15-270 PGXC_WLM_SESSION_INFO columns

Name	Type	Description
datid	oid	OID of the database the backend is connected to
dbname	text	Name of the database the backend is connected to
schemaname	text	Schema name
nodename	text	Name of the CN where the statement is run
username	text	User name 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 this backend. 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 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, or **-1** if a Unix socket is used
query_band	text	Job type, which is specified by the GUC parameter **query_band** parameter. The default value is a null string.
block_time	bigint	Duration that a statement is blocked before being executed, including the statement parsing and optimization duration. The unit is 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 a statement. The unit is ms.
estimate_total_time	bigint	Estimated execution time of a statement. The unit is ms.

Name	Type	Description
status	text	Final statement execution status. Its value can be **finished** (normal) or **aborted** (abnormal). The statement status here is the execution status of the database server. If the statement is successfully executed on the database server but an error is reported in the result set, the statement status is **finished**.
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 a statement on a single instance. The unit is MB. This column takes effect only when the GUC parameter **enable_dynamic_workload** is set to **on**.
min_peak_memory	integer	Minimum memory peak of a statement across all DNs. The unit is MB.
max_peak_memory	integer	Maximum memory peak of a statement across all DNs. The unit is MB.
average_peak_memory	integer	Average memory usage during statement execution. The unit is MB.
memory_skew_percent	integer	Memory usage skew of a statement among DNs
spill_info	text	Statement spill information on all DNs **None** indicates that the statement has not been spilled to disks on any DNs. **All** indicates that the statement has been spilled to disks on every DN. **[*a*:*b*]** indicates that 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. The unit is MB. The default value is **0**.
max_spill_size	integer	Maximum spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
average_spill_size	integer	Average spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.

Name	Type	Description
spill_skew_percent	integer	DN spill skew when a spill occurs
min_dn_time	bigint	Minimum execution time of a statement across all DNs. The unit is ms.
max_dn_time	bigint	Maximum execution time of a statement across all DNs. The unit is ms.
average_dn_time	bigint	Average execution time of a statement across all DNs. The unit is ms.
dntime_skew_percent	integer	Execution time skew of a statement among DNs.
min_cpu_time	bigint	Minimum CPU time of a statement across all DNs. The unit is ms.
max_cpu_time	bigint	Maximum CPU time of a statement across all DNs. The unit is ms.
total_cpu_time	bigint	Total CPU time of a statement across all DNs. The unit is ms.
cpu_skew_percent	integer	CPU time skew of a statement among DNs.
min_peak_iops	integer	Minimum IOPS peak of a 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 a 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 a 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

Name	Type	Description
warning	text	Warning. The following warnings and warnings related to SQL self-diagnosis tuning are displayed: 1. Spill file size large than 256MB 2. Broadcast size large than 100MB 3. Early spill 4. Spill times is greater than 3 5. Spill on memory adaptive 6. Hash table conflict
queryid	bigint	Internal query ID used for statement execution
query	text	Statement to be executed. A maximum of 64 KB of strings can be retained.
query_plan	text	Execution plan of a statement Specification restrictions: 1. Execution plans are displayed only for DML statements. 2. In 8.2.1.100 and later versions, the number of data binding times is added to the execution plans of Parse Bind Execute (PBE) statements to facilitate statement analysis. The number of data binding times is displayed in the format of **PBE bind times:** *Times*.
node_group	text	Logical cluster of the user running the statement
pid	bigint	PID of the backend thread of the statement
lane	text	Fast/Slow lane where the statement is executed
unique_sql_id	bigint	ID of the normalized unique SQL
session_id	text	Unique identifier of a session in the database system. Its format is **session_start_time.tid.node_name**.
min_read_bytes	bigint	Minimum I/O read bytes of a statement across all DNs. The unit is byte.
max_read_bytes	bigint	Maximum I/O read bytes of a statement across all DNs. The unit is byte.
average_read_bytes	bigint	Average I/O read bytes of a statement across all DNs.

Name	Type	Description
min_write_bytes	bigint	Minimum I/O write bytes of a statement across all DNs.
max_write_bytes	bigint	Maximum I/O write bytes of a statement across all DNs.
average_write_bytes	bigint	Average I/O write bytes of a statement across all DNs.
recv_pkg	bigint	Total number of communication packages received by a statement across all DNs.
send_pkg	bigint	Total number of communication packages sent by a statement across all DNs.
recv_bytes	bigint	Total received data of the statement stream, in byte.
send_bytes	bigint	Total sent data of the statement stream, in byte.
stmt_type	text	Query type corresponding to the statement.
except_info	text	Information about the exception rule triggered by the statement.
parse_time	bigint	Total parsing time before statements are queued (including lexical syntax parsing, optimization rewriting, and plan generation time). The unit is ms. This field is supported only by 8.3.0.100 and later versions.

15.3.232 PGXC_WLM_SESSION_HISTORY

PGXC_WLM_SESSION_HISTORY displays load management information for completed jobs executed on all CNs. This view is used by Data Manager to query data from a database. Data in the database is cleared every 3 minutes. For details, see **GS_WLM_SESSION_HISTORY**.

For details about columns in the view, see **Table 15-145**.

15.3.233 PGXC_WLM_SESSION_STATISTICS

PGXC_WLM_SESSION_STATISTICS displays load management information about jobs that are being executed on CNs.

Table 15-271 PGXC_WLM_SESSION_STATISTICS columns

Name	Type	Description
datid	oid	OID of the database this backend is connected to

Name	Type	Description
dbname	name	Name of the database the backend is connected to
schemaname	text	Schema name
nodename	text	Name of the CN where the statement is executed
username	name	User name 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 this backend. 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 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, or **-1** if a Unix socket is used
query_band	text	Job type, which is specified by the GUC parameter **query_band** parameter. The default value is a null string.
pid	bigint	ID of the backend thread
block_time	bigint	Block time before the statement is executed. The unit is ms.
start_time	timestamp with time zone	Time when the statement starts to be executed
duration	bigint	For how long a statement has been executing. The unit is ms.
estimate_total_time	bigint	Estimated execution time of a statement. The unit is ms.
estimate_left_time	bigint	Estimated remaining time of statement execution. The unit is ms.
enqueue	text	Workload management resource status
resource_pool	name	Resource pool used by the user
control_group	text	Cgroup used by the statement

Name	Type	Description
estimate_memory	integer	Estimated memory used by a statement on a single instance. The unit is MB. This column takes effect only when the GUC parameter **enable_dynamic_workload** is set to **on**.
min_peak_memory	integer	Minimum memory peak of a statement across all DNs. The unit is MB.
max_peak_memory	integer	Maximum memory peak of a statement across all DNs. The unit is MB.
average_peak_memory	integer	Average memory usage during statement execution. The unit is MB.
memory_skew_percent	integer	Memory usage skew of a statement among DNs.
spill_info	text	Statement spill information on all DNs. **None** indicates that the statement has not been spilled to disks on any DNs. **All** indicates that the statement has been spilled to disks on every DN. **[*a*:*b*]** indicates that 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. The unit is MB. The default value is **0**.
max_spill_size	integer	Maximum spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
average_spill_size	integer	Average spilled data among all DNs when a spill occurs. The unit is MB. The default value is **0**.
spill_skew_percent	integer	DN spill skew when a spill occurs
min_dn_time	bigint	Minimum execution time of a statement across all DNs. The unit is ms.
max_dn_time	bigint	Maximum execution time of a statement across all DNs. The unit is ms.
average_dn_time	bigint	Average execution time of a statement across all DNs. The unit is ms.
dntime_skew_percent	integer	Execution time skew of a statement among DNs.
min_cpu_time	bigint	Minimum CPU time of a statement across all DNs. The unit is ms.

Name	Type	Description
max_cpu_time	bigint	Maximum CPU time of a statement across all DNs. The unit is ms.
total_cpu_time	bigint	Total CPU time of a statement across all DNs. The unit is ms.
cpu_skew_percent	integer	CPU time skew of a statement among DNs.
min_peak_iops	integer	Minimum IOPS peak of a 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 a 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 a 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.
min_read_speed	integer	Minimum I/O read rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
max_read_speed	integer	Maximum I/O read rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
average_read_speed	integer	Average I/O read rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
min_write_speed	integer	Minimum I/O write rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
max_write_speed	integer	Maximum I/O write rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
average_write_speed	integer	Average I/O write rate of a statement across all DNs within a monitoring period (5s). The unit is KB/s.
recv_pkg	bigint	Total number of communication packages received by a statement across all DNs.

Name	Type	Description
send_pkg	bigint	Total number of communication packages sent by a statement across all DNs.
recv_bytes	bigint	Total received data of the statement stream, in byte.
send_bytes	bigint	Total sent data of the statement stream, in byte.
warning	text	Warning. The following warnings and warnings related to SQL self-diagnosis tuning are displayed: 1. Spill file size large than 256MB 2. Broadcast size large than 100MB 3. Early spill 4. Spill times is greater than 3 5. Spill on memory adaptive 6. Hash table conflict
unique_sql_id	bigint	ID of the normalized unique SQL.
queryid	bigint	Internal query ID used for statement execution
query	text	Statement that is being executed
query_plan	text	Execution plan of a statement Specification restrictions: 1. Execution plans are displayed only for DML statements. 2. In 8.2.1.100 and later versions, the number of data binding times is added to the execution plans of Parse Bind Execute (PBE) statements to facilitate statement analysis. The number of data binding times is displayed in the format of **PBE bind times:** *Times*.
node_group	text	Logical cluster of the user running the statement
stmt_type	text	Query type corresponding to the statement.
except_info	text	Information about the exception rule triggered by the statement.
parse_time	bigint	Total parsing time before statements are queued (including lexical syntax parsing, optimization rewriting, and plan generation time). The unit is ms. This field is supported only by 8.3.0.100 and later versions.

15.3.234 PGXC_WLM_USER_RESOURCE_HISTORY

The **PGXC_WLM_USER_RESOURCE_HISTORY** view displays historical information about resource consumption of all users on the corresponding instances. This view is supported only by clusters of version 8.2.0 or later.

Table 15-272 PGXC_WLM_USER_RESOURCE_HISTORY columns

Name	Type	Description
nodename	name	Instance name, including CNs and DNs.
username	text	Username
timestamp	timestamp with time zone	Timestamp
used_memory	integer	Used memory (unit: MB). On a DN, it indicates a user's memory usage on the current DN. On a CN, it indicates a user's total memory usage on all DNs.
total_memory	integer	Available memory (unit: MB). **0** indicates that the available memory is not limited and depends on the maximum memory available in the database. On a DN, it indicates the memory available to a user on the current DN. On a CN, it indicates the total memory available to a user on all DNs.
used_cpu	double precision	Number of CPU cores in use. Only the CPU usage of complex jobs in the non-default resource pool is collected, and the value is the CPU usage of the related cgroup. On a DN, it indicates a user's CPU core usage on the current DN. On a CN, it indicates a user's total CPU core usage on all DNs.
total_cpu	integer	Total number of CPU cores of the Cgroups associated with a user. On a DN, it indicates the CPU cores available to a user on the current DN. On a CN, it indicates the total CPU cores available to a user on all DNs.

Name	Type	Description
used_space	bigint	Used permanent table storage space (unit: KB) On a DN, it indicates the size of the permanent table storage space used by a user on the current DN. On a CN, it indicates the total size of the permanent table storage space used by a user on all DNs.
total_space	bigint	Available storage space (unit: KB). **-1** indicates that the storage space is not limited. On a DN, it indicates the size of the permanent table storage space available to a user on the current DN. On a CN, it indicates the total size of the permanent table storage space available to a user on all DNs.
used_temp_space	bigint	Used temporary table storage space (unit: KB) On a DN, it indicates the size of the temporary table storage space used by a user on the current DN. On a CN, it indicates the total size of the temporary table storage space used by a user on all DNs.
total_temp_space	bigint	Available temporary table storage space (unit: KB). **-1** indicates that the storage space is not limited. On a DN, it indicates the size of the temporary table storage space available to a user on the current DN. On a CN, it indicates the total size of the temporary table storage space available to a user on all DNs.
used_spill_space	bigint	Size of space used for operator spill to disk, in KB. On a DN, it indicates displays the size of the operator flushing space used by the user on the current DN. On a CN, it indicates the total space used by a user's operators spilled to disk on all DNs.

Name	Type	Description
total_spill_space	bigint	Size of space available for operator spill to disk, in KB. The value **-1** indicates that the space is not limited. On a DN, it indicates displays the size of the operator flushing space that can be used by the user on the current DN. On a CN, it indicates the total space available for a user to spill operators to disk on all DNs.
read_kbytes	bigint	On a CN, it indicates total number of bytes read by a user's complex jobs on all DNs in the last 5 seconds. The unit is KB. On a DN, it indicates the total number of bytes read by a user's complex jobs from the instance startup time to the current time. The unit is KB.
write_kbytes	bigint	On a CN, it indicates total number of bytes written by a user's complex jobs on all DNs in the last 5 seconds. On a DN, it indicates the total number of bytes written by a user's complex jobs from the instance startup time to the current time. The unit is KB.
read_counts	bigint	On a CN, it indicates total number of read times of a user's complex jobs on all DNs in the last 5 seconds. On a DN, it indicates total number of read times of a user's complex jobs from the instance startup time to the current time.
write_counts	bigint	On a CN, it indicates total number of write times of a user's complex jobs on all DNs in the last 5 seconds. On a DN, it indicates total number of write times of a user's complex jobs from the instance startup time to the current time.
read_speed	double precision	On a CN, it indicates the average read rate of a user's complex jobs on a single DN in the last 5 seconds, in KB/s. On a DN, it indicates the average read rate of a user's complex jobs on the DN in the last 5 seconds, in KB/s.

Name	Type	Description
write_speed	double precision	On a CN, it indicates the average write rate of a user's complex jobs on a single DN in the last 5 seconds, in KB/s. On a DN, it indicates the average write rate of a user's complex jobs on the DN in the last 5 seconds, in KB/s.
send_speed	double precision	On a CN, it indicates the sum of the average network sending rates of a user on all DNs in a 5s monitoring period, in KB/s. On a DN, it indicates the average network sending rate of a user on the DN in a 5s monitoring period, in KB/s.
recv_speed	double precision	On a CN, it indicates the sum of the average network receiving rates of a user on all DNs in a 5s monitoring period, in KB/s. On a DN, it indicates the average network receiving rate of a user on the DN in a 5s monitoring period, in KB/s.

15.3.235 PGXC_WLM_WORKLOAD_RECORDS

PGXC_WLM_WORKLOAD_RECORDS displays the status of job executed by the current user on CNs. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view. This view is available only when **enable_dynamic_workload** is set to **on**.

Table 15-273 PGXC_WLM_WORKLOAD_RECORDS columns

Name	Type	Description
node_name	text	Name of the CN where the job is executed
thread_id	bigint	ID of the backend thread
processid	integer	lwpid of a thread
timestamp	bigint	Time when a statement starts to be executed
username	name	Name of the user logging in to the backend
memory	integer	Memory required by a statement
active_points	integer	Number of resources consumed by a statement in a resource pool
max_points	integer	Maximum number of resources in a resource pool

Name	Type	Description
priority	integer	Priority of a job
resource_pool	text	Resource pool of a job
status	text	Job execution status. Its value can be: **pending** **running** **finished** **aborted** **unknown**
control_group	text	Cgroups used by a job
enqueue	text	Queue that a job is in. Its value can be: **GLOBAL**: global queue **RESPOOL**: resource pool queue **ACTIVE**: not in a queue
query	text	Statement that is being executed

15.3.236 PGXC_WORKLOAD_SQL_COUNT

PGXC_WORKLOAD_SQL_COUNT displays statistics on the number of SQL statements executed in workload Cgroups on all CNs in a cluster, including the number of **SELECT**, **UPDATE**, **INSERT**, and **DELETE** statements and the number of DDL, DML, and DCL statements. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view.

Table 15-274 PGXC_WORKLOAD_SQL_COUNT columns

Name	Type	Description
node_name	name	Node name
workload	name	Workload Cgroup 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

Name	Type	Description
ddl_count	bigint	Number of **DDL** statements
dml_count	bigint	Number of **DML** statements
dcl_count	bigint	Number of **DCL** statements

15.3.237 PGXC_WORKLOAD_SQL_ELAPSE_TIME

PGXC_WORKLOAD_SQL_ELAPSE_TIME displays statistics on the response time of SQL statements in workload Cgroups on all CNs in a cluster, including the maximum, minimum, average, and total response time of **SELECT**, **UPDATE**, **INSERT**, and **DELETE** statements. The unit is microsecond. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view.

Table 15-275 PGXC_WORKLOAD_SQL_ELAPSE_TIME columns

Name	Type	Description
node_name	name	Node name
workload	name	Workload Cgroup name
total_select_elapse	bigint	Total response time of **SELECT** statements
max_select_elapse	bigint	Maximum response time of **SELECT** statements
min_select_elapse	bigint	Minimum response time of **SELECT** statements
avg_select_elapse	bigint	Average response time of **SELECT** statements
total_update_elapse	bigint	Total response time of **UPDATE** statements
max_update_elapse	bigint	Maximum response time of **UPDATE** statements
min_update_elapse	bigint	Minimum response time of **UPDATE** statements
avg_update_elapse	bigint	Average response time of **UPDATE** statements
total_insert_elapse	bigint	Total response time of **INSERT** statements

Name	Type	Description
max_insert_elapse	bigint	Maximum response time of **INSERT** statements
min_insert_elapse	bigint	Minimum response time of **INSERT** statements
avg_insert_elapse	bigint	Average response time of **INSERT** statements
total_delete_elapse	bigint	Total response time of **DELETE** statements
max_delete_elapse	bigint	Maximum response time of **DELETE** statements
min_delete_elapse	bigint	Minimum response time of **DELETE** statements
avg_delete_elapse	bigint	Average response time of **DELETE** statements

15.3.238 PGXC_WORKLOAD_TRANSACTION

PGXC_WORKLOAD_TRANSACTION provides transaction information about workload cgroups on all CNs. Only the system administrator or the preset role **gs_role_read_all_stats** can access this view. This view is valid only when the real-time resource monitoring function is enabled, that is, when **enable_resource_track** is **on**.

Table 15-276 PGXC_WORKLOAD_TRANSACTION columns

Name	Type	Description
node_name	name	Node name
workload	name	Workload Cgroup name
commit_counter	bigint	Number of the commit times
rollback_counter	bigint	Number of rollbacks
resp_min	bigint	Minimum response time (unit: μs)
resp_max	bigint	Maximum response time (unit: μs)
resp_avg	bigint	Average response time (unit: μs)

Name	Type	Description
resp_total	bigint	Total response time (unit: μs)

15.3.239 PLAN_TABLE

PLAN_TABLE displays the plan information collected by **EXPLAIN PLAN**. Plan information is in a session-level life cycle. After the session exits, the data will be deleted. Data is isolated between sessions and between users.

Table 15-277 PLAN_TABLE columns

Name	Type	Description
statement_id	varchar2(30)	Query tag specified by a user
plan_id	bigint	ID of a plan to be queried
id	int	ID of each operator in a generated plan
operation	varchar2(30)	Operation description of an operator in a plan
options	varchar2(255)	Operation parameters
object_name	name	Name of an operated object. It is defined by users, not the object alias used in the query.
object_type	varchar2(30)	Object type
object_owner	name	User-defined schema to which an object belongs
projection	varchar2(4000)	Returned column information

NOTE

- A valid **object_type** value consists of a relkind type defined in **PG_CLASS** (**TABLE** ordinary table, **INDEX**, **SEQUENCE**, **VIEW**, **FOREIGN TABLE**, **COMPOSITE TYPE**, or **TOASTVALUE TOAST** table) 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.

15.3.240 PV_FILE_STAT

By collecting statistics about the data file I/Os, **PV_FILE_STAT** displays the I/O performance of the data to detect the performance problems, such as abnormal I/O operations.

Table 15-278 PV_FILE_STAT columns

Name	Type	Description
filenum	oid	File ID
dbid	oid	Database ID
spcid	oid	ID of a tablespace
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 files, in microseconds
writetim	bigint	Total duration of writing files, in microseconds
avgiotim	bigint	Average duration of reading and writing files, in microseconds
lstiotim	bigint	Duration of the last file reading, in microseconds
miniotim	bigint	Minimum duration of reading and writing files, in microseconds
maxiowtm	bigint	Maximum duration of reading and writing files, in microseconds

15.3.241 PV_INSTANCE_TIME

PV_INSTANCE_TIME collects statistics on the running time of processes and the time consumed in each execution phase, in microseconds.

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 within executors
- **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 15-279 PV_INSTANCE_TIME columns

Name	Type	Description
stat_id	integer	Type ID
stat_name	text	Running time type name
value	bigint	Running time value

15.3.242 PV_OS_RUN_INFO

PV_OS_RUN_INFO displays the running status of the current operating system.

Table 15-280 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

15.3.243 PV_SESSION_MEMORY

PV_SESSION_MEMORY displays 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.

Table 15-281 PV_SESSION_MEMORY columns

Name	Type	Description
sessid	text	Thread start time and ID
init_mem	integer	Memory allocated to the currently executed task before the task enters the executor, in MB

Name	Type	Description
used_mem	integer	Memory allocated to the currently executed task, in MB
peak_mem	integer	Peak memory allocated to the currently executed task, in MB

15.3.244 PV_SESSION_MEMORY_DETAIL

PV_SESSION_MEMORY_DETAIL displays statistics about thread memory usage by memory context.

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 **/tmp/dumpmem** directory. *threadid* can be obtained from the following table.

Table 15-282 PV_SESSION_MEMORY_DETAIL columns

Name	Type	Description
sessid	text	Thread start time+thread ID (string: *timestamp.threadid*)
sesstype	text	Thread name
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	Size of used memory in the memory context, in bytes. For TempSmallContextGroup, this parameter specifies the number of collected memory contexts.

Example

Query the usage of all MemoryContexts on the current node.

Locate the thread in which the MemoryContext is created and used based on **sessid**. Check whether the memory usage meets the expectation based on **totalsize**, **freesize**, and **usedsize** to see whether memory leakage may occur.

```
SELECT * FROM PV_SESSION_MEMORY_DETAIL order by totalsize desc;
          sessid          |       sesstype       |                contextname                | level |           parent
| totalsize | freesize | usedsize
----------------------------+----------------------+-------------------------------------------+-------
+-----------------------------+-----------+----------+----------
 0.139975915622720          | postmaster           | gs_signal                                 |     1 |
TopMemoryContext            |  17209904 |  8081136 |  9128768
 1667462258.139973631031040 | postgres             | SRF multi-call context                    |     5 |
FunctionScan_139973631031040 |   1725504 |     3168 |  1722336
 1667461280.139973666686720 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   284456 |  1188088
 1667450443.139973877479168 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   356088 |  1116456
 1667462258.139973631031040 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   128216 |  1344328
 1667461250.139973915236096 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   226352 |  1246192
 1667450439.139974010144512 | WLMarbiter           | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   386736 |  1085808
 1667450439.139974151726848 | WDRSnapshot          | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   159720 |  1312824
 1667450439.139974026925824 | WLMmonitor           | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   297976 |  1174568
 1667451036.139973746386688 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   208064 |  1264480
 1667461250.139973950891776 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   270016 |  1202528
 1667450439.139974076212992 | WLMCalSpaceInfo      | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   393952 |  1078592
 1667450439.139974092994304 | WLMCollectWorker     | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |    94848 |  1377696
 1667461254.139973971343104 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   338544 |  1134000
 1667461280.139973822945024 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   284456 |  1188088
 1667450439.139974202070784 | JobScheduler         | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   216728 |  1255816
 1667450454.139973860697856 | postgres             | CacheMemoryContext                        |     1 |
TopMemoryContext            |   1472544 |   388384 |  1084160
 0.139975915622720          | postmaster           | Postmaster                                |     1 |
TopMemoryContext            |   1004288 |    88792 |  915496
 1667450439.139974218852096 | AutoVacLauncher      | CacheMemoryContext                        |     1 |
TopMemoryContext            |    948256 |   183488 |  764768
 1667461250.139973915236096 | postgres             | TempSmallContextGroup                     |     0
|                           |    584448 |   148032 |      119
 1667462258.139973631031040 | postgres             | TempSmallContextGroup                     |     0
|                           |    579712 |   162128 |      123
```

15.3.245 PV_SESSION_STAT

PV_SESSION_STAT displays session state statistics based on session threads or the **AutoVacuum** thread.

Table 15-283 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

15.3.246 PV_SESSION_TIME

PV_SESSION_TIME displays statistics about the running time of session threads and time consumed in each execution phase, in microseconds.

Table 15-284 PV_SESSION_TIME columns

Name	Type	Description
sessid	text	Thread ID and start time
stat_id	integer	Statistics ID
stat_name	text	Running time type name
value	bigint	Running time value

15.3.247 PV_TOTAL_MEMORY_DETAIL

PV_TOTAL_MEMORY_DETAIL displays statistics about memory usage of the current database node in the unit of MB.

Table 15-285 PV_TOTAL_MEMORY_DETAIL columns

Name	Type	Description
nodename	text	Node name

Name	Type	Description
memorytype	text	Memory type. Its value can be: • **max_process_memory**: memory used by a GaussDB(DWS) cluster instance • **process_used_memory**: memory used by a GaussDB(DWS) process • **max_dynamic_memory**: maximum dynamic memory • **dynamic_used_memory**: used dynamic memory • **dynamic_peak_memory**: dynamic peak value of the memory • **dynamic_used_shrctx**: maximum dynamic shared memory context • **dynamic_peak_shrctx**: dynamic peak value of the shared memory context • **max_shared_memory**: maximum shared memory • **shared_used_memory**: used shared memory • **max_cstore_memory**: maximum memory allowed for column store • **cstore_used_memory**: memory used for column store • **max_sctpcomm_memory**: maximum memory allowed for the communication library • **sctpcomm_used_memory**: memory used for the communication library • **sctpcomm_peak_memory**: memory peak of the communication library • **other_used_memory**: other used memory • **gpu_max_dynamic_memory**: maximum GPU memory • **gpu_dynamic_used_memory**: sum of the available GPU memory and temporary GPU memory • **gpu_dynamic_peak_memory**: maximum memory used for GPU • **pooler_conn_memory**: memory used for pooler connections • **pooler_freeconn_memory**: memory used for idle pooler connections • **storage_compress_memory**: memory used for column-store compression and decompression • **udf_reserved_memory**: memory reserved for the **UDF Worker** process

Name	Type	Description
		• **mmap_used_memory**: memory used for **mmap**
memorymbytes	integer	Size of allocated memory-typed memory

15.3.248 PV_REDO_STAT

PV_REDO_STAT displays statistics on redoing Xlogs on the current node.

Table 15-286 PV_REDO_STAT columns

Name	Type	Description
phywrts	bigint	Number of physical writes
phyblkwrt	bigint	Number of physical write blocks
writetim	bigint	Time consumed by physical writes
avgiotim	bigint	Average time for each write
lstiotim	bigint	Last write time
miniotim	bigint	Minimum write time
maxiowtm	bigint	Maximum write time

15.3.249 PV_RUNTIME_ATTSTATS

PV_RUNTIME_ATTSTATS displays table-level statistics in the memory generated by autoanalyze. The descriptions of the columns in **PV_RUNTIME_RELSTATS** are the same as those in **PG_STATS**. This view is used only by clusters of version 8.2.0 or later.

Table 15-287 PV_RUNTIME_ATTSTATS columns

Column	Type	Reference	Description
schemaname	name	**PG_NAMESPACE**.nspname	Name of the schema that contains the table
tablename	name	**PG_CLASS**.relname	Table name
attname	name	**PG_ATTRIBUTE**.attname	Column name

Column	Type	Reference	Description
inherited	boolean	-	If the value is **true**, the inherited subcolumns are included. If the value is **false**, only the columns in a specified table are included.
null_frac	real	-	Percentage of column entries that are null
avg_width	integer	-	Average width in bytes of column's entries
n_distinct	real	-	• If the value is greater than 0, it indicates the estimated number of distinct values in the column. • Negative of the number of distinct values divided by the number of rows if the value is less than 0 The negated form is used when ANALYZE believes that the number of distinct values is likely to increase as the table grows. The positive form is used when the column seems to have a fixed number of possible values. For example, **-1** indicates a unique column in which the number of distinct values is the same as the number of rows.
n_dndistinct	real	-	Number of unique non-null data values in the **dn1** column • Exact number of distinct values if the value is greater than 0 • 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**.) • 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. If this combination does not have the most common values, it will be **NULL**.

Column	Type	Reference	Description
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**)
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 the most commonly used non-null element values
most_common_elem_freqs	real[]	-	A list of the frequencies of the most commonly used element values
elem_count_histogram	real[]	-	A histogram of the counts of distinct non-null element values

15.3.250 PV_RUNTIME_RELSTATS

PV_RUNTIME_RELSTATS displays table-level statistics in the memory generated by autoanalyze. The descriptions of the columns in **PV_RUNTIME_RELSTATS** are the same as those in **PG_CLASS**. This view is used only by clusters of version 8.2.0 or later.

Table 15-288 PV_RUNTIME_RELSTATS columns

Name	Type	Description
nspname	name	Schema name
relname	name	Name of an object, such as a table or index
relpages	double precision	Size of the on-disk representation of this 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.
relhasindex	boolean	Its value is **true** if this column is a table and has (or recently had) at least one index. 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**.
changes	bigint	Total historical modifications in the table by the time the lightweight autoanalyze is triggered.
level	text	Current phase of the memory statistics generated by the lightweight autoanalyze. It can be **local**, **sendlist**, or **global**.

15.3.251 REDACTION_COLUMNS

REDACTION_COLUMNS displays information about all redaction columns in the current database.

Table 15-289 REDACTION_COLUMNS columns

Name	Type	Description
object_owner	name	Owner of the object to be redacted.
object_name	name	Redacted object name
column_name	name	Redacted column name
function_type	integer	Redaction type

Name	Type	Description
function_parameters	text	Parameter used when the redaction type is **partial** (reserved)
regexp_pattern	text	Pattern string when the redaction type is **regexp** (reserved)
regexp_replace_string	text	Replacement string when the redaction type is **regexp** (reserved)
regexp_position	integer	Start and end replacement positions when the redaction type is **regexp** (reserved)
regexp_occurrence	integer	Replacement times when the redaction type is **regexp** (reserved)
regexp_match_parameter	text	Regular control parameter used when the redaction type is **regexp** (reserved)
function_info	text	Redaction function information
column_description	text	Description of the redacted column
inherited	bool	Whether a redacted column is inherited from another redacted column.
policy_name	name	Name of the data masking policy. This field is supported only by clusters of version 8.2.1.100 or later.

15.3.252 REDACTION_POLICIES

REDACTION_POLICIES displays information about all redaction objects in the current database.

Table 15-290 REDACTION_POLICIES columns

Name	Type	Description
object_owner	name	Owner of the object to be redacted.
object_name	name	Redacted object name
policy_name	name	Name of the redact policy
expression	text	Policy effective expression (for users)
enable	boolean	Policy status (enabled or disabled)
policy_description	text	Description of a policy
inherited	bool	Whether a redacted column is inherited from another redacted column.

15.3.253 REMOTE_TABLE_STAT

REMOTE_TABLE_STAT provides statistics of all tables of the database on all DNs in the cluster. Except the **nodename** column of the name type added in front of each row, the names, types, and sequences of other columns are the same as those in the **GS_TABLE_STAT** view. For details about the columns, see **GS_TABLE_STAT**.

15.3.254 SHOW_TSC_INFO

Queries TSC information about the current node. This view is supported only by clusters of version 8.2.1 or later.

Table 15-291 Parameter

Name	Type	Description
node_name	text	Node name
tsc_mult	bigint	TSC conversion multiplier
tsc_shift	bigint	TSC conversion shifts
tsc_frequency	float8	TSC frequency.
tsc_use_freqency	boolean	Indicates whether to use the TSC frequency for time conversion.

Name	Type	Description
tsc_ready	boolean	Indicates whether the TSC frequency can be used for time conversion
tsc_scalar_error_info	text	Error information about obtaining TSC conversion information
tsc_freq_error_info	text	Error information about obtaining TSC frequency information

15.3.255 SHOW_ALL_TSC_INFO

Queries TSC information about all nodes. This view is supported only by clusters of version 8.2.1 or later.

Table 15-292 Parameter

Name	Type	Description
node_name	text	Node name
tsc_mult	bigint	TSC conversion multiplier
tsc_shift	bigint	TSC conversion shifts
tsc_frequency	float8	TSC frequency.
tsc_use_freqency	boolean	Indicates whether to use the TSC frequency for time conversion.
tsc_ready	boolean	Indicates whether the TSC frequency can be used for time conversion
tsc_scalar_error_info	text	Error information about obtaining TSC conversion information
tsc_freq_error_info	text	Error information about obtaining TSC frequency information

15.3.256 USER_COL_COMMENTS

USER_COL_COMMENTS stores the column comments of the tables and views that the current user can access.

Name	Type	Description
column_name	character varying(64)	Column name
table_name	character varying(64)	Table/View name
owner	character varying(64)	Owner of a table/view

Name	Type	Description
comments	text	Comments

15.3.257 USER_CONSTRAINTS

USER_CONSTRAINTS displays the table constraint information accessible to the current user.

Name	Type	Description
constraint_name	vcharacter varying(64)	Constraint name
constraint_type	text	Constraint type • C: Check constraint. • F: Foreign key constraint • P: Primary key constraint • U: Unique constraint.
table_name	character varying(64)	Name of constraint-related table
index_owner	character varying(64)	Owner of constraint-related index (only for the unique constraint and primary key constraint)
index_name	character varying(64)	Name of constraint-related index (only for the unique constraint and primary key constraint)

Example

Query constraints on a specified table of the current user. Replace **t1** with the actual table name.

```
SELECT * FROM USER_CONSTRAINTS WHERE table_name='t1';
 constraint_name | constraint_type | table_name | index_owner |  index_name
-----------------+-----------------+------------+-------------+---------------
 c_custkey_key   | p               | t1         | u1          | c_custkey_key
(1 row)
```

15.3.258 USER_CONS_COLUMNS

USER_CONSTRAINTS displays the information about constraint columns of the tables accessible to the current user.

Name	Type	Description
table_name	character varying(64)	Name of constraint-related table
column_name	character varying(64)	Name of constraint-related column
constraint_name	character varying(64)	Constraint name
position	smallint	Position of the column in the table

15.3.259 USER_INDEXES

USER_INDEXES displays index information in the current schema.

Name	Type	Description
owner	character varying(64)	Owner of the index
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
generated	character varying(1)	Whether the index name is generated by the system
partitioned	character(3)	Whether the index has the property of the partition table

15.3.260 USER_IND_COLUMNS

USER_IND_COLUMNS displays column information about all indexes accessible to the current user.

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

Name	Type	Description
column_name	name	Column name
column_position	smallint	Position of column in the index

15.3.261 USER_IND_EXPRESSIONS

USER_IND_EXPRESSIONS displays information about the function-based expression index accessible to the current user.

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	The function-based index expression of a specified column
column_position	smallint	Position of column in the index

15.3.262 USER_IND_PARTITIONS

USER_IND_PARTITIONS displays information about index partitions accessible to the current user.

Name	Type	Description
index_owner	character varying(64)	Name of the owner of the partitioned index to which the index partition belongs
schema	character varying(64)	Schema of the partitioned index to which the index partition belongs
index_name	character varying(64)	Index name of the partitioned table to which the index partition belongs
partition_name	character varying(64)	Specifies the name of the index partition.
index_partition_usable	boolean	Whether the index partition is available

Name	Type	Description
high_value	text	Boundary of the table partition corresponding to the index partition. For a range partition, the boundary is the upper boundary. For a list partition, the boundary is the boundary value set. Reserved field for forward compatibility. The parameter **pretty_high_value** is added in version 8.1.3 to record the information.
pretty_high_value	text	Boundary of the table partition corresponding to the index partition. For a range partition, the boundary is the upper boundary. For a list partition, the boundary is the boundary value set. The query result is the instant decompilation output of the partition boundary expression. The output of this column is more detailed than that of **high_value**. The output information can be collation and column data type.
def_tablespace_name	name	Tablespace name of the index partition

15.3.263 USER_JOBS

USER_JOBS displays all scheduled jobs owned by the current user. This view is accessible only to users with system administrator rights.

Table 15-293 USER_JOBS columns

Name	Type	Description
job	int4	Job ID
log_user	name not null	User name of the job creator
priv_user	name not null	User name of the job executor
dbname	name not null	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

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	Same as **THIS_DATE**
next_date	timestamp without time zone	Schedule time of the next job execution
next suc	text	Same as **next_date**
broken	text	Task status **Y**: the system does not try to execute the task. **N**: the system attempts to execute the task.
status	char	Status of the current job. The value range is **'r', 's', 'f', 'd'**. The default value is **'s'**. The indications are as follows: • **r**: running • **s**: finished • **f**: failed • **d**: aborted
interval	text	Time expression used to calculate the next execution time. If this parameter is set to **null**, the job will be executed once only.
failures	smallint	Number of consecutive failures.
what	text	Body of the PL/SQL blocks or anonymous clock that the job executes

15.3.264 USER_OBJECTS

USER_OBJECTS displays all database objects accessible to the current user.

Name	Type	Description
owner	name	Owner of the object
object_name	name	Object name
object_id	oid	OID of the object

Name	Type	Description
object_type	name	Type of the object
namespace	oid	Namespace containing the object
created	timestamp with time zone	Object creation time
last_ddl_time	timestamp with time zone	The last time when an object was modified.

NOTICE

For details about the value ranges of **last_ddl_time** and **last_ddl_time**, see **PG_OBJECT**.

15.3.265 USER_PART_INDEXES

USER_PART_INDEXES displays information about partitioned table indexes accessible to the current user.

Name	Type	Description
index_owner	character varying(64)	Name of the owner of the partitioned table index
schema	character varying(64)	Schema of the partitioned table index
index_name	character varying(64)	Name of the partitioned table index
table_name	character varying(64)	Name of the partitioned table to which the partitioned table index belongs
partitioning_type	text	Partition policy of the partitioned table **NOTE** Currently, only range partitioning and list partitioning are supported.
partition_count	bigint	Number of index partitions of the partitioned table index
def_tablespace_name	name	Tablespace name of the partitioned table index
partitioning_key_count	integer	Number of partition keys of the partitioned table

15.3.266 USER_PART_TABLES

USER_PART_TABLES displays information about partitioned tables accessible to the current user.

Name	Type	Description
table_owner	character varying(64)	Name of the owner of the partitioned table
schema	character varying(64)	Schema of the partitioned table
table_name	character varying(64)	Name of the partitioned table
partitioning_type	text	Partition policy of the partitioned table **NOTE** Currently, only range partitioning and list partitioning are supported.
partition_count	bigint	Number of partitions of the partitioned table
def_tablespace_name	name	Tablespace name of the partitioned table
partitioning_key_count	integer	Number of partition keys of the partitioned table

15.3.267 USER_PROCEDURES

USER_PROCEDURES displays information about all stored procedures and functions in the current schema.

Name	Type	Description
owner	character varying(64)	Owner of the stored procedure or the function
object_name	character varying(64)	Name of the stored procedure or the function
argument_number	smallint	Number of the input parameters in the stored procedure

15.3.268 USER_SEQUENCES

USER_SEQUENCES displays sequence information in the current schema.

Name	Type	Description
sequence_owner	character varying(64)	Owner of the sequence
sequence_name	character varying(64)	Name of the sequence

15.3.269 USER_SOURCE

USER_SOURCE displays information about stored procedures or functions in this mode, and provides the columns defined by the stored procedures or the functions.

Name	Type	Description
owner	character varying(64)	Owner of the stored procedure or the function
name	character varying(64)	Name of the stored procedure or the function
text	text	Definition of the stored procedure or the function

15.3.270 USER_SYNONYMS

USER_SYNONYMS displays synonyms accessible to the current user.

Table 15-294 USER_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.
table_schema_name	text	Schema name of the associated object.
table_name	text	Name of the associated object.

15.3.271 USER_TAB_COLUMNS

USER_TAB_COLUMNS stores information about columns of the tables and views that the current user can access.

Name	Type	Description
owner	character varying(64)	Owner of a table/view
table_name	character varying(64)	Table/View name
column_name	character varying(64)	Column name
data_type	character varying(128)	Data type of the column
column_id	integer	Sequence number of the column when a table/view is created
data_length	integer	Length of the column, in bytes
comments	text	Comments
avg_col_len	numeric	Average length of a column, in bytes
nullable	bpchar	Whether the column can be empty. For the primary key constraint and non-null constraint, the value is n.
data_precision	integer	Precision of the data type. This parameter is valid for the numeric data type and **NULL** for other data types.
data_scale	integer	Number of decimal places. This parameter is valid for the numeric data type and **0** for other data types.
char_length	numeric	Length of a column, in characters. This parameter is valid only for the varchar, nvarchar2, bpchar, and char types.
schema	character varying(64)	Namespace that contains the table or view.
kind	text	Type of the current record. If the column belongs to a table, the value of this column is **table**. If the column belongs to a view, the value of this column is **view**.

15.3.272 USER_TAB_COMMENTS

USER_TAB_COMMENTS displays comments about all tables and views accessible to the current user.

Name	Type	Description
owner	character varying(64)	Owner of the table or the view
table_name	character varying(64)	Name of the table or the view
comments	text	Comments

15.3.273 USER_TAB_PARTITIONS

USER_TAB_PARTITIONS displays all table partitions accessible to the current user. Each partition of a partitioned table accessible to the current user has a piece of record in **USER_TAB_PARTITIONS**.

Name	Type	Description
table_owner	character varying(64)	Owner of the table that contains the partition
schema	character varying(64)	Schema of the partitioned table
table_name	character varying(64)	Table name
partition_name	character varying(64)	Name of the partition
high_value	text	Upper boundary of a range partition or boundary value set of a list partition Reserved field for forward compatibility. The parameter **pretty_high_value** is added in version 8.1.3 to record the information.
pretty_high_value	text	Upper boundary of a range partition or boundary value set of a list partition The query result is the instant decompilation output of the partition boundary expression. The output of this column is more detailed than that of **high_value**. The output information can be collation and column data type.
tablespace_name	name	Name of the tablespace that contains the partition

15.3.274 USER_TABLES

USER_TABLES displays table information in the current schema.

Name	Type	Description
owner	character varying(64)	Table owner
table_name	character varying(64)	Table name
tablespace_name	character varying(64)	Name of the tablespace that contains the table
status	character varying(8)	Whether the current record is valid
temporary	character(1)	Whether the table is a temporary table • **Y** indicates that it is a temporary table. • **N** indicates that it is not a temporary table.
dropped	character varying	Whether the current record is deleted • **YES** indicates that it is deleted. • **NO** indicates that it is not deleted.
num_rows	numeric	The estimated number of rows in the table

15.3.275 USER_TRIGGERS

USER_TRIGGERS displays the information about triggers accessible to the current user.

Name	Type	Description
trigger_name	character varying(64)	Trigger name
table_name	character varying(64)	Name of the table that defines the trigger
table_owner	character varying(64)	Owner of the table that defines the trigger

15.3.276 USER_VIEWS

USER_VIEWS displays information about all views in the current schema.

Name	Type	Description
owner	character varying(64)	Owner of the view
view_name	character varying(64)	View name

15.3.277 V$SESSION

V$SESSION displays all session information about the current session.

Table 15-295 V$SESSION columns

Name	Type	Description
sid	bigint	OID of the background process of the current activity
serial#	integer	Sequence number of the active background process, which is **0** in GaussDB(DWS).
user#	oid	OID of the user that has logged in to the background process
username	name	Name of the user that has logged in to the background process

15.3.278 V$SESSION_LONGOPS

V$SESSION_LONGOPS displays the progress of ongoing operations.

Table 15-296 V$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(DWS).
sofar	integer	Completed workload, which is empty in GaussDB(DWS).
totalwork	integer	Total workload, which is empty in GaussDB(DWS).

16 Collation Support

The collation feature allows specifying the data sorting order and data classification rules in a character set. This alleviates the restriction that the **LC_COLLATE** and **LC_CTYPE** settings of a database cannot be changed after its creation.

Overview

Every expression of a collatable data type has a collation. (The built-in collatable data types are text, varchar, and char. User-defined base types can also be marked collatable, and of course a domain over a collatable data type is collatable.) If the expression is a column reference, the collation of the expression is the defined collation of the column. If the expression is a constant, the collation is the default collation of the data type of the constant. The collation of a more complex expression is derived from the collations of its inputs.

Collation Combination Principles

- The collation of an expression can be the default collation, which means the locale settings defined for the database. It is also possible for an expression's collation to be indeterminate. In such cases, ordering operations and other operations that need to know the collation will fail.
- For a function or operator call, the collation that is derived by examining the argument collations is used at run time for performing the specified operation. If the result of the function or operator call is of a collatable data type, the collation is also used as the defined collation of the function or operator expression, in case there is a surrounding expression that requires knowledge of its collation.
- The collation derivation of an expression can be implicit or explicit. This distinction affects how collations are combined when multiple different collations appear in an expression. An explicit collation derivation occurs when a **COLLATE** clause is used; all other collation derivations are implicit. When multiple collations need to be combined, the following rules are used:
  - If any input expression has an explicit collation derivation, then all explicitly derived collations among the input expressions must be the same, otherwise an error is raised. If any explicitly derived collation is present, that is the result of the collation combination.

  - Otherwise, all input expressions must have the same implicit collation derivation or the default collation. If any non-default collation is present, that is the result of the collation combination. Otherwise, the result is the default collation.
  - If there are conflicting non-default implicit collations among the input expressions, then the combination is deemed to have indeterminate collation. This is not an error condition unless the particular function being invoked requires knowledge of the collation it should apply. If it does, an error will be raised at run-time.
- In a CASE expression, the comparison rule is subject to the COLLATE setting in the WHEN clause.
- Explicit COLLATE derivation takes effect only in the current query (CTE or SUBQUERY). Outside the query, implicit derivation takes effect.

Collation Tips

- Do not use multiple collations in the same query statement. Otherwise, exceptional result sets may be generated.
- Do not use multiple COLLATE clauses to specify a collation.

Case-insensitive Collation Support

Since cluster 8.1.3, GaussDB(DWS) has added the built-in case_insensitive collation, which is case-insensitive to character types in some actions (such as sorting, comparison, and hash).

Constraints:

- Supported character types: char, character, nchar, and varchar/character varying/varchar2/nvarchar2/clob/text.
- The character types **char** and **name** are not supported.
- The following encoding formats are not supported: PG_EUC_JIS_2004, PG_MULE_INTERNAL, PG_LATIN10 and PG_WIN874.
- It cannot be specified to **LC_COLLATE** when **CREATE DATABASE** is executed.
- Regular expressions are not supported.
- Record comparison of the character type (for example, **record_eq**) is not supported.
- Time series tables are not supported.
- Skew optimization is not supported.
- RoughCheck optimization is not supported.

Examples

The COLLATE clause is specified in the statement.

```
SELECT 'a' = 'A', 'a' = 'A' COLLATE case_insensitive;
 ?column? | ?column?
----------+----------
 f        | t
(1 row)
```

Set the column attribute to **case_insensitive** when creating a table.


```
CREATE TABLE t1 (a text collate case_insensitive);
NOTICE:  The 'DISTRIBUTE BY' clause is not specified. Using round-robin as the distribution mode by default.
HINT:  Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
CREATE TABLE
\d t1
            Table "public.t1"
 Column | Type |         Modifiers
--------+------+---------------------------
 a      | text | collate case_insensitive

INSERT INTO t1 values('a'),('A'),('b'),('B');
INSERT 0 4
```

This parameter is specified during table creation and does not need to be specified during query.

```
SELECT a, a='a' FROM t1;
 a | ?column?
---+----------
 A | t
 B | f
 a | t
 b | f
(4 rows)
SELECT a, count(1) FROM t1 GROUP BY a;
 a | count
---+-------
 a |     2
 B |     2
(2 rows)
```

CASE expression, which is subject to the COLLATE setting in the WHEN clause.

```
SELECT a,case a when 'a' collate case_insensitive then 'case1' when 'b' collate "C" then 'case2' else 'case3'
end FROM t1;
 a | case
---+-------
 A | case1
 B | case3
 a | case1
 b | case2
(4 rows)
```

Implicit derivation across subqueries.

```
SELECT * FROM (SELECT a collate "C" from t1) WHERE a in ('a','b');
 a
---
 a
 b
(2 rows)
SELECT * FROM t1,(SELECT a collate "C" from t1) t2 WHERE t1.a=t2.a;
ERROR:  could not determine which collation to use for string hashing
HINT:  Use the COLLATE clause to set the collation explicitly.
```


CAUTION

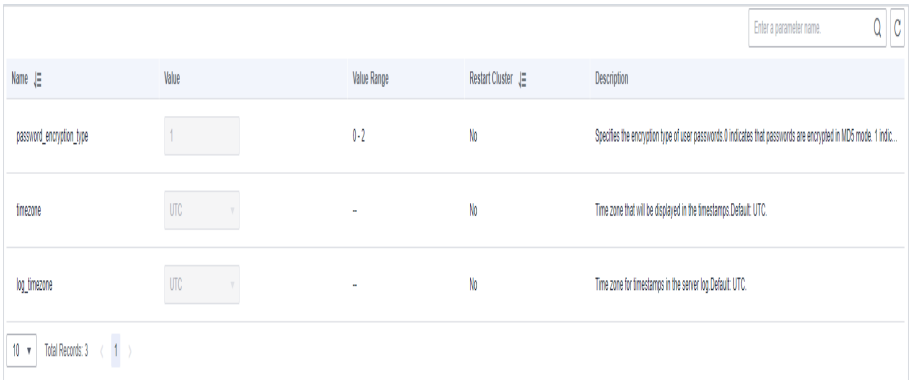
- **collate case_insensitive** is an insensitive sorting, and the result set is uncertain. If sensitive sorting is used after **collate case_insensitive** sorting, the result set may be unstable. Therefore, do not use sensitive sorting and insensitive sorting together in statements.
- If **collate case_insensitive** is used to specify character behaviors as case-insensitive, the performance will be affected. If you require high performance, exercise caution when configuring this parameter.

17 GUC Parameters

17.1 Viewing GUC Parameters

GaussDB(DWS) GUC parameters can control database system behaviors. You can check and adjust the GUC parameters based on your business scenario and data volume.

- After a cluster is installed, you can check database parameters on the GaussDB(DWS) management console.



- You can also connect to a cluster and run SQL commands to check the GUC parameters.
  - Run the **SHOW** command.

    To view a certain parameter, run the following command:

    ```
    SHOW server_version;
    ```

    server_version indicates the database version.

    Run the following command to view values of all parameters:

    ```
    SHOW ALL;
    ```

  - Use the **pg_settings** view.

    To view a certain parameter, run the following command:

    ```
    SELECT * FROM pg_settings WHERE NAME='server_version';
    ```

    Run the following command to view values of all parameters:

    ```
    SELECT * FROM pg_settings;
    ```

17.2 Configuring GUC Parameters

To ensure the optimal performance of GaussDB(DWS), you can adjust the GUC parameters in the database.

Parameter Types and Values

- The GUC parameters of GaussDB(DWS) are classified into the following types:
  - SUSET: database administrator parameters. This type of parameters takes effect immediately after they are set. You do not need to restart the cluster. If a parameter of this type is set in the current session, the parameter takes effect only in the current session.

  - USERSET: common user parameters. This type of parameters takes effect immediately after they are set. You do not need to restart the cluster. If a parameter of this type is set in the current session, the parameter takes effect only in the current session.
  - POSTMASTER: database server parameters. This type of parameters takes effect only after the cluster is restarted. After you modify a parameter of this type, the system displays a message indicating that the cluster is to be restarted. You are advised to manually restart the cluster during off-peak hours for the setting to take effect.
  - SIGHUP: global database parameters. This type of parameters takes effect globally and cannot take effect for single sessions.
  - BACKEND: global database parameters. This type of parameters takes effect globally and cannot take effect for single sessions.
- All parameter names are case insensitive. A parameter value can be an integer, floating point number, string, Boolean value, or enumerated value.
  - 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, or 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.

Setting GUC Parameters

You can configure GUC parameters in the following ways:

- Method 1: After a cluster is created, you can log in to the GaussDB(DWS) management console and modify the database parameters of the cluster. For details, see **Modifying Database Parameters** in .
- Method 2: Connect to a cluster and run SQL commands to configure the parameters of the SUSET or USERSET type.

  Set parameters at database, user, or session levels.
  - Set a database-level parameter.
    ```
    ALTER DATABASE dbname SET paraname TO value;
    ```
    The setting takes effect in the next session.
  - Set a user-level parameter.
    ```
    ALTER USER username SET paraname TO value;
    ```
    The setting takes effect in the next session.
  - Set a session-level parameter.
    ```
    SET paraname TO value;
    ```
    Parameter value in the current session is changed. After you exit the session, the setting becomes invalid.

Procedure

The following example shows how to set **explain_perf_mode**.

Step 1 View the value of **explain_perf_mode**.

```
SHOW explain_perf_mode;
 explain_perf_mode
-------------------
 normal
(1 row)
```

Step 2 Set **explain_perf_mode**.

Perform one of the following operations:

- Set a database-level parameter.
  ```
  ALTER DATABASE gaussdb SET explain_perf_mode TO pretty;
  ```
  If the following information is displayed, the setting has been modified.
  ```
  ALTER DATABASE
  ```
  The setting takes effect in the next session.
- Set a user-level parameter.
  ```
  ALTER USER dbadmin SET explain_perf_mode TO pretty;
  ```
  If the following information is displayed, the setting has been modified.
  ```
  ALTER USER
  ```
  The setting takes effect in the next session.
- Set a session-level parameter.
  ```
  SET explain_perf_mode TO pretty;
  ```
  If the following information is displayed, the setting has been modified.
  ```
  SET
  ```

Step 3 Check whether the parameter is correctly set.

```
SHOW explain_perf_mode;
 explain_perf_mode
--------------
 pretty
(1 row)
```

----End

17.3 GUC Parameter Usage

The database provides many operation parameters. Configuration of these parameters affects the behavior of the database system. Before modifying these parameters, learn the impact of these parameters on the database. Otherwise, unexpected results may occur.

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 database.
- If the allowed maximum value of a parameter is **INT_MAX**, it indicates the maximum parameter value varies by OS.
- If the allowed maximum value of a parameter is **DBL_MAX**, it indicates the maximum parameter value varies by OS.

17.4 Connection and Authentication

17.4.1 Connection Settings

This section describes parameters related to the connection mode between the client and server.

max_connections

Parameter description: Specifies the maximum number of allowed parallel connections to the database. This parameter influences the concurrent processing capability of the cluster.

Type: POSTMASTER

Value range: an integer. For CNs, the value ranges from 100 to 16384. For DNs, the value ranges from 100 to 262143. Because there are internal connections in the cluster, the maximum value is rarely reached. If **invalid value for parameter "max_connections"** is displayed in the log, you need to decrease the **max_connections** value for DNs.

Default value: **800** for CNs and **5000** for DNs. If the default value is greater than the maximum value supported by kernel (determined when the **gs_initdb** command is executed), an error message will be displayed.

Setting suggestions:

Retain the default value of this parameter on CNs. On a DN, the value of this parameter is calculated as follows:

dop_limit x 20 x 6 + 24: **dop_limit** indicates the number of CPUs of each DN in the cluster. It is calculated as follows: **dop_limit** = Number of logical CPU cores of a single server/Number of DNs of a single server.

The minimum value is 5000.

If the parameter is set to a large value, GaussDB(DWS) requires more SystemV shared memories or semaphores, which may exceed the maximum default configuration of the OS. In this case, modify the value as needed.

NOTICE

The value of **max_connections** is related to **max_prepared_transactions**. Before setting **max_connections**, ensure that the value of **max_prepared_transactions** is greater than or equal to that of **max_connections**. In this way, each session has a prepared transaction in the waiting state.

sysadmin_reserved_connections

Parameter description: Specifies the minimum number of connections reserved for administrators.

Type: POSTMASTER

Value range: an integer ranging from 0 to 262143

Default value: **3**

application_name

Parameter description: Specifies the name of the client program connecting to the database.

Type: USERSET

Value range: a string

Default value: **gsql**

connection_info

Parameter description: Specifies the database connection information, including the driver type, driver version, driver deployment path, and process owner. (This is an O&M parameter. Do not configure it by yourself.)

Type: USERSET

Value range: a string

Default value: an empty string

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 x.x.x build 39137c2d) compiled at 2022-09-23 15:43:11 commit 3629 last mr 5138 debug","driver_path":"/usr/local/lib/psqlodbcw.so","os_user":"omm"}
  ```
  For ODBC, JDBC, and GSQL connections, **driver_name**, **driver_version**, **driver_path**, and **os_user** are displayed by default. For other interface connections, **driver_name** and **driver_version** are displayed by default. The display of **driver_path** and **os_user** is specified by users.

17.4.2 Security and Authentication (postgresql.conf)

This section describes parameters about how to securely authenticate the client and server.

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 timeout period, the server automatically breaks the connection from the client so that the faulty client does not occupy connection resources.

Type: SIGHUP

Value range: an integer ranging from 1 to 600. The minimum unit is second (s).

Default value: **1min**

session_timeout

Parameter description: Specifies the longest duration with no operations after the connection to the server.

Type: USERSET

Value range: an integer ranging from 0 to 86400. The minimum unit is second (s). **0** means to disable the timeout.

Default value: **10 min**

NOTICE

- The gsql client of GaussDB(DWS) has an automatic reconnection mechanism. If the initialized local connection of a user to the server times out, gsql disconnects from and reconnects to the server.
- Connections from the pooler connection pool to other CNs and DNs are not controlled by the **session_timeout** parameter.

ssl_ciphers

Parameter description: Specifies the encryption algorithm list supported by the SSL.

Type: POSTMASTER

Value range: a string. Separate multiple encryption algorithms with semicolons (;).

Default value: **ALL**

NOTE

- The default value of **ssl_ciphers** is **ALL**, indicating that all the following encryption algorithms are supported. Users are advised to retain the default value, unless there are other special requirements on the encryption algorithm.
  - TLS1_3_RFC_AES_128_GCM_SHA256
  - TLS1_3_RFC_AES_256_GCM_SHA384
  - TLS1_3_RFC_CHACHA20_POLY1305_SHA256
  - TLS1_3_RFC_AES_128_CCM_SHA256
  - TLS1_3_RFC_AES_128_CCM_8_SHA256
- Currently, SSL connection authentication supports only the TLS1.3 encryption algorithm, which has better performance and security. It is also compatible with SSL connection authentication between clients that comply with TLS1.2.

ssl_renegotiation_limit

Parameter description: Specifies the traffic volume over the SSL-encrypted channel before the session key is renegotiated. The renegotiation traffic limitation 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 sent and received traffic.

Type: USERSET

NOTE

You are advised to retain the default value, that is, disable the renegotiation mechanism. You are not advised to use the **gs_guc** tool or other methods to set the **ssl_renegotiation_limit** parameter in the **postgresql.conf** file. The setting does not take effect.

Value range: an integer ranging from 0 to **INT_MAX**. The unit is KB. **0** indicates that the renegotiation mechanism is disabled.

Default value: **0**

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 modify a GaussDB(DWS) account.

Type: SIGHUP

NOTICE

For security purposes, do not disable the password complexity policy.

Value range: an integer, **0** or **1**

- **0** indicates that no password complexity policy is enabled.
- **1** indicates that the default password complexity policy is disabled.

Default value: **1**

password_reuse_time

Parameter description: Specifies whether to check the reuse days of the new password when you run the **ALTER USER** or **ALTER ROLE** command to change a user password.

Type: SIGHUP

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, the password can be reused if either of the following conditions is met:
- If the value of **password_reuse_time** is **0**, the days of password reuse are not limited and only the times of password reuse are limited.
- If the value of **password_reuse_max** is **0**, the times of password reuse are not limited and only the days of password reuse are limited.
- If the values of both parameters are **0**, password reuse is not restricted.

Value range: a floating number ranging from 0 to 3650. The unit is day.

- **0** indicates that the password reuse days are not checked.
- A positive number indicates that the new password cannot be the one that is used within the specified days.

Default value: **60**

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 user password.

Type: SIGHUP

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, the password can be reused if either of the following conditions is met:
- If the value of **password_reuse_time** is **0**, the days of password reuse are not limited and only the times of password reuse are limited.
- If the value of **password_reuse_max** is **0**, the times of password reuse are not limited and only the days of password reuse are limited.
- If the values of both parameters 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 an account is automatically unlocked.

Type: SIGHUP

NOTICE

- The locking and unlocking functions take effect only when the values of **password_lock_time** and **failed_login_attempts** are positive numbers.
- The integral part of the value of the **password_lock_time** parameter indicates the number of days and its decimal part can be converted into hours, minutes, and seconds.

Value range: a floating number ranging from 0 to 365. The unit is day.

- **0** indicates that the automatic locking function does not take effect if the password verification fails.
- A positive number indicates the duration after which an account is automatically unlocked.

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 in **password_lock_time**. For example, incorrect password attempts during login and password input failures when using the **ALTER USER** command

Type: SIGHUP

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 value of **failed_login_attempts**.

Default value: **10**

NOTICE

- The locking and unlocking functions take effect only when the values of **failed_login_attempts** and **password_lock_time** are positive numbers.
- **failed_login_attempts** works with the SSL connection mode of the client to identify the number of incorrect password attempts. If PGSSLMODE is set to **allow** or **prefer**, two connection requests are generated for a password connection request. One request attempts an SSL connection, and the other request attempts a non-SSL connection. In this case, the number of incorrect password attempts perceived by the user is the value of **failed_login_attempts** divided by 2.

password_encryption_type

Parameter description: Specifies the encryption type of user passwords.

Type: SIGHUP

Value range: an integer, **0**, **1**, or **2**

Table 17-1 Value description

Value	Password Storage Format	Supported Driver
0	Passwords are encrypted using MD5 and stored in ciphertext.	Huawei-developed and open source GaussDB drivers
1	Passwords are encrypted using SHA256 and are compatible with the MD5 user authentication method of the PostgreSQL client. Passwords are encrypted using MD5 and SHA256.	Huawei-developed and open source GaussDB drivers
2	Passwords are encrypted using SHA256 and stored in ciphertext.	Huawei-developed GaussDB drivers

NOTICE

- MD5 is not recommended because it is not a secure encryption algorithm.
- For a user created when **password_encryption_type** is set to **2**, the password has been saved using the SHA256 algorithm. In this case, changing the parameter value does not change the password storage method in the database. So, open source clients using MD5 may still fail to connect to the database.
- When **password_encryption_type** is set to **1** and **pg_hba** is set to **MD5** or **SHA256**, the two encryption modes are checked to ensure compatibility.

Default value: 1

password_min_length

Parameter description: Specifies the minimum account password length.

Type: SIGHUP

Value range: an integer. A password can contain 6 to 999 characters.

Default value: **8**

password_max_length

Parameter description: Specifies the maximum account password length.

Type: SIGHUP

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.

Type: SIGHUP

Value range: an integer ranging from 0 to 999.

- **0** means no limit.
- A positive integer indicates the minimum number of uppercase letters in the password specified for creating an account.

Default value: **0**

password_min_lowercase

Parameter description: Specifies the minimum number of lowercase letters that an account password must contain.

Type: SIGHUP

Value range: an integer ranging from 0 to 999.

- **0** means no limit.
- A positive integer indicates the minimum number of lowercase letters in the password specified for creating an account.

Default value: **0**

password_min_digital

Parameter description: Specifies the minimum number of digits that an account password must contain.

Type: SIGHUP

Value range: an integer ranging from 0 to 999.

- **0** means no limit.
- A positive integer indicates the minimum number of digits in the password specified for creating an account.

Default value: **0**

password_min_special

Parameter description: minimum number of special characters that a password must contain.

Type: SIGHUP

Value range: an integer ranging from 0 to 999.

- **0** means no limit.
- A positive integer indicates the minimum number of special characters in the password specified for creating an account.

Default value: **0**

Table 17-2 Special characters

No.	Character	No.	Character	No.	Character	No.	Character
1	~	9	*	17	|	25	<
2	!	10	(	18	[	26	.
3	@	11	)	19	{	27	>
4	#	12	-	20	}	28	/
5	$	13	_	21	]	29	?
6	%	14	=	22	;	-	-
7	^	15	+	23	:	-	-
8	&	16	\	24	,	-	-

password_effect_time

Parameter description: Specifies the validity period of an account password.

Type: SIGHUP

Value range: a floating number ranging from 0 to 999. The unit is day.

- **0** indicates the function of validity period restriction is disabled.
- A floating point number from 1 to 999 indicates the validity period of the password specified for creating an account. When the password is about to expire or has expired, the system prompts the user to change the password.

Default value: **90**

password_notify_time

Parameter description: Specifies how many days in advance users are notified before the account password expires.

Type: SIGHUP

Value range: an integer ranging from 0 to 999. The unit is day.

- **0** indicates the reminder is disabled.
- A positive integer indicates how long before expiry the reminder will appear.

Default value: **7**

17.4.3 Communication Library Parameters

This section describes parameter settings and value ranges for communication libraries.

comm_max_datanode

Parameter description: Specifies the maximum number of DNs supported by the communication library.

Type: USERSET

Value range: an integer ranging from 1 to 8192

Default value: actual number of DNs

NOTICE

If the number of DNs is increased, the change takes effect immediately. If the number of DNs is reduced, the cluster needs to be restarted for the change to take effect.

comm_max_stream

Parameter description: maximum number of logical connection data structures cached in the communication library.

Type: SIGHUP

Value range: an integer ranging from 1 to 65535

Default value: **1024**

NOTE

If the value of **comm_max_datanode** is small, the process memory is sufficient. In this case, you can increase the value of **comm_max_stream**.

max_stream_pool

Parameter description: Specifies the maximum number of stream threads that can be contained in a stream thread pool.

Type: SUSET

Value range: an integer ranging from -1 to INT_MAX. The values **-1** and **0** indicate that the stream thread pool is disabled.

Default value:

- The formula for calculating the default value of a newly installed cluster is as follows: max_stream_pool=MIN(max_connections, max_process_memory/16/5MB, 1024)
- After an old cluster is upgraded to 8.3.100 or a later version, the default value of max_stream_pool is calculated as follows: max_stream_pool = MIN

(max_connections max_process_memory/16/5MB, 1024, value of the old cluster). During the upgrade, the value of max_stream_pool of the new cluster is forcibly used, but the old value is used.

NOTE

- The number of stream threads in a thread pool can be reduced in real time. If the value of this parameter is increased, the number of stream threads is increased to meet the service requirements.
- Generally, you are advised not to change the value of this parameter because the stream thread pool supports the automatic cleanup function.
- If too many idle stream threads occupy the memory, you can decrease the value of this parameter to save the memory.

enable_stream_sync_quit

Parameter description: whether the stream threads exit synchronously when the stream plan ends.

Type: USERSET

Value range: Boolean

- **on** indicates that threads in the stream thread group exit after the steam plan ends.
- **off** indicates that stream threads exit directly after the stream plan ends without waiting for the threads in the stream thread group to exit.

Default value: **off**

enable_connect_standby

Parameter description: Sets the connection between a CN and a standby DN. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: Boolean

- **on** indicates that the CN connects to the standby server.
- **off** indicates that the CN connects to the primary DN.

Default value: **off**

CAUTION

- You are not advised to use this parameter in routine services. This parameter applies only to O&M operations. You are not advised to use the **gs_guc tool** for global settings. Otherwise, problems such as data inconsistency and result set errors may occur.
- Enabling this parameter for a session with temporary tables will delete the temporary table data on DNs and prevent further actions on those tables.

comm_max_receiver

Parameter description: Specifies the number of internal receiving threads of the communication library.

Type: POSTMASTER

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 continuously sent by the communication library. When you use a 1GE NIC, a small value ranging from 20 KB to 40 KB is recommended.

Type: USERSET

Value range: an integer ranging from 0 to 102400. The default unit is KB. The value **0** indicates that the quota mechanism is not used.

Default value: **1 MB**

comm_usable_memory

Parameter description: Specifies the maximum memory that can be used by the communication library cache on a single DN.

Type: SIGHUP

Value range: an integer ranging from 1 to 256. The default unit is KB. The minimum size cannot be less than 1 GB for installation.

Default value: **max_process_memory/8**

NOTICE

This parameter must be specifically set based on environment memory and the deployment method. If it is too large, out-of-memory (OOM) may occur. If it is too small, the performance of the communication library may deteriorate.

comm_memory_pool_percent

Parameter description: Specifies the percentage of the memory pool resources that can be used by the communication library on a DN. This parameter is used to adaptively reserve memory used by the communication libraries.

Type: POSTMASTER

Value range: an integer ranging from 0 to 100

Default value: **0**

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.

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.

Type: USERSET

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 a cluster are on the same communication 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 a cluster depends on the number of random ports because a port can be used only by one client at a time.

Default value: **off**

comm_no_delay

Parameter description: Specifies whether to use the **NO_DELAY** attribute of the communication library connection. Restart the cluster for the setting to take effect.

Type: USERSET

Value range: Boolean

Default value: off

NOTICE

If packet loss occurs because a large number of packets are received per second, set this parameter to **off** to reduce the total number of packets.

comm_debug_mode

Parameter description: Specifies the debug mode of the communication library, that is, whether to print logs about the communication layer. The setting is effective at the session layer.

NOTICE

When the switch is set to **on**, the number of printed logs is huge, adding extra overhead and reducing database performance. Therefore, set the switch to **on** only in the debug mode.

Type: USERSET

Value range: Boolean

- **on** indicates the detailed debug log of the communication library is printed.
- **off** indicates the detailed debug log of the communication library is 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 package is received.

Type: USERSET

Value range: an integer ranging from 0 to 20000. The unit is millisecond (ms). **0** indicates that automatic ACK triggering is disabled.

Default value: **2000**

comm_timer_mode

Parameter description: Specifies the timer mode of the communication library, that is, whether to print timer logs in each phase of the communication layer. The setting is effective at the session layer.

NOTICE

When the switch is set to **on**, the number of printed logs is huge, adding extra overhead and reducing database performance. Therefore, set the switch to **on** only in the debug mode.

Type: USERSET

Value range: Boolean

- **on** indicates the detailed timer log of the communication library is printed.
- **off** indicates the detailed timer log of the communication library is not printed.

Default value: **off**

comm_stat_mode

Parameter description: Specifies the stat mode of the communication library, that is, whether to print statistics about the communication layer. The setting is effective at the session layer.

NOTICE

When the switch is set to **on**, the number of printed logs is huge, adding extra overhead and reducing database performance. Therefore, set the switch to **on** only in the debug mode.

Type: USERSET

Value range: Boolean

- **on** indicates the statistics log of the communication library is printed.
- **off** indicates the statistics log of the communication library is not printed.

Default value: off

enable_stateless_pooler_reuse

Parameter description: Specifies whether to enable the pooler reuse mode. The setting takes effect after the cluster is restarted.

Type: POSTMASTER

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

Set this parameter to the same value for CNs and DNs. If **enable_stateless_pooler_reuse** is set to **off** for CNs and set to **on** for DNs, the cluster communication fails. Restart the cluster to make the setting take effect.

Default value: **off**

comm_cn_dn_logic_conn

Parameter description: Specifies a switch for logical connections between CNs and DNs. The parameter setting takes effect only after the cluster is restarted.

Type: POSTMASTER

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

  If **comm_cn_dn_logic_conn** is set to **off** for CNs and set to **on** for DNs, cluster communication will fail. You are advised to set this parameter to the same value for all CNs and DNs. Restart the cluster to make the setting take effect.

Default value: off

client_connection_check_interval

Parameter description: Specifies the interval for checking the client connection status. This parameter is supported by version 8.2.0 or later clusters.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX. The unit is ms. The value **0** indicates that the client connection status is not checked.

Default value: **10000**

NOTICE

During a long query executed in a session where a client (such as gsql, JDBC, or ODBC) directly connects to the CN,

- The CN checks the client connection status at the interval specified by **client_connection_check_interval**. If it detects that the client has been disconnected from the CN, the server terminates the long query and releases related resources to avoid waste of cluster resources.
- The DN checks its connection to the CN at the interval specified by **client_connection_check_interval**. If the DN detects that it has been disconnected from the CN, it terminates the long query and releases related resources to avoid waste of cluster resources.

conn_recycle_timeout

Parameter description: the interval for reclaiming idle connections between a CN and other nodes to the connection pool. This parameter is supported only by clusters of version 8.2.1 or later.

Type: USERSET

Value range: an integer ranging from 0 to 3600, in second (s). **0** indicates that the function of reclaiming idle connections is disabled.

Default value: **30**

17.5 Resource Consumption

17.5.1 Memory

This section describes memory parameters.

NOTICE

Parameters described in this section take effect only after the database service restarts.

enable_memory_limit

Parameter description: Specifies whether to enable the logical memory management module.

Type: POSTMASTER

Value range: Boolean

- **on** indicates the logic memory management module is enabled.
- **off** indicates the logic memory management module is disabled.

Default value: **on**

NOTICE

- If the result of **max_process_memory** - **max_shared_memory** - **cstore buffers** is less than 2 GB, **enable_memory_limit** is forcibly set to **off**.
- The **max_shared_memory** parameter is closely related to the **shared_buffer**, **max_connections**, and **max_prepared_transactions** parameters. If the value of **max_shared_memory** is too large, you can decrease the values of the three parameters.
- The dynamic load management function depends on the memory management function. After the **enable_memory_limit** parameter is disabled, the dynamic load management and TopSQL functions become invalid.

max_process_memory

Parameter description: Specifies the maximum physical memory of a database node.

Type: SIGHUP

Value range: an integer ranging from 2 x 1024 x 1024 to INT_MAX/2. The unit is KB.

Default value: Determined based on non-secondary DNs. If multiple DNs are deployed on a server, the value is (Physical memory size) x 0.8/(1 + Number of primary DNs). If a single DN is deployed on a server, the value is (Physical memory size) x 0.6. If the calculation result is less than 2 GB, the value is 2 GB by default. The default size of the secondary DN is 12 GB.

Setting suggestions:

- On DNs, the value of this parameter is determined based on the physical system memory and the number of DNs deployed on a single node. If multiple DNs are deployed on a server, the value of **max_process_memory** is (Physical memory – **vm.min_free_kbytes**) x 0.8/(n + Number of primary DNs). If a single DN is deployed on a server, the value of **max_process_memory** is (Physical memory – **vm.min_free_kbytes**) x 0.6. This parameter aims to ensure system reliability, preventing node OOM caused by increasing memory usage. **vm.min_free_kbytes** indicates OS memory reserved for kernels to receive and send data. Its value is at least 5% of the total memory. That is, **max_process_memory** = Physical memory x 0.8/(n + Number of primary DNs). If the cluster scale (number of nodes in the cluster) is smaller than 256, n=1; if the cluster scale is larger than 256 and smaller than 512, n=2; if the cluster scale is larger than 512, n=3.
- You are not advised to set this parameter to the minimum threshold.
- Set this parameter on CNs to the same value as that on DNs.
- RAM is the maximum memory allocated to the cluster.
- In GaussDB(DWS) 8.2.0 and later versions, the initial value of **max_process_memory** is increased to improve memory resource utilization. However, in an unbalanced cluster where a server has two primary DNs running, using the initial value of **max_process_memory** may cause OOM. In 8.2.0 and later versions, the **max_process_memory** parameter is changed to the SIGHUP type and can be manually adjusted. The **max_process_memory_auto_adjust** parameter is added. If a cluster is unbalanced, its CM will dynamically adjust **max_process_memory** based on the cluster status. The value of **max_process_memory** is (Physical memory – **vm.min_free_kbytes**) x 0.8/Number of primary DNs.
- In GaussDB(DWS) 8.2.1 or later, the application scope of dynamically adjusting the value of **max_process_memory** is expanded from clusters where each server has only one DN to all cluster deployment modes.
  - If **max_process_memory_auto_adjust** is set to **on**, the value of **max_process_memory** is dynamically adjusted between the upper limit and the lower limit. The lower limit is calculated as follows: (Physical memory size) x 0.8/(1 + Number of primary DNs). The upper limit is specified by the GUC parameter **max_process_memory_balanced**. (For details about how to set **max_process_memory_balanced**, contact technical support.)
  - When the cluster works in load balancing mode, the upper limit of **max_process_memory** is used to improve the overall memory usage of the node. Compared with earlier versions, the memory usage is improved.
  - When the cluster is not in load balancing mode, the lower limit of **max_process_memory** is used. The overall memory usage of the node is the same as that in versions earlier than 8.2.1.
  - In upgrade scenarios, to ensure forward compatibility, the system does not set **max_process_memory_balanced**, and **max_process_memory** uses the value set before the upgrade by default.

max_process_memory_auto_adjust

Parameter description: Specifies whether to enable automatic adjustment for **max_process_memory** parameter. (This parameter is supported only by cluster

versions 8.2.0 and later.) In a cluster where each server only has one DN, if this function is enabled, the CM dynamically adjusts the value of **max_process_memory** on the corresponding DN during an active/standby switchover.

Type: SIGHUP

Value range: Boolean

Default value: **on**

Suggestion: Set this parameter to **on**. For a cluster where each server only has one DN, the initial value of **max_process_memory** is increased in 8.2.0 and later versions to improve memory resource utilization. However, after a primary/standby switchover, there will be two primary DNs running on the same server. Using the initial value of **max_process_memory** in this case may cause OOM, and you need to let the CM dynamically adjust the value.

shared_buffers

Parameter description: Specifies the size of shared memory used by GaussDB(DWS). If this parameter is set to a large value, GaussDB(DWS) may require more System V shared memory than the default setting.

Type: POSTMASTER

Value range: an integer ranging from 128 to INT_MAX. The unit is 8 KB.

Changing the value of **BLCKSZ** will result in a change in the minimum value of the **shared_buffers**.

Default value: The value of CN is half of the value of DN. The value of DN is calculated using the following formula: **POWER(2,ROUND(LOG(2, max_process_memory/18),0))**. If the maximum value allowed by the OS is smaller than 32 MB, this parameter will be automatically changed to the maximum value allowed by the OS during database initialization.

Setting suggestions:

You are advised to set this parameter for DNs to a value greater than that for CNs, because GaussDB(DWS) pushes its most queries down to DNs.

It is recommended that **shared_buffers** be set 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

If you want to increase the value of **shared_buffers**, you also need to increase the value of **checkpoint_segments**, because a longer period of time is required to write a large amount of new or changed data.

bulk_write_ring_size

Parameter description: Specifies the size of the ring buffer used for data parallel import.

Type: USERSET

Value range: an integer ranging from 16384 to INT_MAX. The unit is KB.

Default value: **2 GB**

Setting suggestions: Increase the value of this parameter on DNs if a huge amount of data is to be imported.

buffer_ring_ratio

Parameter description: ring buffer threshold for parallel data export

Type: USERSET

Value range: integer in the range 1–1000

Default value: 250

NOTE

- The default value indicates that the threshold is 250/1000 (a quarter) of **shared_buffers**.
- The minimum value is 1/1000 of the value of **shared_buffers**.
- The maximum value is the value of **shared_buffers**.

Setting suggestions: If the cache hit ratio is not as expected during export, you are advised to configure this parameter on DNs.

enable_cstore_ring_buffer

Parameter description: Specifies whether to enable column-store RingBuffer. This parameter is supported only by cluster versions 8.2.0 and later.

Type: USERSET

Value range: Boolean

Default value: **off**

Suggestion: If workloads have been running for a period of time, a large amount of frequently queried data has been stored in the CStoreBuffer, and you want to query large tables that are rarely accessed, you are advised to enable this function before the query and disable it after the query.

temp_buffers

Parameter description: Specifies the maximum size of local temporary buffers used by each database session.

Type: USERSET

Value range: an integer ranging from 800 to INT_MAX/2. The unit is 8 KB.

Default value: **8 MB**

NOTE

- 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.
- Based on the value of **temp_buffers**, a session allocates temporary buffers as required. The cost of setting a large value in sessions that do not require many temporary buffers is only a buffer descriptor. If a buffer is used, 8192 bytes will be consumed for it.

max_prepared_transactions

Parameter description: Specifies the maximum number of transactions that can stay in the **prepared** state simultaneously. If this parameter is set to a large value, GaussDB(DWS) may require more System V shared memory than the default setting.

When GaussDB(DWS) is deployed as an HA system, set this parameter on the standby server to the same value or a value greater than that on the primary server. Otherwise, queries will fail on the standby server.

Type: POSTMASTER

Value range: an integer ranging from 0 to 536870911. The value of CN set to **0** indicates that the prepared transaction feature is disabled.

Default value: **800** for both CNs and DNs

NOTE

Set this parameter to a value greater than or equal to that of **max_connections** to avoid failures in preparation.

work_mem

Parameter description: Specifies the memory capacity to be used by internal sort operations and Hash tables before writing to temporary disk files. Sort operations are used for **ORDER BY**, **DISTINCT**, and merge joins. Hash tables are required for Hash joins as well as Hash-based aggregations and **IN** subqueries.

For a complex query, several sort or Hash operations may be running in parallel; each operation will be allowed to use as much memory as this value specifies. If the memory is insufficient, data is 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**.

Type: USERSET

Value range: an integer ranging from 64 to INT_MAX. The unit is KB.

Default value: 512 MB for small-scale memory and 2 GB for large-scale memory (If **max_process_memory** is greater than or equal to 30 GB, it is large-scale memory. Otherwise, it is small-scale memory.)

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.

- In complex serial query scenarios, each query requires five to ten associated operations. Set **work_mem** using the following formula: **work_mem** = 50% of the memory/10.
- In simple serial query scenarios, 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, use the formula: **work_mem** = **work_mem** in serialized scenario/Number of concurrent SQL statements.

query_mem

Parameter description: Specifies the memory used by query. If the value of **query_mem** is greater than 0, the optimizer adjusts the estimated query memory to this value when generating an execution plan.

Type: USERSET

Value range: **0** or an integer greater than 32 MB. The default unit is KB. If the value is set to a negative value or less than 32 MB, the default value **0** is used. In this case, the optimizer does not adjust the estimated query memory.

Default value: **0**

query_max_mem

Parameter description: Specifies the maximum memory that can be used by query. If the value of **query_max_mem** is greater than 0, when generating an execution plan, the optimizer uses this value to set the available memory for operators. If job memory usage exceeds the value of this parameter, an error is reported and the job exits.

Type: USERSET

Value range: **0** or an integer greater than 32 MB. The default unit is KB. If the value is less than 32 MB, the system automatically sets this parameter to the default value **0**. In this case, the optimizer does not limit the memory usage of jobs.

Default value: **0**

agg_max_mem

Parameter description: Specifies the maximum memory that can be used by the Agg operator when the number of aggregation columns exceeds 5. This parameter takes effect only if the value of **agg_max_mem** is greater than 0. (This parameter is supported only in 8.1.3.200 and later cluster versions.)

Type: USERSET

Value range: **0** or an integer greater than 32 MB. The default unit is KB. If the value is less than 32 MB, the system automatically sets this parameter to the default value **0**. In this case, the memory usage of the Agg operator is not limited based on the value.

Default value:

- If the current cluster is upgraded from an earlier version to 8.1.3 or later, the value in the earlier version is inherited. The default value is **INT_MAX**.
- If the current cluster version is 8.1.3 or later, the default value is **2GB**.

enable_rowagg_memory_control

Parameter description: Specifies the upper limit of the memory used by the row-store agg operator.

Type: USERSET

Value range: Boolean

- **on** indicates that the memory usage limit of the row-store agg operator is enabled. Setting this parameter to **on** can avoid OOM caused by the row-store agg operator, but may affect the agg performance.
- **off** indicates that the memory usage limit of the row-store agg operator is disabled. If this parameter is set to **off**, the system memory may be unavailable.

Default value: **on**

maintenance_work_mem

Parameter description: Specifies the maximum size of memory to be used for 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.

Type: USERSET

Value range: an integer ranging from 1024 to INT_MAX. The unit is KB.

Default value: 512 MB for small-scale memory and 2 GB for large-scale memory (If **max_process_memory** is greater than or equal to 30 GB, it is large-scale memory. Otherwise, it is small-scale memory.)

Setting suggestions:

- You are advised to set this parameter to the same value of **work_mem** so that database dump can be cleared or restored more quickly. In a database session, only one maintenance operation can be performed at a time. Maintenance is usually performed when there are not much sessions.
- When the **Automatic Cleanup** process is running, up to **autovacuum_max_workers** times of this memory may be allocated. Set **maintenance_work_mem** to a value equal to or larger than the value of **work_mem**.
- If a large amount of data needs to be processed in the cluster, increase the value of this parameter in sessions.

psort_work_mem

Parameter description: Specifies the memory used for internal sort operations on column-store tables before they are written into 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.

Type: USERSET

NOTICE

Multiple running sessions may perform partial sorting on a table at the same time. Therefore, the total memory usage may be several times of the **psort_work_mem** value.

Value range: an integer ranging from 64 to INT_MAX. The unit is KB.

Default value: **512 MB**

max_loaded_cudesc

Parameter description: Specifies the number of loaded CuDescs per column when a column-store table is scanned. Increasing the value will improve the query performance and increase the memory usage, particularly when there are many columns in the column tables.

Type: USERSET

Value range: an integer ranging from 100 to INT_MAX/2

Default value: **1024**

NOTICE

When the value of **max_loaded_cudesc** is set to a large value, the memory may be insufficient.

max_stack_depth

Parameter description: Specifies the maximum safe depth of GaussDB(DWS) 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.

Type: SUSET

Take the following into consideration when setting this parameter:

- The ideal value of this parameter is the maximum stack size enforced by the kernel (value of **ulimit -s**).
- Setting this parameter to a value larger than the actual kernel limit means that a running recursive function may crash an individual backend process. In an OS where GaussDB(DWS) can check the kernel limit, such as the SLES, GaussDB(DWS) will prevent this parameter from being set to a value greater than the kernel limit.
- Since not all the OSs provide this function, you are advised to set a specific value for this parameter.

Value range: an integer ranging from 100 to INT_MAX. The unit is KB.

Default value: **2 MB**

NOTE

2 MB is a small value and will not incur system breakdown in general, but may lead to execution failures of complex functions.

cstore_buffers

Parameter description: Specifies the size of the shared buffer used by ORC, Parquet, or CarbonData data of column-store tables and OBS or HDFS column-store foreign tables.

Type: POSTMASTER

Value range: an integer ranging from 16384 to INT_MAX. The unit is KB.

Default value: The CN size is 32 MB, and the DN size is calculated as follows: **POWER(2,ROUND(LOG(2, max_process_memory/18),0))**.

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**.

Use **cstore_buffers** to specify the cache of ORC, Parquet, or CarbonData metadata and data for OBS or HDFS foreign tables. The metadata cache size should be 1/4 of **cstore_buffers** and not exceed 2 GB. The remaining cache is shared by column-store data and foreign table column-store data.

enable_orc_cache

Parameter description: Specifies whether to reserve 1/4 of **cstore_buffers** for storing ORC metadata when the cstore buffer is initialized.

Type: POSTMASTER

Value range: Boolean

Default value:

- **on** indicates that the orc metadata cache is enabled, which improves the query performance of the HDFS table but occupies the column-store buffer resources. The column-store performance deteriorates.
- **off** indicates the orc metadata cache is disabled.

dfs_max_memory

Parameter description: Specifies the maximum memory that can be occupied during ORC export. If the memory is insufficient when a wide table is exported, increase the value of this parameter and try again. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: an integer ranging from 131072 to 10485760. The unit is KB.

Default value: 262144 KB (256 MB)

schedule_splits_threshold

Parameter description: Specifies the maximum number of files that can be stored in memory when you schedule an HDFS foreign table. If the number is exceeded, all files in the list will be spilled to disk for scheduling.

Type: USERSET

Value range: an integer ranging from 1 to INT_MAX

Default value: **60000**

bulk_read_ring_size

Parameter description: Specifies the ring buffer size used for data parallel export.

Type: USERSET

Value range: an integer ranging from 256 to INT_MAX. The unit is KB.

Default value: **16 MB**

check_cu_size_threshold

Parameter description: If the amount of data inserted to a CU is greater than the value of this parameter when data is inserted to a column-store table, the system starts row-level size verification to prevent the generation of a CU whose size is greater than 1 GB (non-compressed size).

Type: USERSET

Value range: an integer ranging from 0 to 1048576. The unit is MB.

Default value: 1 GB

max_volatile_memory

Parameter description: Specifies the maximum total memory occupied by contexts related to volatile temporary tables in all sessions. The memory used by a query to create a volatile table cannot exceed the value of this parameter, or an error will be reported. This parameter is supported by version 8.2.0 or later clusters.

Type: SIGHUP

Value range: an integer ranging from 1024 to INT_MAX. The unit is KB.

Default value: 1 GB

17.5.2 Statement Disk Space Control

This section describes parameters related to statement disk space control, which are used to limit the disk space usage of statements.

sql_use_spacelimit

Parameter description: Specifies the allowed maximum space for files to be spilled to disks in a single SQL statement on a single DN. This parameter limits the space occupied by ordinary tables, temporary tables, and intermediate result sets spilled to disks. System administrators are also restricted by this parameter.

Type: USERSET

Value range: an integer ranging from -1 to INT_MAX. The unit is KB. **–1** indicates no limit.

Default value: Set **sql_use_spacelimit** to 10% of the total disk space of the instance.

NOTE

For example, if **sql_use_spacelimit** is set to **100** in the statement, and the data spilled to disks on a single DN exceeds 100 KB, DWS will stop the query and display a message indicating threshold exceeded.

```
insert into user1.t1 select * from user2.t1;
ERROR:  The space used on DN (104 kB) has exceeded the sql use space limit (100 kB).
```

Handling suggestion:

- Optimize the statement to reduce the data spilled to disks.
- If the disk space is sufficient, increase the value of this parameter.

temp_file_limit

Parameter description: Specifies the total space for files spilled to disks in a single thread. The temporary file can be the one used by sorting or hash tables, or cursors in a session.

This is a session-level setting.

Type: SUSET

Value range: an integer ranging from -1 to INT_MAX. The unit is KB. **–1** indicates no limit.

Default value: Set **temp_file_limit** to 10% of the total disk space of the instance.

NOTICE

This parameter does not apply to disk space occupied by temporary tablespaces used for executing SQL queries.

bi_page_reuse_factor

Parameter description: Specifies the percentage of idle space of old pages that can be reused when page replication is used for data synchronization between primary and standby DNs in the scenario where data is inserted into row-store tables in batches.

Type: USERSET

Value range: an integer ranging from 0 to 100. The value is a percentage. Value **0** indicates that the old pages are not reused and new pages are requested.

Default value: **70**

NOTICE

- You are not advised to set this parameter to a value less than **50** (except **0**). If the idle space of the reused page is small, too much old page data will be transmitted between the primary and standby DNs. As a result, the batch insertion performance deteriorates.
- You are not advised to set this parameter to a value greater than **90**. If this parameter is set to a value greater than **90**, idle pages will be frequently queried, but old pages cannot be reused.

17.5.3 Kernel Resources

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.

But on some platforms, especially on most BSD systems, the kernel allows independent processes to open far more files than the system can really support. If the message "Too many open files" is displayed, try to reduce the setting. Generally, the number of file descriptors must be greater than or equal to the maximum number of concurrent tasks multiplied by the number of primary DNs on the current physical machine (*max_files_per_process*3).

Type: POSTMASTER

Value range: an integer ranging from 25 to INT_MAX

Default value: **1000**

max_files_per_node

Parameter description: Specifies the maximum number of files that can be opened by a single SQL statement on a single node. Generally, you do not need to set this parameter. This parameter is supported by version 8.1.3 or later clusters.

Parameter type: SUSET

Value range: an integer ranging from -1 to INT_MAX. The value **-1** indicates that the maximum number is not limited.

Default value: **50000**

NOTE

If the error message "The last file name is [%s] and %d files have already been opened on data node [%s] with a maximum of %d files." is displayed during statement execution, increase the value of **max_files_per_node**.

enable_fd_check

Parameter description: Specifies whether to perform verification when FD is used. This parameter is supported only by 8.2.1.300 and later versions.

Type: SIGHUP

Value range: Boolean

- **on** indicates that FD verification is enabled.
- **off** indicates that FD verification is enabled.

Default value: **on**

17.5.4 Cost-based Vacuum Delay

The purpose of cost-based vacuum delay is to allow administrators to reduce the I/O impact of **VACUUM** and **ANALYZE** statements on concurrently active databases. For example, when maintenance statements such as **VACUUM** and **ANALYZE** do not need to be executed quickly and do not interfere with other database operations, administrators can use this function to achieve this purpose.

NOTICE

Certain operations hold critical locks and should be complete as quickly as possible. In GaussDB(DWS), cost-based vacuum delays do not take effect during such operations. To avoid uselessly long delays in such cases, the actual delay is calculated as follows and is the maximum value of the following calculation results:

- vacuum_cost_delay*accumulated_balance/vacuum_cost_limit
- vacuum_cost_delay*4

During the execution of the ANALYZE | ANALYSE and 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 value other than 0.

vacuum_cost_delay

Parameter description: Specifies the length of time that the process will sleep when **vacuum_cost_limit** has been exceeded.

Type: USERSET

Value range: an integer ranging from 0 to 100. The unit is millisecond (ms). A positive number enables cost-based vacuum delay and **0** disables cost-based vacuum delay.

Default value: **0**

NOTICE

- On many systems, the effective resolution of sleep length is 10 ms. 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 set to a small value, such as 10 or 20 milliseconds. Adjusting vacuum's resource consumption is best done by changing other parameters.

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 page.

Type: USERSET

Value range: an integer ranging from 0 to 10000. The unit is millisecond (ms).

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.

Type: USERSET

Value range: an integer ranging from 0 to 10000. The unit is millisecond (ms).

Default value: **2**

vacuum_cost_page_dirty

Parameter description: Specifies the estimated cost charged when vacuum modifies a block that was previously clean. It represents the I/Os required to flush the dirty block out to disk again.

Type: USERSET

Value range: an integer ranging from 0 to 10000. The unit is millisecond (ms).

Default value: **20**

vacuum_cost_limit

Parameter description: Specifies the cost limit. The cleanup process will sleep if this limit is exceeded.

Type: USERSET

Value range: an integer ranging from 1 to 10000. The unit is ms.

Default value: 200

17.5.5 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.

Type: SUSET

Value range: Boolean

- **on** or **true** indicates the log switch is enabled.
- **off** or **false** indicates the log switch is disabled.

Default value: **off**

enable_fast_allocate

Parameter description: Specifies whether the quick allocation switch of the disk space is enabled. This switch can be enabled only in the XFS file system.

Type: SUSET

Value range: Boolean

- **on** or **true** indicates that this function is enabled.
- **off** or **false** indicates that the function is disabled.

Default value: **off**

prefetch_quantity

Parameter description: Specifies the number of row-store prefetches using the ADIO.

Type: USERSET

Value range: an integer ranging from 1024 to 1048576. The unit is 8 KB.

Default value: **32 MB**

backwrite_quantity

Parameter description: Specifies the number of row-store writes using the ADIO.

Type: USERSET

Value range: an integer ranging from 1024 to 1048576. The unit is 8 KB.

Default value: **8MB**

cstore_prefetch_quantity

Parameter description: Specifies the number of column-store prefetches using the ADIO.

Type: USERSET

Value range: an integer. The value range is from 1024 to 1048576 and the unit is KB.

Default value: **32 MB**

cstore_backwrite_quantity

Parameter description: Specifies the number of column-store writes using the ADIO.

Type: USERSET

Value range: an integer. The value range is from 1024 to 1048576 and the unit is KB.

Default value: **8MB**

cstore_backwrite_max_threshold

Parameter description: Specifies the maximum number of column-store writes buffered in the database using the ADIO.

Type: USERSET

Value range: An integer. The value range is from 4096 to INT_MAX/2 and 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.

Type: SUSET

Value range: an integer. The value range is from 1024 to 1048576 and the unit is KB.

Default value: **8MB**

effective_io_concurrency

Parameter description: Specifies the number of requests that can be simultaneously processed by the disk subsystem. For the RAID array, the parameter value must be the number of disk drive spindles in the array.

Type: USERSET

Value range: an integer ranging from 0 to 1000

Default value: **1**

17.6 Parallel Data Import

GaussDB(DWS) 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 in GaussDB(DWS).

raise_errors_if_no_files

Parameter description: Specifies whether 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 **true** and the problem "the imported file does not exist" occurs, GaussDB(DWS) will report the error message "file does not exist".

Type: SUSET

Value range: Boolean

- **on** indicates 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 the messages of "the number of imported file records is empty" and "the imported file does not exist" are not distinguished when files are imported.

Default value: **off**

partition_max_cache_size

Parameter description: To optimize the inserting of column-store partitioned tables in batches, data is cached during the inserting process and then written to the disk in batches. You can use **partition_max_cache_size** to specify the size of the data buffer. 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.

Type: USERSET

Value range: 4096 to INT_MAX/2. The minimum unit is KB.

Default value: **2 GB**

partition_mem_batch

Parameter description: To optimize the performance of batch insert into column-store partitioned tables, data is cached during the inserting process and then written to the disk in batches. If **partition_max_cache_size** is configured, **partition_mem_batch** can be used to specify the number of caches. If this parameter is set to a large value, the available cache of each partition will be small, and the performance of batch insert into column-store partitioned tables will deteriorate. If this parameter is set to a small value, the available cache of each partition will be large, consuming much system memory.

Type: USERSET

Value range: 1 to 65535

Default value: **256**

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 this way, 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.

Type: USERSET

Value range: Boolean

- **on** indicates that the GDS debug function is enabled.
- **off** indicates that the GDS debug function is disabled.

Default value: **off**

max_copy_data_display

Parameter description: GUC control added for the length of the **rawrecord** field in the copy error table, in the text type. The maximum value is 1 GB minus 8203 bytes (that is, 1073733621 bytes). This parameter is supported only by clusters of versions 8.2.1.100 or later.

When this parameter is set, it indicates the maximum number of characters that can be displayed. If the number of characters exceeds the maximum, an ellipsis (...) is displayed at the end.

Type: USERSET

Value range: 0 to 1073733616

Default value: **1024**

17.7 Write Ahead Logs

17.7.1 Settings

wal_level

Parameter description: Specifies the level of the information that is written to WALs.

Type: POSTMASTER

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 only contain basic information required for the recovery from a database server crash or an emergency shutdown. Archived WALs cannot be used to restore data.

- 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 is little measurable difference in performance between using **hot_standby** and **archive** levels, so feedback is welcome if any production performance impacts are noticeable.

Default value: **hot_standby**

NOTICE

- To enable WAL archiving and data streaming replication between primary and standby servers, set this parameter to **archive** or **hot_standby**.
- If this parameter is set to **archive**, **hot_standby** must be set to **off**. Otherwise, the database startup fails.

synchronous_commit

Parameter description: Specifies the synchronization mode of the current transaction.

Type: USERSET

Value range: enumerated values

- **on** indicates synchronization logs of a standby server are updated to disks.
- **off** indicates asynchronous commit.
- **local** indicates local commit.
- **remote_write** indicates synchronization logs of a standby server are written to disks.
- **remote_receive** indicates synchronization logs of a standby server are required to receive data.

Default value: **on**

wal_buffers

Parameter description: Specifies the number of XLOG_BLCKSZs used for storing WAL data. The size of each XLOG_BLCKSZ is 8 KB.

Type: POSTMASTER

Value range: -1 to 2^{18}. The unit is 8 KB.

- If this parameter is set to **-1**, the value of **wal_buffers** is automatically changed to 1/32 of **shared_buffers**. The minimum value is 8 x **XLOG_BLCKSZ**, and the maximum value is 2048 x **XLOG_BLCKSZ**.
- If it is set to a value smaller than **8**, the value **8** is used. If it is set to a value greater than 2048, the value **2048** is used.

Default value: **256 MB**

Setting suggestions: The content of WAL buffers is written to disks at each transaction commit, and setting this parameter to a large value does not significantly improve system performance. Setting this parameter to hundreds of megabytes can improve the disk writing performance on the server, to which a large number of transactions are committed. Based on experiences, the default value meets user requirements in most cases.

enable_wal_decelerate

Parameter description: Specifies whether to enable WAL log rate limiting. This parameter is supported only by cluster versions 8.2.0 and later.

Type: SIGHUP

Value range: Boolean

- **on** indicates that this feature is enabled.
- **off** indicates that this feature is disabled.

Default value: **on**

wal_decelerate_policy

Parameter description: Specifies the behavior policy after rate limiting is triggered. This parameter is supported only by clusters of 8.2.0 and later versions.

Type: USERSET

Value range: enumerated values

- **warning** indicates that an alarm is generated but the rate is not limited.
- **decelerate** indicates that the rate will be limited based on policy settings.

Default value: **warning**

NOTE

Setting the parameter to **warning** does not affect performance. Setting it to **decelerate** will limit the rate based on policy settings if the rate exceeds the threshold.

wal_write_speed

Parameter description: Specifies the maximum WAL write speed (byte/s) allowed by each query on a single DN. This parameter is supported only by clusters of 8.2.0 or later.

Type: USERSET

Value range: an integer ranging from 1024 to 10240000, in KB.

Default value: **30MB**

NOTE

The rate of a large number of jobs with index copy and deletion operations will be limited.

wal_decelerate_trigger_threshold

Parameter description: Specifies the threshold of WAL write rate limiting for each query on a single DN. This parameter is supported only by cluster versions 8.2.0 and later.

Type: USERSET

Value range: an integer ranging from 1024 to 100000000000, in KB.

Default value: **128MB**

NOTE

This function is triggered only if the number of Xlogs generated by a single query is greater than the value of this parameter. DDL operations or a small number of DML operations are not affected.

commit_delay

Parameter description: Specifies the duration of committed data be stored in the WAL buffer.

Type: USERSET

Value range: an integer, ranging from 0 to 100000 (unit: μs). **0** indicates no delay.

Default value: **0**

NOTICE

- When this parameter is set to a value other than 0, the committed transaction is stored in the WAL buffer instead of being written to the WAL immediately. Then, the WalWriter 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 transactions are waiting to be submitted, the delay is a waste of time.

commit_siblings

Parameter description: Specifies a limit on the number of ongoing transactions. If the number of ongoing transactions is greater than the limit, a new transaction will wait for the period of time specified by **commit_delay** before it is submitted. If the number of ongoing transactions is less than the limit, the new transaction is immediately written into a WAL.

Type: USERSET

Value range: an integer ranging from 0 to 1000

Default value: **5**

enable_xlog_group_insert

Parameter description: Specifies whether to enable the group insertion mode for WALs. Only the Kunpeng architecture supports this parameter.

Type: SIGHUP

Value range: Boolean

- **on**: enabled
- **off**: disabled

Default value: **on**

wal_compression

Parameter description: Specifies whether to compress FPI pages.

Type: USERSET

Value range: Boolean

- **on**: enable the compression
- **off**: disable the compression

Default value: **on**

NOTICE

- Only zlib compression algorithm is supported.
- For clusters that are upgraded to the current version from an earlier version, this parameter is set to **off** by default. You can run the **gs_guc** command to enable the FPI compression function if needed.
- If the current version is a newly installed version, this parameter is set to **on** by default.
- If this parameter is manually enabled for a cluster upgraded from an earlier version, the cluster cannot be rolled back.

wal_compression_level

Parameter description: Specifies the compression level of zlib compression algorithm when the **wal_compression** parameter is enabled.

Type: USERSET

Value range: an integer ranging from 0 to 9.

- **0** indicates no compression.

- **1** indicates the lowest compression ratio.
- **9** indicates the highest compression ratio.

Default value: **9**

17.7.2 Checkpoints

checkpoint_segments

Parameter description: minimum number of WAL segment files in the period specified by **checkpoint_timeout**. The size of each log file is 16 MB.

Type: SIGHUP

Value range: an integer. The minimum value is **1**.

Default value: **64**

NOTICE

Increasing the value of this parameter speeds up the export of big data. Set this parameter based on **checkpoint_timeout** and **shared_buffers**. This parameter affects the number of WAL log 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 log segment files which will be later used.

checkpoint_timeout

Parameter description: Specifies the maximum time between automatic WAL checkpoints.

Type: SIGHUP

Value range: an integer ranging from 30 to 3600 (s)

Default value: **15min**

NOTICE

If the value of **checkpoint_segments** is increased, you need to increase the value of this parameter. The increase of them further requires the increase of **shared_buffers**. Consider all these parameters during setting.

17.7.3 Archiving

archive_mode

Parameter description: When **archive_mode** is enabled, completed WAL segments are sent to archive storage by setting **archive_command**.

Type: SIGHUP

Value range: Boolean

- **on**: The archiving is enabled.
- **off**: The archiving is disabled.

Default value: **off**

NOTICE

When **wal_level** is set to **minimal**, **archive_mode** cannot be used.

archive_command

Parameter description: Specifies the command used to archive WALs set by the administrator. You are advised to set the archive log path to an absolute path.

Type: SIGHUP

Value range: a string

Default value: **(disabled)**

NOTICE

- Any **%p** in the string is replaced with the absolute path of the file to archive, and any **%f** is replaced with 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. Example:
```
archive_command = 'cp --remove-destination %p /mnt/server/archivedir/%f'
archive_command = 'copy %p /mnt/server/archivedir/%f'  # Windows
```
- **--remove-destination** indicates that files will be overwritten during the archiving.
- When **archive_mode** is set to **on** or not specified, a **backup** folder will be created in the **pg_xlog** directory and WALs will be compressed and copied to the **pg_xlog/backup** directory.

archive_timeout

Parameter description: Specifies the archiving period.

Type: SIGHUP

Value range: an integer ranging from 0 to INT_MAX. The unit is second. **0** indicates that archiving timeout is disabled.

Default value: **0**

NOTICE

- The server is forced to switch to a new WAL segment file with the period specified by this parameter.
- Archived files that are closed early due to a forced switch are still of the same length as completely full files. Therefore, a very short **archive_timeout** will bloat the archive storage. You are advised to set **archive_timeout** to **60s**.

17.8 HA Replication

17.8.1 Sending Server

wal_keep_segments

Parameter description: Specifies the number of Xlog file segments. Specifies the minimum number of transaction log files stored in the **pg_xlog** directory. The standby server obtains log files from the primary server for streaming replication.

Type: SIGHUP

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 retains more log files than the number specified by **wal_keep_segments**.
- If this parameter is set to a too small value, a transaction log may have been overwritten by a new transaction log before requested by the standby server. As a result, the request fails, and the relationship between the primary and standby servers is interrupted.
- 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.

max_build_io_limit

Parameter description: Specifies the data volume that can be read from the disk per second when the primary server provides a build session to the standby server.

Type: SIGHUP

Value range: an integer ranging from 0 to 1048576. The unit is KB.

Default value: 0, indicating that the I/O flow is not restricted when the primary server provides a build session to the standby server.

Setting suggestions: Set this parameter based on the disk bandwidth and job model. If there is no flow restriction or job interference, for disks with good

performance such as SSDs, a full build consumes a relatively small proportion of bandwidth and has little impact on service performance. In this case, you do not need to set the threshold. If the service performance of a common 10,000 rpm SAS disk deteriorates significantly during a build, you are advised to set the parameter to 20 MB.

This setting directly affects the build speed and completion time. Therefore, you are advised to set this parameter to a value larger than 10 MB. During off-peak hours, you are advised to remove the flow restriction to restore to the normal build speed.

NOTE

- This parameter is used during peak hours or when the disk I/O pressure of the primary server is high. It limits the build flow rate on the standby server to reduce the impact on primary server services. After the service peak hours, you can remove the restriction or reset the flow rate threshold.
- You are advised to set a proper threshold based on service scenarios and disk performance.

17.8.2 Primary Server

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.

Type: SIGHUP

Value range: an integer ranging from 0 to 1000000. **0** means no delay.

Default value: **0**

data_replicate_buffer_size

Parameter description: Specifies the size of memory used by queues when the sender sends data pages to the receiver. The value of this parameter affects the buffer size copied for the replication between the primary and standby servers.

Type: POSTMASTER

Value range: an integer ranging from 4 to 1023. The unit is MB.

Default value: **16MB** for CNs and **128MB** for DNs

enable_data_replicate

Parameter description: Specifies the data synchronization mode between the primary and standby servers when data is imported to row-store tables in a database.

Type: USERSET

Value range: Boolean

- **on** indicates that data pages are used for the data synchronization between the primary and standby servers when data is imported to row-store tables in a database. This parameter cannot be set to **on** if **replication_type** is set to **1**.
- **off** indicates that the primary and standby servers synchronize data using Xlogs while the data is imported to a row-store table.

Default value: **on**

enable_incremental_catchup

Parameter description: Specifies the data catchup mode between the primary and standby nodes.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the standby node 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 nodes and then performs catchup between the primary and standby nodes.
- **off** indicates that the standby node uses the full catchup mode. That is, the standby node scans all local data files on the primary node to obtain the list of differential data files between the primary and standby nodes and performs catchup between the primary and standby nodes.

Default value: **on**

wait_dummy_time

Parameter description: Specifies the maximum duration for the primary, standby, and secondary clusters to wait for the secondary cluster to start in sequence and the maximum duration for the secondary cluster to send the scanning list when incremental data catchup is enabled.

Type: SIGHUP

Value range: Integer, from 1 to **INT_MAX**, in seconds.

Default value: **300s**

CAUTION

The unit can only be second.

17.8.3 Standby Server

build_backup_param

Parameter description: Specifies the minimum specifications for disk backup during incremental build.

Type: SIGHUP

Value range: a string

Default value: (1%, 1G, 1G)

NOTE

This parameter specifies whether the **pg_rewind_bak** directory is generated during incremental build. The character string takes effect only when it is configured in the 'x %, yG, zG' format. This parameter is valid only when **gs_guc set** is set to a valid value. **x** indicates the percentage of minimum remaining space, **y** indicates the minimum remaining space, and **z** indicates the total disk space.

The **pg_rewind_bak** file is generated and backed up only when both of the following conditions are met:

- Condition 1: The total disk capacity is greater than or equals to **z** GB. If this condition is not met, the backup is not performed. If this condition is met, the system continues to check condition 2.
- Condition 2: The remaining disk space is greater than or equals to **y** GB and the percentage of the remaining disk space is greater than or equals to **x %**.

17.9 Query Planning

17.9.1 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 adding the statistics collected in a specific column using **ALTER TABLE SET STATISTICS**.

enable_bitmapscan

Parameter description: Controls whether the query optimizer uses the bitmap-scan plan type.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_hashagg

Parameter description: Controls whether the query optimizer uses the Hash aggregation plan type.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_mixedagg

Parameter description: Controls whether the query optimizer uses the Mixed Agg plan type. (This parameter is supported by version 8.2.0 or later clusters.)

Type: USERSET

Value range: Boolean

- **on** indicates that a Mixed Agg query plan is generated for the Grouping Sets statement (including Rollup or Cube) that meets certain conditions.
- **off** indicates it is disabled.

Default value: **off**

NOTICE

The Mixed Agg query plan can be used to improve the performance of statements dealing with a large amount of data (the data volume of a single DN table is greater than 100 GB).

Mixed Agg is not supported in the following scenarios:

- The data type of the columns in the **GROUP BY** clause do not support hashing.
- The aggregate function uses **DISTINCT** for deduplication or **ORDER BY** for sorting.
- The **GROUPING SETS** clause does not contain empty groups.

enable_hashjoin

Parameter description: Controls whether the query optimizer uses the Hash-join plan type.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_indexscan

Parameter description: Controls whether the query optimizer uses the index-scan plan type.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_indexonlyscan

Parameter description: Controls whether the query optimizer uses the index-only-scan plan type.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_material

Parameter description: Controls whether the query optimizer uses materialization. It is impossible to suppress materialization entirely, but setting this parameter to **off** prevents the optimizer from inserting materialized nodes.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_mergejoin

Parameter description: Controls whether the query optimizer uses the merge-join plan type.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **off**

enable_nestloop

Parameter description: Controls whether the query optimizer uses the nested-loop join plan type to fully scan internal tables. It is impossible to suppress nested-loop joins entirely, but setting this parameter to **off** allows the optimizer to choose other methods if available.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **off**

enable_index_nestloop

Parameter description: Controls whether the query optimizer uses the nested-loop join plan type to scan the parameterized indexes of internal tables.

Type: USERSET

Value range: Boolean

- **on** indicates the query optimizer uses the nested-loop join plan type.
- **off** indicates the query optimizer does not use the nested-loop join plan type.

Default value: The default value for a newly installed cluster is **on**. If the cluster is upgraded from R8C10, the forward compatibility is retained. If the version is upgraded from R7C10 or an earlier version, the default value is **off**.

left_join_estimation_enhancement

Parameter description: Specifies whether to use the optimized estimated number of rows for left join. This parameter is supported only by clusters of version 8.3.0.100 or later.

Type: USERSET

Value range: Boolean

- **on** indicates GEQO is enabled.
- **off** indicates it is disabled.

Default value: **off**

enable_seqscan

Parameter description: Controls whether the query optimizer uses the sequential scan plan type. It is impossible to suppress sequential scans entirely, but setting this variable to **off** allows the optimizer to preferentially choose other methods if available.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_sort

Parameter description: Controls whether the query optimizer uses the sort method. It is impossible to suppress explicit sorts entirely, but setting this variable to **off** allows the optimizer to preferentially choose other methods if available.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

max_opt_sort_rows

Parameter description: Specifies the maximum number of optimized limit+offset rows in an ORDER BY clause. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: an integer ranging from **0** to **INT_MAX**

- If the value is **0**, the parameter does not take effect.
- If this parameter is set to any other value, the optimization takes effect when the number of limit+offset rows in the ORDER BY clause is less than the value of this parameter. If the number of limit+offset rows in the order by clause is greater than the value of this parameter, the optimization does not take effect. After the optimization, the time required is reduced, but the memory usage may increase.

Default value: **0**

enable_tidscan

Parameter description: Controls whether the query optimizer uses the Tuple ID (TID) scan plan type.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is 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.

Type: SUSET

Value range: Boolean

- **on** indicates the unlocking is allowed.
- **off** indicates the unlocking is not allowed.

Default value: **off**

enforce_oracle_behavior

Parameter description: Controls the rule matching modes of regular expressions.

Type: USERSET

Value range: Boolean

- **on** indicates that the ORACLE matching rule is used.
- **off** indicates that the POSIX matching rule is used.

Default value: **on**

enable_stream_concurrent_update

Parameter description: Controls the use of **stream** in concurrent updates. This parameter is restricted by the **enable_stream_operator** parameter.

Type: USERSET

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_ctescan

Parameter description: Specifies whether a stream plan supports **ctescan**.

Type: USERSET

Value range: Boolean

- **on** indicates that **ctescan** is supported for the stream plan.
- **off** indicates that **ctescan** is not supported for the stream plan.

Default value: **off**

enable_stream_operator

Parameter description: Controls whether the query optimizer uses streams.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_stream_recursive

Parameter description: Specifies whether to push **WITH RECURSIVE** join queries to DNs for processing.

Type: USERSET

Value range: Boolean

- **on**: **WITH RECURSIVE** join queries will be pushed down to DNs.
- **off**: **WITH RECURSIVE** join queries will not be pushed down to DNs.

Default value: **on**

enable_value_redistribute

Parameter description: Specifies whether to generate value redistribute plans. In 8.2.0 and later cluster versions, this parameter takes effect for **rank**, **dense_rank**, and **row_number** without the **PARTITION BY** clause.

Type: USERSET

Value range: Boolean

- **on** indicates that value redistribute plans are generated.
- **off** indicates that no value redistribute plans are generated.

Default value: **on**

max_recursive_times

Parameter description: Specifies the maximum number of **WITH RECURSIVE** iterations.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX

Default value: **200**

enable_vector_engine

Parameter description: Controls whether the query optimizer uses the vectorized executor.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_broadcast

Parameter description: Controls whether the query optimizer uses the broadcast distribution method when it evaluates the cost of stream.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

enable_redistribute

Parameter description: Controls whether the query optimizer uses the local redistribute or split redistribute distribution method when estimating the cost of streams. This parameter is supported only by clusters of version 8.2.1.300 or later.

Type: USERSET

Value range: Boolean

- **on** indicates that either of the distribution methods is used.
- **off** indicates that none of the distribution methods is used.

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.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **off**

enable_fstream

Parameter description: Controls whether the query optimizer uses streams when it delivers statements. This parameter is only used for external HDFS tables.

This parameter has been discarded. To reserve forward compatibility, set this parameter to **on**, but the setting does not make a difference.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **off**

enable_hashfilter

Parameter description: Controls whether hashfilters can be generated for plans that contain replication tables (including dual and constant tables). This parameter is supported by version 8.2.0 or later clusters.

Type: USERSET

Value range: Boolean

- **on** indicates that hashfilters can be generated.
- **off** indicates that no hashfilters can be generated.

Default value: **on**

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 query optimizer to generate which type of hashagg plans.

Type: USERSET

Value range: an integer ranging from 0 to 3.

- When the value is set to **1**, the first plan is forcibly generated.
- When the value 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 value 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 value is set to **0**, the query optimizer chooses the most optimal plan based on the estimated costs of the three plans above.

Default value: **0**

index_selectivity_cost

Parameter description: controls the cost calculation (selection rate > 0.001) of cbtree during the scan of column-store table indexes. This parameter is supported only by clusters of version 8.2.1.100 or later.

Type: USERSET

Value range: a floating point, which can be -1 or ranges from 0 to 1000.

- If this parameter is set to **0**, the index selection rate is not affected by the threshold 0.001.
- If the value is **-1**, the value is affected by **disable_cost**.
- When it is set to other values, the value is the coefficient for cbtree cost calculation.

Default value: **-1**

index_cost_limit

Parameter description: threshold for disabling the cost calculation of cbtree during column-store table index scanning. This parameter is supported only by clusters of version 8.2.1.100 or later.

Type: USERSET

Value range: an integer ranging from 0 to 2147483647

- If the value is **0**, the parameter does not take effect.
- If this parameter is set to other values and the number of rows in a table is less than the value of this parameter, the table is not affected by the index selection rate threshold 0.001.

Default value: **0**

volatile_shipping_version

Parameter description: Controls the execution scope of volatile functions to be pushed down. This parameter is supported by version 8.2.0 or later clusters.

Type: USERSET

Value range: **0**, **1**, 3, and **2**

- When the value is **3**, the inline CTE can be pushed down when it is referenced only once. This value is supported only by clusters of version 8.2.1.105 or later.
- When the value is **2**, pushdown can be performed when VOLATILE functions are contained in the target column of the copied CTE result.
- If this parameter is set to **1**, the **nextval**, **uuid_generate_v1**, **sys_guid**, and **uuid** functions can be completely pushed down if they are in the target column of a statement.
- If this parameter is set to **0**, random functions can be completely pushed down. The **nextval** and **uuid_generate_v1** functions can be pushed down only if **INSERT** contains simple query statements.

Default value: **3**

agg_redistribute_enhancement

Parameter description: When the aggregate operation is performed, which contains multiple **group by** columns and all of the columns are not in the distribution column, you need to select one **group by** column for redistribution. This parameter controls the policy of selecting a redistribution column.

Type: USERSET

Value range: Boolean

- **on** indicates the column that can be redistributed and evaluates the most distinct value for redistribution.
- **off** indicates the first column that can be redistributed for redistribution.

Default value: **off**

enable_valuepartition_pruning

Parameter description: Specifies whether the DFS partitioned table is dynamically or statically optimized.

Type: USERSET

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 an appropriate one for the current operator.

Type: USERSET

Value range: a string

- **optimal**: The list of candidate computing Node Groups consists of the Node Group where the operator's operation objects are located and the DNs in the Node Groups on which the current user has the COMPUTE permission.
- **query**: The list of candidate computing Node Groups consists of the Node Group where the operator's operation objects are located and the DNs in the Node Groups where base tables involved in the query are located.
- **bind**: If the current session user is a logical cluster user, the candidate computing Node Group is the Node Group of the logical cluster associated with the current user. If the session user is not a logical cluster user, the candidate computing Node Group selection rule is the same as that when this parameter is set to **query**.
- Node Group name:
  - If **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.
  - If **enable_nodegroup_debug** is set to **on**, the specified Node Group is used as the candidate Node Group.

Default value: **bind**

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.

Type: USERSET

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 for optimizer to calculate the final cost of stream operators.

The base stream cost is multiplied by this weight to make the final cost.

Type: USERSET

Value range: a floating point number ranging from 0 to 10000

Default value: **1**

NOTICE

This parameter is applicable only to Redistribute and Broadcast streams.

qrw_inlist2join_optmode

Parameter description: Specifies whether enable inlist-to-join (inlist2join) query rewriting.

Type: USERSET

Value range: a string

- **disable**: inlist2join disabled
- **cost_base**: cost-based inlist2join query rewriting
- **rule_base**: forcible rule-based inlist2join query rewriting
- A positive integer: 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**

setop_optmode

Parameter description: Specifies whether to perform deduplication on the query branch statements of a set operation (**UNION**/**EXCEPT**/**INTERSECT**) without the **ALL** option. This parameter is supported by version 8.2.0 or later clusters.

Type: USERSET

Value range: enumerated values

- **disable**: The query branch does not perform deduplication.
- **force**: The query branch forcibly performs deduplication.
- **cost**: The optimizer compares the costs of query branches with and without deduplication, and choose the execution mode with lower costs.

The default value is **disable**.

NOTICE

This parameter takes effect only if the execution plan of a SQL statement meets the following conditions:

- The **UNION**, **EXCEPT**, and **INTERSECT** operations in the SQL statement do not contain the **ALL** option.
- Data redistribution has been performed on the query branches where the set operation is to be performed.

skew_option

Parameter description: Specifies whether an optimization policy is used

Type: USERSET

Value range: a string

- **off**: policy disabled
- **normal**: radical policy. All possible skews are optimized.
- **lazy**: conservative policy. Uncertain skews are ignored.

Default value: normal

prefer_hashjoin_path

Parameter description: whether to preferentially generate hashjoin paths so that other paths with high costs can be pre-pruned to shorten the overall plan generation time. This parameter is supported only by clusters of version 8.2.1 or later.

Type: USERSET

Value range: Boolean

- **off**: disables the optimizations generated in advance in the hashjoin path.
- **on**: enables the optimizations generated in advance in the hashjoin path.

Default value: **on**

enable_hashfilter_test

Parameter description: whether to add hash filters to columns for base table scan to check whether the results meet expectations. In addition, this parameter

determines whether to check the DN accuracy when data is inserted (that is, whether the current data should be inserted into the current DN). This parameter is supported only by clusters of version 8.2.1.300 or later.

Type: USERSET

Value range: Boolean

- **off** indicates that hash filters are not added to columns for base table scan, and the DN accuracy is not verified during data insertion.
- **on** indicates that hash filters are added to columns for base table scan, and the DN accuracy is verified during data insertion.

Default value: **on**

NOTICE

- This parameter is valid only for tables distributed in hash mode.
- If this parameter is set to **on**, DN accuracy is verified during data insertion, affecting data insertion performance.

17.9.2 Optimizer Cost Constants

This section describes the optimizer cost constants. The cost variables described in this section are measured on an arbitrary scale. Only their relative values matter, therefore scaling them all in or out by the same factor will result in no differences 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.

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.

Type: USERSET

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.

Type: USERSET

Value range: a floating point number ranging from 0 to DBL_MAX

Default value: **4**

NOTE

- Although the server allows you to set the value of **random_page_cost** to 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.
- This value can be overwritten for tables and indexes in a particular tablespace by setting the tablespace parameter of the same name.
- Comparing to **seq_page_cost**, reducing this value will cause the system to prefer index scans and raising it makes index scans relatively more expensive. You can increase or decrease both values at the same time to change the disk I/O cost relative to CPU cost.

cpu_tuple_cost

Parameter description: Specifies the optimizer's estimated cost of processing each row during a query.

Type: USERSET

Value range: a floating point number ranging from 0 to DBL_MAX

Default value: **0.01**

cpu_index_tuple_cost

Parameter description: Specifies the optimizer's estimated cost of processing each index entry during an index scan.

Type: USERSET

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 during a query.

Type: USERSET

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.

When setting this parameter you should consider both GaussDB(DWS)'s shared buffer and the kernel's disk cache. Also, take into account the expected number of concurrent queries on different tables, since they will have to share the available space.

This parameter has no effect on the size of shared memory allocated by GaussDB(DWS). It is used only for estimation purposes and does not reserve

kernel disk cache. The value is in the unit of disk page. Usually the size of each page is 8192 bytes.

Type: USERSET

Value range: an integer ranging is from 1 to INT_MAX. The unit is 8 KB.

A value greater than the default one may enable index scanning, and a value less than the default one may enable sequence scanning.

Default value: **128MB**

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.

Type: USERSET

Value range: a floating point number ranging from 0 to DBL_MAX

Default value: **0**

smp_thread_cost

Parameter description: Specifies the optimizer's cost for calculating parallel threads of an operator. This parameter is used for tuning if **query_dop** is not suitable for system load management. (This parameter is supported by version 8.2.0 or later clusters.)

Type: USERSET

Value range: a floating point number ranging from 1 to 10000

Default value: **1000**

17.9.3 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 searching. This algorithm reduces planning time for complex queries and the cost of producing plans are sometimes inferior to those found by the normal exhaustive-search algorithm.

geqo

Parameter description: Controls the use of genetic query optimization.

Type: USERSET

Value range: Boolean

- **on** indicates GEQO is enabled.
- **off** indicates GEQO is disabled.

Default value: **on**

NOTICE

Generally, do not set this parameter to **off**. **geqo_threshold** provides more subtle control of GEQO.

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.

Type: USERSET

Value range: an integer ranging from 2 to INT_MAX

Default value: **12**

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.

geqo_effort

Parameter description: Controls the trade-off between planning time and query plan quality in GEQO.

Type: USERSET

Value range: an integer ranging from 1 to 10

Default value: **5**

NOTICE

- Larger values increase the time spent in query planning, but also increase the probability that an efficient query plan is chosen.
- **geqo_effort** does not have direct effect. This parameter is only used to compute the default values for the other variables that influence GEQO behavior. You can manually set other parameters as required.

geqo_pool_size

Parameter description: Specifies the pool size used by GEQO, that is, the number of individuals in the genetic population.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX

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**, GaussDB(DWS) selects a proper value based on **geqo_effort** and the number of tables.

Default value: **0**

geqo_generations

Parameter description: Specifies the number parameter iterations of the algorithm used by GEQO.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX

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.

Type: USERSET

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.

Type: USERSET

Value range: a floating point number ranging from 0.0 to 1.0

NOTICE

Varying the value changes the setting of join paths explored, and may result in a better or worse path being found.

Default value: **0**

17.9.4 Other Optimizer Options

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%. During sampling, the random sampling size is **default_statistics_target** x 300. For example, if the **default_statistics_target** is 100, 30,000 data records from 30,000 pages are randomly sampled.

Type: USERSET

Value range: an integer ranging from -100 to 10,000

NOTICE

- A larger positive number than the parameter 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 optimize the query plan.
- 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.
- **AUTOANALYZE** does not allow you to set a sampling size for temporary table sampling. Its default value will be used for sampling.
- If statistics are forcibly calculated based on memory, the sampling size is limited by the **maintenance_work_mem** parameter.

Default value: **100**

random_function_version

Parameter description: Specifies the random function version selected by ANALYZE during data sampling. This feature is supported only in 8.1.2 or later.

Type: USERSET

Value range: enumerated values

- The value **0** indicates that the random function provided by the C standard library is used.
- The value **1** indicates that the optimized and enhanced random function is used.

Default value:

- If the current cluster is upgraded from an earlier version to 8.2.0.100, the default value is **0** to ensure forward compatibility.
- If the cluster version 8.2.0.100 is newly installed, the default value is **1**.

constraint_exclusion

Parameter description: Controls the query optimizer's use of table constraints to optimize queries.

Type: USERSET

Value range: enumerated values

- **on** indicates the constraints for all tables are examined.
- **off**: No constraints are examined.
- **partition** indicates that only constraints for inherited 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, this parameter is set to **on** by default to partition tables. If this parameter is set to **on**, extra planning is imposed on simple queries, which has no benefits. 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.

Type: USERSET

Value range: a floating point number ranging from 0.0 to 1.0

NOTICE

Smaller values than the default value 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.

Type: USERSET

Value range: an integer ranging from 1 to INT_MAX

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.

Type: USERSET

Value range: an integer ranging from 1 to INT_MAX

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**

enable_from_collapse_hint

Parameter description: Specifies whether to rewrite the **FROM** list to make the hint take effect, and then rewrite it again based on the **from_collapse_limit** and **join_collapse_limit** parameters. This parameter is supported by version 8.2.0 or later clusters.

Type: USERSET

Value range: Boolean

- **on** indicates that the **FROM** list is first rewritten in hint mode.
- **off** indicates that the **FROM** list is rewritten without difference.

NOTICE

- If this parameter is enabled, the optimizer preferentially rewrites the **FROM** list in hint mode. However, you can learn whether a hint takes effect only after the plan is generated.
- If this parameter is disabled, the plan is generated in the same way as that in versions earlier than 8.2.0. That is, the plan is generated regardless of whether the table has hints.

Default value: **on**

plan_mode_seed

Parameter description: This is a commissioning parameter. Currently, it supports only OPTIMIZE_PLAN and RANDOM_PLAN. **OPTIMIZE_PLAN** indicates the optimal plan, the cost of which is estimated using the dynamic planning algorithm, and its value is **0**. **RANDOM_PLAN** indicates the plan that is randomly generated. If **plan_mode_seed** is set to **-1**, you do not need to specify the value of the seed identifier. Instead, the optimizer generates a random integer ranging from **1** to **2147483647**, and then generates a random execution plan based on this random number. If **plan_mode_seed** is set to an integer ranging from **1** to **2147483647**, you need to specify the value of the seed identifier, and the optimizer generates a random execution plan based on the seed value.

Type: USERSET

Value range: an integer ranging from -1 to 2147483647

Default value: **0**

NOTICE

- If **plan_mode_seed** is set to **RANDOM_PLAN**, the optimizer generates different random execution plans, which may not be the optimal. 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_hdfs_predicate_pushdown

Parameter description: Specifies whether the function of pushing down predicates the native data layer is enabled.

Type: SUSET

Value range: Boolean

- **on** indicates this function is enabled.
- **off** indicates this function is disabled.

Default value: **on**

windowagg_pushdown_enhancement

Parameter description: Specifies whether to enable enhanced predicate pushdown for window functions in aggregation scenarios. (This parameter is supported by version 8.2.0 or later clusters.)

Type: SUSET

Value range: Boolean

- **on** indicates that the predicate pushdown enhancement for window functions is enabled in aggregation scenarios.
- **off** indicates that the predicate pushdown enhancement for window functions is disabled in aggregation scenarios.

Default value: **on**

implied_quality_optmode

Parameter description: Specifies how to pass conditions for the equivalent columns in a statement. (This parameter is supported by version 8.2.0 or later clusters.)

Type: SUSET

Value range: enumerated values

- **normal** indicates forward compatibility with 8.1.3 and earlier versions, that is, the implied expression behavior is optimized.
- **negative** indicates that the implied expression behavior is not optimized.
- **positive** indicates that type conversion expressions are optimized in addition to the operations specified by **normal**.

Default value: normal

enable_random_datanode

Parameter description: Specifies whether the function that random query about DNs in the replication table is enabled. A complete data table is stored on each DN for random retrieval to release the pressure on nodes.

Type: USERSET

Value range: Boolean

- **on**: This function is enabled.
- **off**: This function is disabled.

Default value: **on**

hashagg_table_size

Parameter description: Specifies the hash table size during **HASH AGG** execution.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX/2

Default value: **0**

enable_codegen

Parameter description: Specifies whether code optimization can be enabled. Currently, the code optimization uses the LLVM optimization.

Type: USERSET

Value range: Boolean

- **on** indicates code optimization can be enabled.
- **off** indicates code optimization cannot be enabled.

NOTICE

Currently, the LLVM optimization only supports the vectorized executor and SQL on Hadoop features. You are advised to set this parameter to **off** in other cases.

Default value: **on**

codegen_strategy

Parameter description: Specifies the codegen optimization strategy that is used when an expression is converted to codegen-based.

Type: USERSET

Value range: enumerated values

- **partial** indicates that you can still call the LLVM dynamic optimization strategy using the codegen framework of an expression even if functions that are not codegen-based exist in the expression.
- **pure** indicates that the LLVM dynamic optimization strategy can be called only when all functions in an expression can be codegen-based.

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.

Type: USERSET

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.

Type: USERSET

Value range: an integer ranging from **0** to **INT_MAX**

Default value: **10000**

llvm_compile_expr_limit

Parameter description: Specifies the limit for compiling expressions with LLVM. If there are more expressions than the limit, only the first ones are compiled and an alarm is generated. (To allow the alarm to be generated, execute **SET analysis_options="on(LLVM_COMPILE)"** before **explain performance** is executed.) This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: an integer ranging from –1 to INT_MAX

Default value: **500**

llvm_compile_time_limit

Parameter description: If the percentage of the LLVM compilation time to the executor running time exceeds the threshold specified by **llvm_compile_time_limit**, an alarm is generated. (To allow the alarm to be generated, execute **SET analysis_options="on(LLVM_COMPILE)"** before **explain performance** is executed.) This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: a floating point number ranging from 0.0 to 1.0

Default value: **0.2**

enable_constraint_optimization

Parameter description: Specifies whether the informational constraint optimization execution plan can be used for an HDFS foreign table.

Type: SUSET

Value range: Boolean

- **on** indicates the plan can be used.
- **off** indicates the plan cannot be used.

Default value: **on**

enable_bloom_filter

Parameter description: Specifies whether the BloomFilter optimization is used.

Type: USERSET

Value range: Boolean

- **on** indicates the BloomFilter optimization can be used.
- **off** indicates the BloomFilter optimization cannot be used.

Default value: **on**

NOTICE

Scenario: If in a HASH JOIN, the thread of the foreign table contains HDFS tables or column-store tables, the Bloom filter is triggered.

Constraints:

1. Only **INNER JOIN**, **SEMI JOIN**, **RIGHT JOIN**, **RIGHT SEMI JOIN**, **RIGHT ANTI JOIN** and **RIGHT ANTI FULL JOIN** are supported.
2. The number of rows in the internal table in the join cannot exceed 50,000.
3. JOIN condition of the internal table: It cannot be an expression for HDFS internal or foreign tables. It can be an expression for column-store tables, but only at the non-join layer.
4. The join condition of the foreign table must be simple column join.
5. When the join conditions of the internal and foreign tables (HDFS) are both simple column joins, the estimated data that can be removed at the plan layer must be over 1/3.
6. Joined columns cannot contain NULL values.
7. Data is not spilled to disks at the JOIN layer.
8. Data type:
   - HDFS internal and foreign tables support SMALLINT, INTEGER, BIGINT, REAL/FLOAT4, DOUBLE PRECISION/FLOAT8, CHAR(n)/CHARACTER(n)/NCHAR(n), VARCHAR(n)/CHARACTER VARYING(n), CLOB and TEXT.
   - Column-store tables support SMALLINT, INTEGER, BIGINT, OID, "char", CHAR(n)/CHARACTER(n)/NCHAR(n), VARCHAR(n)/CHARACTER VARYING(n), NVARCHAR2(n), CLOB, TEXT, DATE, TIME, TIMESTAMP and TIMESTAMPTZ. The collation of the character type must be **C**.

enable_extrapolation_stats

Parameter description: Specifies whether to use the extrapolation logic based on historical statistics. Using this logic may increase the accuracy of estimation for tables whose statistics have not been collected. However, there is also a possibility that the estimation is too large due to incorrect inference.

Type: USERSET

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:

- If the current cluster is upgraded from an earlier version to 8.2.0.100, the default value is **off** to ensure forward compatibility.
- If the cluster version 8.2.0.100 is newly installed, the default value is **on**.

autoanalyze

Parameter description: Specifies whether to allow automatic statistics collection for a table that has no statistics or a table whose amount of data modification reaches the threshold for triggering **ANALYZE** when a plan is generated. In this case, **AUTOANALYZE** cannot be triggered for foreign tables or temporary tables with the **ON COMMIT [DELETE ROWS|DROP]** option. To collect statistics, you need to 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.

NOTICE

If the amount of data modification reaches the threshold for triggering **ANALYZE**, the amount of data modification exceeds **autovacuum_analyze_threshold** + **autovacuum_analyze_scale_factor** * *reltuples*. *reltuples* indicates the estimated number of rows in the table recorded in **pg_class**.

Type: SUSET

Value range: Boolean

- **on** indicates that the table statistics are automatically collected.
- **off** indicates that the table statistics are not automatically collected.

Default value: **on**

query_dop

Parameter description: Specifies the user-defined degree of parallelism.

Type: USERSET

Value range: an integer ranging from -64 to 64.

[1, 64]: Fixed SMP is enabled, and the system will use the specified degree.

0: SMP adaptation function is enabled. The system dynamically selects the optimal parallelism degree [1,8] (x86 platforms) or [1,64] (Kunpeng platforms) for each query based on the resource usage and query plans.

[-64, -1]: SMP adaptation is enabled, and the system will dynamically select a degree from the limited range.

NOTE

- For TP services that mainly involve short queries, if services cannot be optimized through lightweight CNs or statement delivery, it will take a long time to generate an SMP plan. You are advised to set **query_dop** to **1**. For AP services with complex statements, you are advised to set **query_dop** to **0**.
- 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**

query_dop_ratio

Parameter description: Specifies the DOP multiple used to adjust the optimal DOP preset in the system when **query_dop** is set to **0**. That is, DOP = Preset DOP x query_dop_ratio (ranging from 1 to 64). If this parameter is set to **1**, the DOP cannot be adjusted.

Type: USERSET

Value range: a floating point number ranging from 0 to 64

Default value: **1**

debug_group_dop

Parameter description: Specifies the unified DOP parallelism degree allocated to the groups that use the Stream operator as the vertex in the generated execution plan when the value of **query_dop** is **0**. This parameter is used to manually specify the DOP for specific groups for performance optimization. Its format is **G1,D1,G2,D2,...,**, where **G1** and **G2** indicate the group IDs that can be obtained from logs and **D1** and **D2** indicate the specified DOP values and can be any positive integers.

Type: USERSET

Value range: a string

Default value: empty

NOTICE

This parameter is used only for internal optimization and cannot be set. You are advised to use the default value.

enable_analyze_check

Parameter description: Checks whether statistics were collected about tables whose **reltuples** and **relpages** are shown as **0** in **pg_class** during plan generation. **This parameter has been discarded in clusters of version 8.1.3 or later, but is reserved for compatibility with earlier versions. The setting of this parameter does not take effect.**

Type: SUSET

Value range: Boolean

- **on** enables the check.
- **off** disables the check.

Default value: **on**

enable_sonic_hashagg

Parameter description: Specifies whether to use the Hash Agg operator for column-oriented hash table design when certain constraints are met.

Type: USERSET

Value range: Boolean

- **on** indicates that the Hash Agg operator is used for column-oriented hash table design when certain constraints are met.
- **off** indicates that the Hash Agg operator is not used for column-oriented hash table design.

NOTE

- If **enable_sonic_hashagg** is enabled and certain constraints are met, the Hash Agg operator will be used for column-oriented hash table design, and the memory usage of the operator can be reduced. However, in scenarios where the code generation technology (enabled by **enable_codegen**) can significantly improve performance, 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**.

Default value: **on**

enable_sonic_hashjoin

Parameter description: Specifies whether to use the Hash Join operator for column-oriented hash table design when certain constraints are met.

Type: USERSET

Value range: Boolean

- **on** indicates that the Hash Join operator is used for column-oriented hash table design when certain constraints are met.
- **off** indicates that the Hash Join operator is not used for column-oriented hash table design.

NOTE

- Currently, the parameter can be used only for Inner Join.
- If **enable_sonic_hashjoin** is enabled, the memory usage of 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**.

Default value: **on**

enable_sonic_optspill

Parameter description: Specifies whether to optimize the number of hash join or hash agg files spilled to disks in the sonic scenario. This parameter takes effect only when **enable_sonic_hashjoin** or **enable_sonic_hashagg** is enabled.

Type: USERSET

Value range: Boolean

- **on** indicates that the number of files spilled to disks is optimized.
- **off** indicates that the number of files spilled to disks is not optimized.

NOTE

For the hash join or hash agg operator that meets the sonic criteria, if this parameter is set to **off**, one file is spilled to disks for each column. If this parameter is set to **on** and the data types of different columns are similar, only one file (a maximum of five files) will be spilled to disks.

Default value: **on**

expand_hashtable_ratio

Parameter description: Specifies the expansion ratio used to resize the hash table during the execution of the Hash Agg and Hash Join operators.

Type: USERSET

Value range: a floating point number of 0 or ranging from 0.5 to 10

NOTE

- Value **0** indicates that the hash table is adaptively expanded based on the current memory size.
- The value ranging from 0.5 to 10 indicates the multiple used to expand the hash table. Generally, a larger hash table delivers better performance but occupies more memory space. If the memory space is insufficient, data may be spilled to disks in advance, causing performance deterioration.

Default value: **0**

plan_cache_mode

Parameter description: Specifies the policy for generating an execution plan in the **prepare** statement.

Type: USERSET

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 a **prepare** statement where parameters in the execute statement is embedded in the **prepare** statement. 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 for 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 solution 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 parameter field. When some bound parameters are used, the plan execution performance is poor.

Default value: **auto**

wlm_query_accelerate

Parameter description: Specifies whether the query needs to be accelerated when short query acceleration is enabled.

Type: USERSET

Value range: an integer ranging from **–1** to **1**

- **-1**: indicates that short queries are controlled by the fast lane, and the long queries are controlled by the slow lane.
- **0**: indicates that queries are not accelerated. Both short and long queries are controlled by the slow lane.
- **1**: indicates that queries are accelerated. Both short queries and long queries are controlled by the fast lane.

Default value: **–1**

show_unshippable_warning

Parameter description: Specifies whether to print the alarm for the statement pushdown failure to the client.

Type: USERSET

Value range: Boolean

- **on**: Records the reason why the statement cannot be pushed down in a WARNING log and prints the log to the client.
- **off**: Logs the reason why the statement cannot be pushed down only.

Default value: **off**

hashjoin_spill_strategy

Parameter description: specifies the hash join policy for spilling data to disks. This feature is supported in 8.1.2 or later.

Type: USERSET

Value range: The value is an integer ranging from 0 to 6.

- **0**: If an inner table is too large to be fully stored in database memory, the table will be partitioned. If the table cannot be further partitioned and there is not enough memory for storing it, the system will check whether the foreign table can be stored in memory and be used to create a hash table. If the foreign table can be stored in the memory and used to create a hash table, HashJoin will be performed. Otherwise, NestLoop will be performed.
- **1**: If an inner table is too large to be fully stored in database memory, the table will be partitioned. If the table cannot be further partitioned and there is still not enough memory for storing it, the system will check whether the foreign table can be stored in memory and be used to create a hash table. If both the inner and outer tables are large, a hash join is forcibly performed.
- **2**: If the size of the inner table is large and cannot be partitioned after data is spilled to disks for multiple times, HashJoin will be forcibly performed.
- **3**: If the size of the inner table is large and cannot be partitioned after data is spilled to disks for multiple times, the system attempts to place the outer table in the available memory of the database to create a hash table. If both the inner and outer tables are large, an error is reported.
- **4**: If the size of the inner table is large and cannot be partitioned after data is spilled to disks for multiple times, an error is reported.
- **5**: If the inner table is large and cannot be fully stored in database memory, and the foreign table can be fully stored in memory, the foreign table will be used to create a hash table and perform HashJoin. If the foreign table cannot be fully stored in memory, it will be partitioned until the inner and foreign tables cannot be further partitioned. Then, NestLoop will be performed.
- **6**: If the inner table is large and cannot be fully stored in database memory, and the foreign table can be fully stored in memory, the foreign table will be used to create a hash table and perform HashJoin. If the foreign table cannot be fully stored in memory, it will be partitioned until the inner and foreign tables cannot be further partitioned. Then, HashJoin will be forcibly performed.

NOTE

- This parameter is valid only for a vectorized hash join operator.
- If the number of distinct values is small and the data volume is large, data may fail to be flushed to disks. As a result, the memory usage is too high and the memory is out of control. If this parameter is set to **0**, the system attempts to swap the inner and outer tables or perform a nested loop join to prevent this problem. However, a nested loop join may deteriorate performance in some scenarios. In this case, this parameter can be set to **1**, **2**, or **6** to forcibly perform HashJoin.
- The value **0** does not take effect for a vectorized full join, and the behavior is the same as that of the value **1**. The system attempts to create a hash table only for the outer table and does not perform a nested loop join.
- If the inner table is too large to be fully stored in memory, but the foreign table can be stored in memory, you are advised to set this parameter to **5** or **6** rather than **0** or **1**, directly performing Hashjoin on the foreign table without multiple rounds of partitioning and spill to disk. If a foreign table contains only a small amount of distinct data, creating a hash table using the foreign table may cause performance deterioration. In this case, you can change the value of this parameter to **0** or **1**.

Default value: **0**

max_streams_per_query

Parameter description: Controls the number of Stream nodes in a query plan. (This parameter is supported only in 8.1.1 and later cluster versions.)

Type: SUSET

Value range: an integer ranging from –1 to 10000.

- **-1** indicates that the number of Stream nodes in the query plan is not limited.
- A value within the range **0** to **10000** indicates that when the number of Stream nodes in the query plan exceeds the specified value, an error is reported and the query plan will not be executed.

NOTE

- This parameter controls only the Stream nodes on DNs and does not control the Gather nodes on the CN.
- This parameter does not affect the EXPLAIN query plan, but affects EXPLAIN ANALYZE and EXPLAIN PERFORMANCE.

Default value: **–1**

enable_agg_limit_opt

Parameter description: Specifies whether to optimize **select distinct col from table limit N**. This parameter is valid only if N is less than 16,384. The parameter **table** indicates a column-store table. This parameter is supported only by clusters of version 8.2.0.101 or later.

Type: USERSET

Value range: Boolean

- **on** indicates that the optimization is enabled. After this function is enabled, query results are from different DNs, and you do not need to create a full hash table on each DN, significantly improving query performance.

- **off** indicates that the optimization is disabled.

Default value: **off**

stream_ctescan_pred_threshold

Parameter description: minimum number of filter criteria contained in a CTE when **enable_stream_ctescan** is set to **on** and the CTE contains only a single table filtering condition. If the value is greater than or equal to the value of this parameter, the share scan mode is used. If the value is less than the value of this parameter, the inline mode is used. This parameter is supported only by clusters of version 8.2.1 or later.

Type: SUSET

Value range: an integer ranging from **0** to **INT_MAX**

Default value: **2**

stream_ctescan_max_estimate_mem

Parameter description: maximum estimated memory value of the CTE when **enable_stream_ctescan** is set to **on**. This parameter must be used together with **stream_ctescan_refcount_threshold**. If the estimated memory is greater than the value of **stream_ctescan_max_estimate_mem** and the number of references is less than the value of **stream_ctescan_refcount_threshold**, the inline mode is used. Otherwise, the sharescan mode is used. This parameter is supported only by clusters of version 8.2.1 or later.

Type: SUSET

Value range: an integer ranging from 32 x 1024 (32 MB) to INT_MAX, in KB.

Default value: **256 MB**

stream_ctescan_refcount_threshold

Parameter description: maximum number of times that the CTE can be referenced when **enable_stream_ctescan** is set to **on**. This parameter must be used together with **stream_ctescan_max_estimate_mem**. If the estimated memory is greater than the value of **stream_ctescan_max_estimate_mem** and the number of references is less than the value of **stream_ctescan_refcount_threshold**, the inline mode is used. Otherwise, the sharescan mode is used. This parameter is supported only by clusters of version 8.2.1 or later.

Type: SUSET

Value range: an integer ranging from 0 to INT_MAX

Default value: 4

NOTE

This parameter takes effect only when the value is greater than 0. When the value is 0, only **stream_ctescan_max_estimate_mem** is used to control the inline behavior.

inlist_rough_check_threshold

Parameter description: Specifies the maximum number of values in the **IN** condition when **enable_csqual_pushdown** is enabled and the filter criterion is **IN** for rough check pushdown. If the number of values in the **IN** filter condition exceeds the value of this parameter, the maximum and minimum values in the **IN** filter condition are used for pushdown. This parameter is supported only by clusters of version 8.2.0.101 or later.

Type: SUSET

Value range: an integer ranging from 0 to 10000

Default value: **100**

NOTE

If the **IN** condition is executed on the only distribution column of a table, values can be filtered on DNs. In this case, the maximum number of values in the **IN** condition is **inlist_rough_check_threshold** multiplied by the number of DNs.

enable_array_optimization

Parameter description: whether to split the Array type generated by the IN, ANY, or ALL condition into common expressions for execution. This parameter will support multiple optimizations such as vectorized execution, rough check pruning, and partition pruning. This parameter is supported only by clusters of version 8.2.1 or later.

Type: SUSET

Value range: Boolean

- **on** indicates that expressions of the Array type are split for optimization.
- **off** indicates that expressions of the Array type are not split for optimization.

Default value: **on**

max_skew_num

Parameter description: controls the number of skew values allowed by the optimizer for redistribution optimization. This parameter is supported only by clusters of version 8.2.1 or later.

Type: SUSET

Value range: an integer ranging from 0 to INT_MAX

Default value: **10**

17.10 Error Reporting and Logging

17.10.1 Logging Time

client_min_messages

Parameter description: Specifies which level of messages are sent to the client. Each level covers all the levels following it. The lower the level is, the fewer messages are sent.

Type: USERSET

NOTICE

When the values of **client_min_messages** and **log_min_messages** are the same, the levels are different.

Valid values: Enumerated values. Valid values: **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error** For details about the parameters, see **Table 17-3**.

Default value: notice

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.

Type: SUSET

NOTICE

When the values of **client_min_messages** and **log_min_messages** are the same, the levels are different.

Value range: enumerated type. Valid values: **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error**, **fatal**, **panic** For details about the parameters, see **Table 17-3**.

Default value: **warning**

log_min_error_statement

Parameter description: Specifies which SQL statements that cause errors condition will be recorded in the server log.

Type: SUSET

Value range: enumerated type. Valid values: **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error**, **fatal**, **panic** For details about the parameters, see **Table 17-3**.

NOTE

- The default is **error**, indicating that statements causing errors, log messages, fatal errors, or panics will be logged.
- **panic**: This feature is disabled.

Default value: **error**

log_min_duration_statement

Parameter description: Specifies the threshold for logging statement execution durations. The execution duration that is greater than the specified value will be logged.

This parameter helps track query statements that need to be optimized. For clients using extended query protocol, durations of the Parse, Bind, and Execute are logged independently.

Type: SUSET

NOTICE

If this parameter and **log_statement** are used at the same time, statements recorded based on the value of **log_statement** will not be logged again after their execution duration exceeds the value of this parameter. 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 current statement message to the last logged duration.

Value range: an integer ranging from -1 to INT_MAX. The unit is millisecond.

- If this parameter is set to **250**, execution durations of SQL statements that run 250 ms or longer will be logged.
- **0**: Execution durations of all the statements are logged.
- **–1**: This feature is disabled.

Default value: **30min**

backtrace_min_messages

Parameter description: Prints the function's stack information to the server's log file if the level of information generated is greater than or equal to this parameter level.

Type: SUSET

NOTICE

This parameter is used for locating customer on-site problems. Because frequent stack printing will affect the system's overhead and stability, therefore, when you locate the onsite problems, set the value of this parameter to ranks other than **fatal** and **panic**.

Value range: enumerated values

Valid values: **debug5**, **debug4**, **debug3**, **debug2**, **debug1**, **info**, **log**, **notice**, **warning**, **error**, **fatal**, **panic** For details about the parameters, see **Table 17-3**.

Default value: **panic**

Table 17-3 explains the message security levels used in GaussDB(DWS). If logging output is sent to **syslog** or **eventlog**, severity is translated in GaussDB(DWS) as shown in the table.

Table 17-3 Message Severity Levels

Severity	Description	syslog	eventlog
debug[1-5]	Provides detailed debug information.	DEBUG	INFORMATION
log	Reports information of interest to administrators, for example, checkpoint activity.	INFO	INFORMATION
info	Provides information implicitly requested by the user, for example, output from **VACUUM VERBOSE**.	INFO	INFORMATION
notice	Provides information that might be helpful to users, for example, notice of 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 interval of performance log data.

Type: SUSET

NOTICE

This parameter value is in milliseconds. You are advised to set this parameter to a value that is a multiple of 1000. That is, the value is in seconds. Name extension of the performance log files controlled by this parameter is .prf. These log files are stored in the **$GAUSSLOG/gs_profile/**<*node_name*> directory. *node_name* is the value of **pgxc_node_name** in the **postgres.conf** file. You are advised not to use this parameter externally.

Value range: an integer ranging from 0 to INT_MAX. The unit is millisecond (ms).

- **0** indicates that the current session will not output performance log data.
- A value other than 0 indicates the output interval of performance log data. The smaller the value is, the more log data is output, resulting in more negative impact on the performance.

Default value: **3s**

profile_logging_module

Parameter description: Specifies the type of performance logs. When using this parameter, ensure that the value of **plog_merge_age** is not 0. This parameter is a session-level parameter, and you are not advised to use the **gs_guc** tool to set it. Only clusters of 8.1.3 and later versions support this function.

Type: USERSET

Value range: a string

Default value: OBS, HADOOP and REMOTE_DATANODE are enabled. MD is disabled. You can run the **SHOW profile_logging_module** command to view the value.

Setting method: First, you can run **SHOW profile_logging_module** to view which module is controllable. For example, the query output result is as follows:

```
show profile_logging_module;
profile_logging_module
-------------------------------------------
ALL,on(OBS,HADOOP,REMOTE_DATANODE),off(MD)(1 row)
```

Open the MD performance log and view the setting. The ALL identifier is equivalent to a shortcut operation. That is, logs of all modules can be enabled or disabled.

```
set profile_logging_module='on(md)';
SET

show profile_logging_module;
profile_logging_module
-----------------------------------------------
ALL,on(MD,OBS,HADOOP,REMOTE_DATANODE),off()(1 row)
```

17.10.2 Logging Content

debug_print_parse

Parameter description: Specifies whether to print parsing tree results.

Type: SIGHUP

Value range: Boolean

- **on** indicates the printing result function is enabled.
- **off** indicates the printing result function is disabled.

Default value: **off**

debug_print_rewritten

Parameter description: Specifies whether to print query rewriting results.

Type: SIGHUP

Value range: Boolean

- **on** indicates the printing result function is enabled.
- **off** indicates the printing result function is disabled.

Default value: **off**

debug_print_plan

Parameter description: Specifies whether to print query execution results.

Type: SIGHUP

Value range: Boolean

- **on** indicates the printing result function is enabled.
- **off** indicates the printing result function is disabled.

Default value: **off**

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**, and then provide the information to external maintenance engineers for fault locating. After you finish using the logs, delete them as soon as possible.

debug_pretty_print

Parameter description: Specifies the logs produced by **debug_print_parse**, **debug_print_rewritten**, and **debug_print_plan**. The output format is more

readable but much longer than the output generated when this parameter is set to **off**.

Type: USERSET

Value range: Boolean

- **on** indicates the indentation is enabled.
- **off** indicates the indentation is disabled.

Default value: **on**

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.

Type: SUSET

Value range: Boolean

- If this parameter is set to **off**, the difference between setting this parameter and setting **log_min_duration_statement** is that exceeding **log_min_duration_statement** forces the text of the query to be logged, but this parameter does not.
- If this parameter is set to **on** and **log_min_duration_statement** has a positive value, all durations are 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: **on**

log_error_verbosity

Parameter description: Specifies the amount of detail written in the server log for each message that is logged.

Type: SUSET

Value range: enumerated values

- **terse** indicates that the output excludes the logging of 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 logging of 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_lock_waits

Parameter description: If the time that a session used to wait 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.

Type: SUSET

Value range: Boolean

- **on** indicates the information is recorded.
- **off** indicates the information is not recorded.

Default value: **off**

log_statement

Parameter description: Specifies whether to record SQL statements. 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).

Type: SUSET

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 the extended query protocol is used, this setting also does not log statements before the execution phase (during parse analysis or planning). 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.
- **all** indicates that all statements are recorded. The PREPARE, EXECUTE, and EXPLAIN ANALYZE statements are also recorded.

Default value: **none**

log_temp_files

Parameter description: Specifies whether to record the delete information of temporary files. Temporary files can be created for sorting, hashing, and temporary querying results. A log entry is generated for each temporary file when it is deleted.

Type: SUSET

Value range: an integer ranging from -1 to INT_MAX. The unit is KB.

- A positive value indicates that the delete information of temporary files whose values are larger than that of **log_temp_files** is recorded.

- If the parameter is set to **0**, all the delete information of temporary files is recorded.
- If the parameter is set to **-1**, the delete information of no temporary files is recorded.

Default value: **–1**

logging_module

Parameter description: Specifies whether module logs can be output on the server. This parameter is a session-level parameter, and you are not advised to use the **gs_guc** tool to set it.

Type: USERSET

Value range: a string

Default value: **off**. All the module logs on the server can be viewed by running **show logging_module**.

Setting method: First, you can run **show logging_module** to view which module is controllable. For example, the query output result is as follows:

```
show logging_module;
logging_module
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
------------------------------
ALL,on(),off(DFS,GUC,HDFS,ORC,SLRU,MEM_CTL,AUTOVAC,ANALYZE,CACHE,ADIO,SSL,GDS,TBLSPC,WLM,SP
ACE,OBS,EXECUTOR,VEC_EXECUTOR,STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,
OPT_SETOP,OPT_CARD,OPT_SKEW,SMP,UDF,COOP_ANALYZE,WLMCP,ACCELERATE,PLANHINT,PARQUET,CARB
ONDATA,SNAPSHOT,XACT,HANDLE,CLOG,TQUAL,EC,REMOTE,CN_RETRY,PLSQL,TEXTSEARCH,SEQ,INSTR,CO
MM_IPC,COMM_PARAM,CSTORE,JOB,STREAMPOOL,STREAM_CTESCAN)
(1 row)
```

Controllable modules are identified by uppercase letters, and the special ID ALL is used for setting all module logs. You can control module logs to be exported by setting the log modules to **on** or **off**. Enable log output for SSL:

```
set logging_module='on(SSL)';
SET
show
logging_module;

                                                                   logging_module
-----------------------------------------------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------------------------------------------
-----------------------------------------------

ALL,on(SSL),off(DFS,GUC,HDFS,ORC,SLRU,MEM_CTL,AUTOVAC,ANALYZE,CACHE,ADIO,GDS,TBLSPC,WLM,SP
ACE,OBS,EXECUTOR,VEC_EXECUTOR,STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,
OPT_SETOP,OPT_CARD,OPT_SKEW,SMP,UDF,COOP_ANALYZE,WLMCP,A
CCELERATE,PLANHINT,PARQUET,CARBONDATA,SNAPSHOT,XACT,HANDLE,CLOG,TQUAL,EC,REMOTE,CN_RET
RY,PLSQL,TEXTSEARCH,SEQ,INSTR,COMM_IPC,COMM_PARAM,CSTORE,JOB,STREAMPOOL,STREAM_CTESCA
N)
(1 row)
```

SSL log output is enabled.

The ALL identifier is equivalent to a shortcut operation. That is, logs of all modules can be enabled or disabled.


```
set logging_module='off(ALL)';
SET
show
logging_module;

                                        logging_module
------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------

ALL,on(),off(DFS,GUC,HDFS,ORC,SLRU,MEM_CTL,AUTOVAC,ANALYZE,CACHE,ADIO,SSL,GDS,TBLSPC,WLM,SP
ACE,OBS,EXECUTOR,VEC_EXECUTOR,STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,
OPT_SETOP,OPT_CARD,OPT_SKEW,SMP,UDF,COOP_ANALYZE,WLMCP,
ACCELERATE,PLANHINT,PARQUET,CARBONDATA,SNAPSHOT,XACT,HANDLE,CLOG,TQUAL,EC,REMOTE,CN_RE
TRY,PLSQL,TEXTSEARCH,SEQ,INSTR,COMM_IPC,COMM_PARAM,CSTORE,JOB,STREAMPOOL,STREAM_CTESCA
N)
(1 row)

set logging_module='on(ALL)';
SET
show
logging_module;

                        logging_module
------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------------------
-------------------------------------------------

ALL,on(DFS,GUC,HDFS,ORC,SLRU,MEM_CTL,AUTOVAC,ANALYZE,CACHE,ADIO,SSL,GDS,TBLSPC,WLM,SPACE,
OBS,EXECUTOR,VEC_EXECUTOR,STREAM,LLVM,OPT,OPT_REWRITE,OPT_JOIN,OPT_AGG,OPT_SUBPLAN,OPT_
SETOP,OPT_CARD,OPT_SKEW,SMP,UDF,COOP_ANALYZE,WLMCP,ACCELE
RATE,PLANHINT,PARQUET,CARBONDATA,SNAPSHOT,XACT,HANDLE,CLOG,TQUAL,EC,REMOTE,CN_RETRY,PLS
QL,TEXTSEARCH,SEQ,INSTR,COMM_IPC,COMM_PARAM,CSTORE,JOB,STREAMPOOL,STREAM_CTESCAN),off()
(1 row)
```

COMM_IPC logs must be enabled or disabled explicitly. You can run either of the following command to enable the log function of COMM_IPC:

```
set logging_module='on(ALL)';
SET
set logging_module='on(COMM_IPC)';
SET
```

After the setting is performed, the log function of the COMM_IPC module will not be automatically disabled. To disable the log function of the COMM_IPC module, you must run the following commands:

```
set logging_module='off(ALL)';
SET
set logging_module='off(COMM_IPC)';
SET
```

Dependency relationship: The value of this parameter depends on the settings of **log_min_messages**.

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.

Type: SUSET

Value range: Boolean

- **on**: Statements not pushed down will be logged.
- **off**: Statements not pushed down will not be logged.

Default value: **on**

17.11 Alarm Detection

During cluster running, error scenarios can be detected in a timely manner to inform users as soon as possible.

enable_alarm

Parameter description: Enables the alarm detection thread to detect the fault scenarios that may occur in the database.

Type: POSTMASTER

Value range: Boolean

- **on** indicates the alarm detection thread can be enabled.
- **off** indicates the alarm detection thread cannot be enabled.

Default value: **on**

connection_alarm_rate

Parameter description: Specifies the ratio restriction that 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**.

Type: SIGHUP

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.

Type: SIGHUP

Value range: a non-negative integer. The unit is second.

Default value: **10**

17.12 Statistics During the Database Running

17.12.1 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 an

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 families 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.

Type: SUSET

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 data activities.

Type: SUSET

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 invoking timing in the database. The I/O timing statistics can be queried by using the **pg_stat_database** parameter.

Type: SUSET

Value range: Boolean

- If this parameter is set to **on**, the collection function is enabled. In this case, the collector repeatedly queries the OS at the current time. As a result, large numbers 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 about invoking times and duration in a function.

Type: SUSET

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.
- **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.

Type: POSTMASTER

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.

Type: SUSET

Value range: Boolean

- **on** indicates that the statistics collection function is enabled.
- **off** indicates that the statistics collection function is disabled.

Default value: **off**

track_thread_wait_status_interval

Parameter description: Specifies the interval of collecting the thread status information periodically.

Type: SUSET

Value range: an integer ranging from 0 to 1440. The unit is minute (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.

Type: USERSET

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

enable_save_dataaccess_timestamp

Parameter description: Specifies whether to record the last access time of a table.

Type: USERSET

Value range: Boolean

- **on** indicates that the last access time of the table is recorded.
- **off** indicates that the last access time of the table is not recorded.

Default value: **off**

instr_unique_sql_count

Parameter description: Specifies whether to collect Unique SQL statements and the maximum number of collected Unique SQL statements.

Type: SIGHUP

Value range: an integer ranging from 0 to INT_MAX

- If it is set to **0**, Unique SQL statistics are not collected.
- If the value is greater than **0**, the number of Unique SQL statements collected on the CN cannot exceed the value of this parameter. When the number of collected Unique SQL statements reaches the upper limit, the collection is stopped. In this case, you can increase the value of **reload** to continue the collection.

Default value: **0**

> **CAUTION**
>
> If a new value is less than the original value, the Unique SQL statistics collected on the corresponding CN will be cleared. Note that the clearing operation is performed by the background thread of the resource management module. If the GUC parameter **use_workload_manager** is set to **off**, the clearing operation may fail. In this case, you can use the **reset_instr_unique_sql** function for clearing.

instr_unique_sql_timeout

Parameter description: Specifies the lifetime of a Unique SQL statement. The background thread of StatCollector checks all Unique SQL statements every hour. If a Unique SQL statement is not executed for more than **instr_unique_sql_timeout** hours, the Unique SQL statement will be deleted. This feature is supported in 8.1.2 or later.

Type: SIGHUP

Value range: an integer ranging from **0** to **INT_MAX**. The unit is hour.

- The value **0** indicates that expired Unique SQL statements will not be deleted.
- If the value is greater than **0**, the Unique SQL statement that is not executed for more than **instr_unique_sql_timeout** hours will be deleted.

Default value: **24**

track_sql_count

Parameter description: Specifies whether to collect statistics on the number of the **SELECT**, **INSERT**, **UPDATE**, **DELETE**, and **MERGE INTO** statements that are being executed in each session, the response time of the **SELECT**, **INSERT**, **UPDATE**, and **DELETE** statements, and the number of DDL, DML, and DCL statements.

Type: SUSET

Value range: Boolean

- **on** indicates that the statistics collection function is enabled.
- **off** indicates that the statistics collection function is disabled.

Default value: **on**

NOTE

- The **track_sql_count** parameter is restricted by the **track_activities** parameter.
  - If **track_activities** is set to **on** and **track_sql_count** is set to **off**, a warning message indicating that **track_sql_count** is disabled will be displayed when the view **gs_sql_count**, **pgxc_sql_count**, **gs_workload_sql_count**, **pgxc_workload_sql_count**, **global_workload_sql_count**, **gs_workload_sql_elapse_time**, **pgxc_workload_sql_elapse_time**, or **global_workload_sql_elapse_time** are queried.
  - If both **track_activities** and **track_sql_count** are set to **off**, two logs indicating that **track_activities** is disabled and **track_sql_count** is disabled will be displayed when the views are queried.
  - If **track_activities** is set to **off** and **track_sql_count** is set to **on**, a log indicating that **track_activities** is disabled will be displayed when the views are queried.
- If this parameter is disabled, querying the view returns **0**.

enable_track_wait_event

Parameter description: Specifies whether to collect statistics on waiting events, including the number of occurrence times, number of failures, duration, maximum waiting time, minimum waiting time, and average waiting time.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the statistics collection function is enabled.
- **off** indicates that the statistics collection function is disabled.

Default value: **off**

NOTE

- The **enable_track_wait_event** parameter is restricted by **track_activities**. Its functions cannot take effect no matter whether it is enabled if **track_activities** is disabled.
- When **track_activities** or **enable_track_wait_event** is disabled, if you query the **get_instr_wait_event** function, **gs_wait_events** view, or **pgxc_wait_events** view, a message is displayed indicating that the GUC parameter is disabled and the query result is 0.
- If **track_activities** or **enable_track_wait_event** is disabled during cluster running, GaussDB(DWS) will not collect statistics on waiting events. However, statistics that have been collected are not affected.

enable_wdr_snapshot

Parameter description: Specifies whether to enable the performance view snapshot function. After this function is enabled, GaussDB(DWS) will periodically create snapshots for some system performance views and save them permanently. In addition, it will accept manual snapshot creation requests.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the snapshot function is enabled.
- **off** indicates that the snapshot function is disabled.

Default value: **off**

NOTE

- If the **create_wdr_snapshot** function is executed to manually create a view when the **enable_wdr_snapshot** parameter is disabled, a message is displayed indicating that the GUC parameter is not enabled.
- If the **enable_wdr_snapshot** parameter is modified during the snapshot creation process, the snapshot that is being created is not affected. The modification takes effect when the snapshot is manually or periodically created next time.

wdr_snapshot_interval

Parameter description: Specifies the interval for automatically creating performance view snapshots.

Type: SIGHUP

Value range: an integer ranging from 10 to 180, in minutes

Default value: **60**

NOTE

- The value of this parameter must be set in accordance with the cluster load. You are advised to set this parameter to a value greater than the time required for creating a snapshot.
- If the value of **wdr_snapshot_interval** is less than the time required for creating a snapshot, the system will skip this snapshot creation because it finds that the previous snapshot creation is not complete when the time for this automatic snapshot creation arrives.

wdr_snapshot_retention_days

Parameter description: Specifies the maximum number of days for storing performance snapshot data.

Type: SIGHUP

Value range: an integer ranging from 1 to 15 days

Default value: **8**

NOTE

- If **enable_wdr_snapshot** is enabled, snapshot data that has been stored for **wdr_snapshot_retention_days** days will be automatically deleted.
- The value of this parameter must be set in accordance with the available disk space. A larger value requires more disk space.
- The modification of this parameter does not take effect immediately. The expired snapshot data will be cleared only when a snapshot is automatically created next time.

17.12.2 Performance Statistics

During the running of the database, the lock access, disk I/O operation, and invalid message process are involved. All these operations are the bottleneck of the database performance. The performance statistics method provided by GaussDB(DWS) can facilitate the performance fault location.

Generating Performance Statistics Logs

Parameter description: For each query, the following four parameters control the performance statistics of corresponding modules recorded in the server log:

- The **og_parser_stats** parameter controls the performance statistics of a parser recorded in the server log.
- The **log_planner_stats** parameter controls the performance statistics of a query optimizer recorded in the server log.
- The **log_executor_stats** parameter controls the performance statistics of an executor recorded in the server log.
- The **log_statement_stats** parameter controls the performance statistics of the whole statement recorded in the server log.

All these parameters can only provide assistant analysis for administrators, which are similar to the getrusage() of the Linux OS.

Type: SUSET

NOTICE

- **log_statement_stats** records the total statement statistics while other parameters only record statistics about each statement.
- The **log_statement_stats** parameter cannot be enabled together with other parameters recording statistics about each statement.

Value range: Boolean

- **on** indicates the function of recording performance statistics is enabled.
- **off** indicates the function of recording performance statistics is disabled.

Default value: **off**

17.13 Resource Management

If database resource usage is not controlled, concurrent tasks easily 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(DWS) workload management function balances the database workload based on available resources to avoid database overloading.

use_workload_manager

Parameter description: Specifies whether to enable the resource management function. This parameter must be applied on both CNs and DNs.

Type: SIGHUP

Value range: Boolean

- **on** indicates the resource management function is enabled.
- **off** indicates the resource management function is disabled.

NOTE

- If method 2 in **Setting GUC Parameters** 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**, the resource management view becomes available, and you can query the storage resource usage collected in the **off** state. If there are slight errors and the storage resource usage needs to be corrected, run the following command. If data is inserted into the table during the command execution, the statistics may be inaccurate.

```
select gs_wlm_readjust_user_space(0);
```

Default value: **on**

enable_perm_space

Parameter description: Specifies whether to enable the perm space function. This parameter must be applied on both CNs and DNs.

Type: POSTMASTER

Value range: Boolean

- **on** indicates the perm space function is enabled.
- **off** indicates the perm space function is disabled.

Default value: **on**

space_once_adjust_num

Parameter description: In the space control and space statistics functions, specifies the threshold of the number of files processed each time during slow building and fine-grained calibration. This parameter is supported by version 8.1.3 or later clusters.

Type: SIGHUP

Value range: an integer ranging from 0 to INT_MAX

- The value **0** indicates that the slow build and fine-grained calibration functions are disabled.

Default value: **300**

NOTE

The file quantity threshold affects database resources. You are advised to set the threshold to a proper value.

space_readjust_schedule

Parameter description: In the space control and space statistics functions, specifies the space error threshold for triggering automatic calibration. This parameter is supported by version 8.1.3 or later clusters.

Type: SIGHUP

Value range: string

- **off** indicates that the automatic calibration function is disabled.
- **auto** indicates that the automatic calibration function is enabled and the error threshold for triggering automatic calibration is **1 GB**.
- **auto (*space size* + K/M/G)** indicates that the automatic calibration is enabled and the error threshold for triggering automatic calibration is *xxx* KB/MB/GB (user-defined). For example, **auto(200M)** indicates that the automatic calibration is enabled and the error threshold for triggering automatic calibration is **200 MB**.

Default value: **auto**

default_partition_cache_strategy

Parameter description: Specifies the default policy for controlling partition caching. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: enumerated values

- **cache_each_partition_as_possible** enables maximum data caching. Data may not be written to CUs when being inserted into different partitions.
- **flush_when_switch_partition** indicates that data is written to CUs if the data belongs to different partitions during insertion.

Default value: **cache_each_partition_as_possible**

enable_libcomm_schedule

Parameter description: Specifies whether to enable network control. This parameter is supported by version 8.2.1 or later clusters.

Type: POSTMASTER

Value range: Boolean

- **on** indicates that network control is enabled.
- **off** indicates that network control is disabled.

Default value: **on**

max_active_statements

Parameter description: Specifies the maximum global concurrency. This parameter applies to a job on a CN.

The database administrator changes the value of this parameter based on system resources (for example, CPU, I/O, and memory resources) so that the system fully supports the concurrency tasks and avoids too many concurrency tasks resulting in system crash.

Type: SIGHUP

Value range: an integer ranging from –1 to INT_MAX. The values **–1** and **0** indicate that the number of concurrent requests is not limited.

Default value: **60**

max_queue_statements

Parameter description: Specifies the maximum queue length. This parameter is supported only by clusters of version 8.3.0 or later.

This parameter applies to CNs only and affects all cluster jobs. The system gives an error if the job queue length surpasses this parameter when delivering jobs.

This parameter applies to all types of queues, such as global concurrent, fast lane, slow lane, CCN global memory, and CCN resource pool queues. Each queue is measured independently.

Type: SIGHUP

Value range: an integer ranging from -1 to INT_MAX. The value **-1** indicates that the number of queuing jobs is not limited.

Default value: **–1**

parctl_min_cost

Parameter description: Specifies the minimum estimated cost of a complex job under static resource management. Threshold for dividing simple jobs and complex jobs. A job whose estimated cost is less than the value of this parameter is a simple job, and a job whose estimated cost is larger than or equal to the value of this parameter is a complex job.

Type: SIGHUP

Value range: an integer ranging from –1 to INT_MAX

- If **parctl_min_cost** is **-1**, all jobs are simple jobs.
- Jobs whose estimated cost is less than 10 are simple jobs.

Default value: **100000**

cgroup_name

Parameter description: Specifies the name of the Cgroup in use. It can be used to change the priorities of jobs in the queue of a Cgroup.

If you set **cgroup_name** and then **session_respool**, the Cgroups associated with **session_respool** take effect. If you reverse the order, Cgroups associated with **cgroup_name** take 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.

Type: USERSET

You are not advised to set **cgroup_name** and **session_respool** at the same time.

Value range: a string

Default value: **DefaultClass:Medium**

NOTE

DefaultClass:Medium indicates the **Medium** Cgroup belonging 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 changes the value of this parameter based on system resources (for example, CPU, I/O, and memory resources) so that the system fully supports the concurrency tasks and avoids too many concurrency tasks resulting in system crash.

Type: SIGHUP

Value range: an integer ranging from 1 to INT_MAX. The unit is second.

Default value: **30**

enable_cgroup_switch

Parameter description: Specifies whether the database automatically switches to the **TopWD** group when executing statements by group type.

Type: USERSET

Value range: Boolean

- **on**: The database automatically switches to the **TopWD** group when executing statements by group type.
- **off**: The database does not automatically switch to the **TopWD** group when executing statements by group type.

Default value: **off**

memory_tracking_mode

Parameter description: Specifies the memory information recording mode.

Type: USERSET

Value range:

- **none**: Memory statistics is not collected.
- **normal:** Only memory statistics is collected in real time and no file is generated.
- **executor:** The statistics file is generated, containing the context information about all allocated memory used by the execution layer.
- **fullexec**: The generated file includes the information about all memory contexts requested by the execution layer.

Default value: **none**

memory_detail_tracking

Parameter description: Specifies the sequence number of the memory background information distributed in the needed thread and **plannodeid** of the query where the current thread is located.

Type: USERSET

Value range: a string

Default value: empty

NOTICE

It is recommended that you retain the default value for this parameter.

enable_resource_track

Parameter description: Specifies whether the real-time resource monitoring function is enabled. This parameter must be applied on both CNs and DNs.

Type: SIGHUP

Value range: Boolean

- **on** indicates the resource monitoring function is enabled.
- **off** indicates the resource monitoring function is disabled.

Default value: **on**

enable_resource_record

Parameter description: Specifies whether resource monitoring records are archived. When this parameter is enabled, records that have been executed are archived to the corresponding **INFO** views (**GS_WLM_SESSION_INFO** and **GS_WLM_OPERARON_INFO**). This parameter must be applied on both CNs and DNs.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the resource monitoring records are archived.
- **off** indicates that the resource monitoring records are not archived.

Default value: **on**

NOTE

The default value of this parameter is **on** for a new cluster. In upgrade scenarios, the default value of this parameter is the same as that of the source version.

enable_track_record_subsql

Parameter description: Specifies whether to enable the function of recording and archiving sub-statements. When this function is enabled, sub-statements in stored

procedures and anonymous blocks are recorded and archived to the corresponding **INFO** table (**GS_WLM_SESSION_INFO**). This parameter is a session-level parameter. It can be configured and take effect in the session connected to the CN and affects only the statements in the session. It can also be configured on both the CN and DN and take effect globally.

Type: USERSET

Value range: Boolean

- **on** indicates that the sub-statement resource monitoring records are archived.
- **off** indicates that the sub-statement resource monitoring records are not archived.

Default value: **on**

enable_user_metric_persistent

Parameter description: Specifies whether the user historical resource monitoring dumping function is enabled. When this function is enabled, data in the **PG_TOTAL_USER_RESOURCE_INFO** view is periodically sampled and saved to the **GS_WLM_USER_RESOURCE_HISTORY** system catalog, and data in the **GS_RESPOOL_RESOURCE_INFO** view is periodically sampled and saved to the **GS_RESPOOL_RESOURCE_HISTORY** system catalog.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the user historical resource monitoring dumping function is enabled.
- **off** indicates that the user historical resource monitoring dumping function is disabled.

Default value: **on**

user_metric_retention_time

Parameter description: Specifies the retention time of the user historical resource monitoring data. This parameter is valid only when **enable_user_metric_persistent** is set to **on**.

Type: SIGHUP

Value range: an integer ranging from 0 to 3650. The unit is day.

- If this parameter is set to **0**, user historical resource monitoring data is permanently stored.
- If the value is greater than **0**, user historical resource monitoring data is stored for the specified number of days.

Default value: **7**

enable_instance_metric_persistent

Parameter description: Specifies whether the instance resource monitoring dumping function is enabled. When this function is enabled, the instance monitoring data is saved to the system catalog **GS_WLM_INSTANCE_HISTORY**.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the instance resource monitoring dumping function is enabled.
- **off**: Specifies that the instance resource monitoring dumping function is disabled.

Default value: **on**

instance_metric_retention_time

Parameter description: Specifies the retention time of the instance historical resource monitoring data. This parameter is valid only when **enable_instance_metric_persistent** is set to **on**.

Type: SIGHUP

Value range: an integer ranging from 0 to 3650. The unit is day.

- If this parameter is set to **0**, instance historical resource monitoring data is permanently stored.
- If the value is greater than **0**, the instance historical resource monitoring data 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**.

Type: USERSET

Value range: enumerated values

- **none**: Resources are not monitored.
- **query**: enables query-level resource monitoring. If this function is enabled, the plan information (similar to the output information of EXPLAIN) of SQL statements will be recorded in top SQL statements.
- **perf**: enables the perf-level resource monitoring. If this function is enabled, the plan information (similar to the output information of EXPLAIN ANALYZE) that contains the actual execution time and the number of execution rows will be recorded in the top SQL.
- **operator**: enables the operator-level resource monitoring. If this function is enabled, not only the information including the actual execution time and number of execution rows is recorded in the top SQL statement, but also the operator-level execution information is updated to the top SQL statement.

Default value: **query**

time_track_strategy

Parameter description: Specifies the policy used to collect the operator execution time of the current session. This parameter is supported by version 8.2.1 or later clusters.

Type: SIGHUP

Value range: enumerated values

- **tsc**: Use Time-Stamp Counter (TSC) to collect the operator execution time. This method is applicable to perf-level top SQL statements and EXPLAIN and applies only to non-vectorized operators. In other scenarios, the time function is still used.
- **vector**: Disable the collection of the execution time of the non-vectorized operators in the top SQL statements at the perf level. Other scenarios use the time function perform collection and are not affected.
- **timer**: The time function used in all scenarios to collect the operator execution time. In cluster 8.2.0 and earlier versions, only this method is used.

Default value: **timer**

NOTE

- The TSC has two methods of converting the time, including the TSC frequency and TSC conversion factors. By default, only the TSC frequency can be used on the x86 platform, and the TSC conversion factor is prioritized on the ARM platform. You can use TSC-related views or functions to view the TSC conversion information of the current node or all nodes.
- In a cluster installation scenario, the default value of this parameter is **tsc**. In an upgrade scenario, the default value of this parameter is **timer** to ensure forward compatibility.

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**.

Type: USERSET

Value range: an integer ranging from –1 to INT_MAX

- **–1** indicates that resource monitoring is disabled.
- A value greater than or equal to **0** indicates that statements whose execution cost exceeds this value will be monitored.

Default value: **0**

NOTE

The default value of this parameter is **0** for a new cluster. In upgrade scenarios, the default value of this parameter is the same as that of the source version.

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 (see **Table 14-1**) 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**.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX. The unit is second (s).

- **0** indicates that information about all statements recorded in the real-time resource monitoring view (see **Table 14-1**) will be archived into historical views.
- If the value is greater than **0**, information about statements recorded in the real-time resource monitoring view (see **Table 14-1**), whose execution time exceeds this value will be archived into historical views.

Default value: **60s**

resource_track_subsql_duration

Parameter description: Filters the minimum execution time of substatements in a stored procedure. This parameter is supported by version 8.2.1 or later clusters.

If the execution time of a sub-statement in a stored procedure is greater than the value of this parameter, the job information is archived to the Top SQL table. This parameter takes effect only when **enable_track_record_subsql** is set to **on**.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX. The unit is second (s).

- If the value is **0**, historical information about all substatements in the stored procedure is archived.
- If the value is greater than **0**, historical information is archived when the execution time of a substatement in a stored procedure exceeds the value of this parameter.

Default value: 180s

query_exception_count_limit

Parameter description: Specifies the maximum number of times that a job triggers an exception rule. If the number of times that a job triggers an exception rule reaches the upper limit, the job will be automatically added to the blocklist and cannot be executed anymore. The job can be resumed only after it is removed from the blocklist.

Type: USERSET

Value range: an integer ranging from –1 to INT_MAX

- If the value is **-1**, the number of times that a job triggers an exception rule is not limited. That is, the job will not be automatically added to blocklist even if it triggers an exception rule for many times.
- If the value is greater than or equal to **0**, the job will be added to the blocklist immediately when the number of times it triggers an exception rule reaches the threshold. The values **0** and **1** both indicate that a job is added to blocklist once the job triggers an exception rule.

Default value: **–1**

dynamic_memory_quota

Parameter description: Specifies the memory quota in adaptive load scenarios, that is, the proportion of maximum available memory to total system memory.

Type: SIGHUP

Value range: an integer ranging from 1 to 100

Default value: **80**

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.

Type: USERSET

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.

Type: USERSET

Value range: a string

Default value: empty

enable_dynamic_workload

Parameter description: Specifies whether to enable the dynamic workload management function.

Type: POSTMASTER

Value range: Boolean

- **on** indicates the dynamic workload management function is enabled.

- **off** indicates the dynamic workload management function is disabled.

Default value: on

NOTICE

- If memory adaptation is enabled, you do not need to use **work_mem** to optimize the operator memory usage after collecting statistics. The system will generate a plan for each statement based on the current load, estimating the memory used by each operator and by the entire statement. In a concurrency scenario, statements are queued based on the system load and their memory usage.
- The optimizer may not accurately estimate the number of rows and will probably underestimate or overestimate 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 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 DN peak memory and adjust the value of **query_max_mem**. For details, see **Adjusting Key Parameters During SQL Tuning**.
- As the memory estimated by the optimizer may be inaccurate, in cluster versions earlier than 8.2.1, the **enable_dynamic_workload** parameter needs to be disabled to prevent CCN global queuing. This will cause the dynamic load management function to be unavailable. Therefore, **enable_global_memctl** is introduced in 8.2.1. When a CCN exception occurs, you can disable the **enable_global_memctl** parameter so that jobs can be delivered to and run in the resource pool.

enable_global_memctl

Parameter description: Specifies whether to enable the global memory management function. This parameter is supported by version 8.2.1 or later clusters.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the global memory management is enabled.
- **off** indicates that global memory management is disabled.

Default value: **on**

NOTE

The dynamic load function consists of two layers of memory management: global memory management and resource pool management. Global memory management determines whether a job can be delivered based on its estimated memory. Resource pool management determines whether a job can be delivered based on resource pool parameters. In versions earlier than 8.2.1, the global memory management function is enabled by default after the dynamic load management function is enabled. The statement memory usage may be underestimated or overestimated by the optimizer. As a result, jobs are queued in the global memory management queue on the CCN. In GaussDB 8.2.1, this parameter is used to control whether to enable the global memory management to improve job efficiency and reduce CCN queue exceptions.

CAUTION

Pay attention to the following when modifying this parameter:

1. If this parameter is enabled, the CCN management function is not required and the CCN memory negative feedback mechanism will not work.
2. When a job is running, if the value of GUC is changed from **OFF** to **ON**, the CCN memory negative feedback mechanism takes effect. If the concurrency is high, the memory may be temporarily unavailable. After the running job is done, the dynamic load function recovers.
3. When a job is running and most jobs are delivered by users from the default resource pool, you are not advised to change the GUC parameter from **enabled** to **disabled** . It may cause a memory error. When there is no job delivered by users from the default resource pool, then you can change the parameter. You are advised to bind a user resource pool before delivering jobs.

enable_wlm_internal_memory_limit

Parameter description: Specifies whether to enable the built-in limit on estimated statement memory usage in load management. (This parameter is supported by version 8.2.0 or later clusters.)

In the memory management module of load management, some built-in restrictions are imposed on the estimated memory of statements. For example:

- The estimated memory of statements cannot exceed 80% of the memory upper limit of the associated resource pool.
- If the concurrency control parameter **active_statements** of the resource pool is not set to **1**, the estimated memory of the statement cannot exceed 40% of the memory upper limit of the associated resource pool.
- During the estimation of statement memory usage, a range is provided first. The maximum value indicates the memory required for optimal statement running performance. The minimum value indicates the memory required for statement running when data spilling is allowed. The final estimation will be within this range. The maximum estimated memory cannot exceed 90% of the memory upper limit of the associated resource pool.

These built-in restrictions can prevent overestimation of statement memory. If memory usage is overestimated, statements will preoccupy too much memory, causing subsequent jobs to queue and affecting resource utilization. To avoid such

problems, the kernel limits the estimated memory usage of a single statement. Execution plans under the built-in restrictions may not be optimal, and may affect the performance of a statement. The memory negative feedback mechanism is provided in 8.2.0 and later cluster versions to alleviate this problem. The **enable_wlm_internal_memory_limit** parameter is added in 8.2.0 and later versions. You can determine whether to enable the built-in restrictions.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the built-in restrictions on statement memory estimation are enabled.
- **off** indicates that the built-in restrictions on statement memory estimation are disabled.

Default value: **on**

enable_strict_memory_expansion

Parameter description: Specifies whether to enable strict control over the increase of statement memory usage. (This parameter is supported by version 8.2.0 or later clusters.)

The CN calculates the estimated memory for a statement and preempts memory accordingly. If there is sufficient memory, the DN can increase the memory used for a statement to facilitate its execution. If this parameter is enabled, the increase of memory usage for a statement will be strictly controlled. The memory usage of a statement will not be allowed to exceed its estimated maximum usage. The memory usage of an operator is increased proportionally each time, so the memory usage after an increase may exceed the allowed maximum, but to a limited extent.

Type: SIGHUP

Value range: Boolean

- **on** indicates that strict control over statement memory usage is enabled.
- **off** indicates that strict control over statement memory usage is disabled.

Default value: **off**

allow_zero_estimate_memory

Parameter description: Specifies whether the estimated memory usage of a statement can be 0. (This parameter is supported by version 8.2.0 or later clusters.)

If the table queried by a statement does not contain statistics, the estimated memory of the statement on the CN may be 0. In this case, the memory usage of operators in the statement is limited by **work_mem**. (**work_mem** is not recommended for operator memory usage control). If **work_mem** is large and there are many operators in a statement, the actual memory of the statement will be large. If this parameter is set to **off**, the estimated memory usage cannot be 0 for queries that have not been analyzed. This setting can help reduce unexpected problems.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the estimated memory usage of a statement can be 0.
- **off** indicates that the estimated memory usage of a statement cannot be 0.

Default value: **on**

wlm_memory_feedback_adjust

Parameter description: Specifies whether to enable memory negative feedback in dynamic load management. (This parameter is supported by version 8.2.0 or later clusters.)

Memory is preempted based on the estimated statement memory usage calculated on the CN. If the estimated memory usage of a statement is too high, it will preempt too much memory, causing subsequent jobs to be queued. With the negative memory feedback mechanism, if the cluster memory usage has been overestimated for a period of time, the CCN node will dynamically release some memory for subsequent jobs, improving resource utilization.

Type: SIGHUP

Value range: string

- **on** indicates that memory negative feedback is enabled.
- **off** indicates that memory negative feedback is disabled.
- **on(***Time_required_for_triggering_negative_feedback*, *Estimated_memory_percentage_required_for_triggering_negative_feedback***)** indicates that memory negative feedback is enabled. For example, **on(60,50)** indicates that to trigger the negative feedback mechanism, the memory must be overestimated for 60 consecutive seconds, and the preempted memory needs must exceed 50% of the available memory. By default, the wait time before the negative feedback mechanism takes effect is 50 seconds. The minimum estimated total memory usage for triggering the mechanism is over 40% of the available system memory.

Default value: **on**

bbox_dump_count

Parameter description: Specifies the maximum number of core files that are generated by GaussDB(DWS) 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 if **enable_bbox_dump** is set to **on**.

Type: USERSET

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**.

io_limits

Parameter description: This parameter has been discarded in version 8.1.2 and is reserved for compatibility with earlier versions. This parameter is invalid in the current version.

Type: USERSET

Value range: an integer ranging from 0 to 1073741823

Default value: **0**

io_priority

Parameter description: This parameter has been discarded in version 8.1.2 and is reserved for compatibility with earlier versions. This parameter is invalid in the current version.

Type: USERSET

Value range: enumerated values

- None
- Low
- Medium
- High

Default value: **None**

session_respool

Parameter description: Specifies the resource pool associated with the current session.

Type: USERSET

If you set **cgroup_name** and then **session_respool**, the Cgroups associated with **session_respool** take effect. If you reverse the order, Cgroups associated with **cgroup_name** take 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: whether to control transaction block statements and stored procedure statements.

Type: USERSET

Value range: Boolean

- **on**: Transaction block statements and stored procedure statements are controlled.
- **off**: Transaction block statements and stored procedure statements are not controlled.

Default value: **on**

session_history_memory

Parameter description: Specifies the memory size of a historical query view.

Type: SIGHUP

Value range: an integer ranging from 10 MB to 50% of **max_process_memory**

Default value: 100MB

topsql_retention_time

Parameter description: Specifies the retention period of historical Top SQL data in the **gs_wlm_session_info** and **gs_wlm_operator_info** tables.

Type: SIGHUP

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: **30**

CAUTION

- Before setting this GUC parameter to enable the data retention function, delete data from the **gs_wlm_session_info** and **gs_wlm_operator_info** tables.
- The default value of this parameter is **30** for a new cluster. In upgrade scenarios, the default value of this parameter is the same as that of the source version.

transaction_pending_time

Parameter description: maximum queuing time of transaction block statements and stored procedure statements if **enable_transaction_parctl** is set to **on**.

Type: USERSET

Value range: an integer ranging from –1 to INT_MAX. The unit is second (s).

- **–1** or **0**: No queuing timeout is specified for transaction block statements and stored procedure statements. The statements can be executed when resources are available.
- Value greater than **0**: 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 (for details, see **PG_SESSION_WLMSTAT**) is **Transaction** or **StoredProc**.

wlm_sql_allow_list

Parameter description: Specifies whitelisted SQL statements for resource management. Whitelisted SQL statements are not monitored by resource management.

Type: SIGHUP

Value range: a string, which contains a maximum of 1,024 characters

Default value: empty

NOTICE

- One or more whitelisted SQL statements can be specified in **wlm_sql_allow_list**. If multiple SQL statements are to be whitelisted, use semicolons (;) to separate them.
- The system determines whether SQL statements are monitored based on the prefix match. The SQL statements are case insensitive. For example, if **wlm_sql_allow_list** is set to **'SELECT'**, all **SELECT** statements are not monitored by the resource management module.
- The system identifies spaces at the beginning of the parameter value. For example, **'SELECT'** and **' SELECT'** have different representations. **' SELECT'** filters only the **SELECT** statements with spaces at the beginning.
- The system has some whitelisted SQL statements by default, which cannot be modified. You can query the default whitelisted SQL statements and the SQL statements that have been successfully added to the whitelist by GUC through the system view **gs_wlm_sql_allow**.
- New SQL statements cannot be appended to the whitelisted SQL statements specified by **wlm_sql_allow_list** but can be set only through overwriting. To add an SQL statement, query the original GUC value, add the new statement to the end of the original value, separate the statements with a semicolon (;), and set the GUC value again.

17.14 Automatic Cleanup

The automatic cleanup process (**autovacuum**) in the system automatically runs the **VACUUM** and **ANALYZE** statements to reclaim the record space marked as deleted and update statistics about the table.

NOTE

autovacuum does not block service statements initiated by users. **autovacuum** and **autoanalyze** statements can be executed concurrently without conflicts. This function is supported only in versions later than 8.2.1.300.

autovacuum

Parameter description: Specifies whether to start the automatic cleanup process (**autovacuum**). Ensure that the **track_counts** parameter is set to **on** before enabling the automatic cleanup process.

Type: SIGHUP

Value range: Boolean

- **on** indicates the database automatic cleanup process is enabled.
- **off** indicates that the database automatic cleanup process is disabled.

Default value: **on**

NOTE

Set **autovacuum** to **on** if you want to enable the function of automatically cleaning up two-phase transactions after the system recovers from faults.

- If **autovacuum** is set to **on** and **autovacuum_max_workers** to **0**, the **autovacuum** process will not be automatically performed and only abnormal two-phase transactions are cleaned up after the system recovers from faults.
- If **autovacuum** is set to **on** and the value of **autovacuum_max_workers** is greater than **0**, the system will automatically clean up two-phase transactions and processes after recovering from faults.

NOTICE

Even if this parameter is set to **off**, the database initiates a cleanup process when transaction ID wraparound needs to be prevented. When a **CREATE DATABASE** or **DROP DATABASE** operation fails, the transaction may have 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 whose transactions are in the prepared status. Administrators connect to an available database such as gaussdb to run the **SET xc_maintenance_mode = on** statement.
3. Commit or roll back the two-phase transaction based on the global transaction status.

autovacuum_mode

Parameter description: Specifies whether the **autoanalyze** or **autovacuum** function is enabled. This parameter is valid only when **autovacuum** is set to **on**.

Type: SIGHUP

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_mode

Parameter description: Specifies the autoanalyze mode. This parameter is supported by version 8.2.0 or later clusters.

Type: USERSET

Value range: enumerated values

- **normal** indicates common autoanalyze.
- **light** indicates lightweight autoanalyze.

Default value:

- If the current cluster is upgraded from an earlier version to 8.2.0, the default value is **normal** to ensure forward compatibility.
- If the cluster version 8.2.0 is newly installed, the default value is **light**.

autoanalyze_timeout

Parameter description: Specifies the timeout period of **autoanalyze**. If the duration of **analyze** on a table exceeds the value of **autoanalyze_timeout**, **analyze** is automatically canceled.

Type: SIGHUP

Value range: an integer ranging from 0 to 2147483. The unit is second.

Default value: **5min**

analyze_stats_mode

Parameter description: Specifies the mode for **ANALYZE** to calculate statistics.

Type: USERSET

Value range: enumerated values

- **memory** indicates that the memory is forcibly used to calculate statistics. Multi-column statistics are not calculated.
- **sample_table** indicates that temporary sampling tables are forcibly used to calculate statistics. Temporary tables do not support this mode.
- **dynamic** indicates that the statistics calculation mode is determined based on the size of **maintenance_work_mem**. If **maintenance_work_mem** can store samples, the memory mode is used. Otherwise, the temporary sampling table mode is used.

Default value:

- If the current cluster is upgraded from an earlier version to 8.2.0.100, the default value is **memory** to ensure forward compatibility.
- If the cluster version 8.2.0.100 is newly installed, the default value is **dynamic**.

analyze_sample_mode

Parameter description: Specifies the sampling model used by **ANALYZE**.

Type: USERSET

Value range: an integer ranging from **0** to **2**

- **0** indicates the default reservoir sampling.
- **1** indicates the optimized reservoir sampling.
- **2** indicates range sampling.

Default value: **0**

autovacuum_io_limits

Parameter description: Specifies the upper limit of I/Os triggered by the **autovacuum** process per second. This parameter has been discarded in version 8.1.2 and is reserved for compatibility with earlier versions. This parameter is invalid in the current version.

Type: SIGHUP

Value range: an integer ranging from –1 to 1073741823. **–1** indicates that the default Cgroup is used.

Default value: **–1**

autovacuum_max_workers

Parameter description: Specifies the maximum number of automatic cleanup threads running at the same time.

Type: SIGHUP

Value range: an integer ranging from 0 to 128. **0** indicates that **autovacuum** is disabled.

Default value: **4**

NOTE

This parameter works with **autovacuum**. The rules for clearing system catalogs and user tables are as follows:

- When **autovacuum_max_workers** is set to **0**, **autovacuum** is disabled and no tables are cleared.
- If **autovacuum_max_workers > 0** and **autovacuum = off** are configured, the system only clears the system catalogs and column-store tables with delta tables enabled (such as **vacuum delta tables**, **vacuum cudesc tables**, and **delta merge**).
- If **autovacuum_max_workers > 0** and **autovacuum = on** are configured, all tables are cleared.

autovacuum_naptime

Parameter description: Specifies the interval between two automatic cleanup operations.

Type: SIGHUP

Value range: an integer ranging from 1 to 2147483. The unit is second.

Default value: **60s**

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.

Type: SIGHUP

Value range: an integer ranging from **0** to **INT_MAX**

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.

Type: SIGHUP

Value range: an integer ranging from **0** to **INT_MAX**

Default value:

- If the current cluster is upgraded from an earlier version to 8.1.3, the default value is **10000** to ensure forward compatibility.
- If the current cluster version is 8.1.3, the default value is **50**.

autovacuum_vacuum_scale_factor

Parameter description: Specifies the size scaling factor of a table added to the **autovacuum_vacuum_threshold** parameter when a **VACUUM** event is triggered.

Type: SIGHUP

Value range: a floating point number ranging from 0.0 to 100.0

Default value: **0.2**

autovacuum_analyze_scale_factor

Parameter description: Specifies the size scaling factor of a table added to the **autovacuum_analyze_threshold** parameter when an **ANALYZE** event is triggered.

Type: SIGHUP

Value range: a floating point number ranging from 0.0 to 100.0

Default value:

- If the current cluster is upgraded from an earlier version to 8.1.3, the default value is **0.25** to ensure forward compatibility.
- If the current cluster version is 8.1.3, the default value is **0.1**.

autovacuum_freeze_max_age

Parameter description: Specifies the maximum age (in transactions) that a table's **pg_class.relfrozenxid** column can attain before a VACUUM operation is forced to prevent transaction ID wraparound within the table.

The old files under the subdirectory of **pg_clog/** can also be deleted by the VACUUM operation. Even if the automatic cleanup process is forbidden, the system will invoke the automatic cleanup process to prevent the cyclic repetition.

Type: SIGHUP

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.

Type: SIGHUP

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: **2ms**

autovacuum_vacuum_cost_limit

Parameter description: Specifies the value of the cost limit used in the **autovacuum** operation.

Type: SIGHUP

Value range: an integer ranging from –1 to 10000. **-1** indicates that the normal vacuum cost limit is used.

Default value: **–1**

enable_pg_stat_object

Parameter description: Specifies whether **AUTO VACUUM** updates the **PG_STAT_OBJECT** system catalog. This parameter is supported by version 8.2.1 or later clusters.

Type: USERSET

Value range: Boolean

- **on** indicates that the **PG_STAT_OBJECT** system catalog is updated during **AUTO VACUUM**.

- **off** indicates that the **PG_STAT_OBJECT** system catalog is not updated during **AUTO VACUUM**.

Default value: **on**

enable_col_index_vacuum

Parameter description: Specifies whether to allow **AUTO VACUUM** to clear dirty data in column-store indexes. Clearing dirty data of column-store indexes can prevent index space expansion and optimize the performance of importing tables with indexes to the database. This parameter is supported by version 8.2.1.100 or later clusters.

Type: SIGHUP

Value range: Boolean

- **on** indicates that **AUTO VACUUM** is allowed to clear dirty data of column-store indexes.
- **off** indicates that **AUTO VACUUM** is not allowed to clear dirty data of column-store indexes.

Default value: **on**

NOTICE

By default, this parameter is set to **on** in a newly installed cluster and **off** after an old cluster is upgraded.

17.15 Default Settings of Client Connection

17.15.1 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 (,).

Type: USERSET

- If the schema of a temporary table 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 a temporary table has the highest search priority and is always searched before all the 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 only searched for database objects, including tables, views, and data types. Functions or operator names will not be searched for.

- The schema of a system catalog, **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.
- When an object is created without specifying a particular schema, the object will be placed in the first valid schema listed in **search_path**. An error will be 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**, a database can be shared (where no users have private schemas, and all share use of public), and 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.

Type: USERSET

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 specifies 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 consulted instead.
- This parameter is not used when users create databases. By default, a new database inherits its tablespace setting from the template database.

Type: USERSET

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.

Type: USERSET

Value range: a string

- **installation**: indicates that the table is created in the installed Node Group by default.
- **random_node_group**: indicates that the table is created in a randomly selected Node Group by default. This feature is supported in 8.1.2 or later and is used only in the test environment.
- **roach_group**: indicates that the table is created in all nodes by default. This value is reserved for the Roach tool and cannot be used in other scenarios.
- A value other than the preceding three options indicates that the table is created in a specified Node Group.

Default value: **installation**

default_colversion

Parameter description: Sets the storage format version of the column-store table that is created by default.

Type: SIGHUP

Value range: enumerated values

- **1.0**: Each column in a column-store table is stored in a separate file. The file name is **relfilenode.C1.0**, **relfilenode.C2.0**, **relfilenode.C3.0**, or similar.
- **2.0**: All columns of a column-store table are combined and stored in a file. The file is named **relfilenode.C1.0**.

Default value: 2.0

temp_tablespaces

Parameter description: Specifies tablespaces to which temporary objects will be created (temporary tables and their indexes) when a **CREATE** command does not

explicitly specify a tablespace. Temporary files for sorting large data are created in these tablespaces.

The value of this parameter is a list of names of tablespaces. When there is more than one name in the list, GaussDB(DWS) chooses a random tablespace from the list upon the creation of a temporary object each time. Except that 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(DWS) will automatically use the default tablespace of the current database instead.

Type: USERSET

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 restore function definitions from a dump.

Type: USERSET

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.

Type: USERSET

Value range: enumerated values

- **READ COMMITTED**: Only committed data is read. This is the default.
- **READ UNCOMMITTED**: GaussDB(DWS) does not support **READ UNCOMMITTED**. If **READ UNCOMMITTED** is set, **READ COMMITTED** is executed instead.
- **REPEATABLE READ**: Only the data committed before transaction start is read. Uncommitted data or data committed in other concurrent transactions cannot be read.
- **SERIALIZABLE**: GaussDB(DWS) does not support **SERIALIZABLE**. If **SERIALIZABLE** is set, **REPEATABLE READ** is executed instead.

Default value: **READ COMMITTED**

default_transaction_read_only

Parameter description: Specifies whether each new transaction is in read-only state.

Type: SIGHUP

Value range: Boolean

- **on** indicates the transaction is in read-only state.
- **off** indicates the transaction is in read/write state.

Default value: **off**

default_transaction_deferrable

Parameter description: Specifies the default delaying state of each new transaction. It currently has no effect on read-only transactions or those running at isolation levels lower than serializable.

GaussDB(DWS) does not support the serializable isolation level of each transaction. The parameter is insignificant.

Type: USERSET

Value range: Boolean

- **on** indicates a transaction is delayed by default.
- **off** indicates 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.

Type: USERSET

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 when the server receives the command) is longer than the duration specified by the parameter, error information is displayed when you attempt to execute the statement and the statement then exits.

Type: USERSET

Value range: an integer ranging from 0 to 2147483647. The unit is ms.

Default value:

- If the current cluster is upgraded from an earlier version to 8.2.0, the value in the earlier version is inherited. The default value is **0**.
- If the cluster version 8.2.0 is newly installed, the default value is **24h**.

vacuum_freeze_min_age

Parameter description: Specifies the minimum cutoff age (in the same transaction), based on which **VACUUM** decides whether to replace transaction IDs with FrozenXID while scanning a table.

Type: USERSET

Value range: an integer from 0 to 576460752303423487.

NOTE

Although you can set this parameter to a value ranging from **0** to **1000000000** anytime, **VACUUM** will limit the effective value to half the value of **autovacuum_freeze_max_age** by default.

Default value: **5000000000**

vacuum_freeze_table_age

Parameter description: Specifies the time that VACUUM freezes tuples while scanning the whole table. **VACUUM** performs a whole-table scan if the value of the **pg_class**.**relfrozenxid** column of the table has reached the specified time.

Type: USERSET

Value range: an integer from 0 to 576460752303423487.

NOTE

Although users can set this parameter to a value ranging from **0** to **2000000000** anytime, **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: **15000000000**

bytea_output

Parameter description: Specifies the output format for values of the bytea type.

Type: USERSET

Value range: enumerated values

- **hex** indicates the binary data is converted to the two-byte hexadecimal digit.
- **escape** indicates 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.

Default value: **hex**

xmlbinary

Parameter description: Specifies how binary values are to be encoded in XML.

Type: USERSET

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.

Type: USERSET

Value range: enumerated values

- **document** indicates an HTML document.
- **content** indicates a common string.

Default value: **content**

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 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 modifying index storage parameters.

Type: USERSET

Value range: an integer ranging from 64 to INT_MAX. The unit is KB.

Default value: **4 MB**

17.15.2 Zone 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.

Type: USERSET

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**.

Suggestion: The ISO format is recommended. Postgres, SQL, and German use abbreviations for time zones, such as **EST**, **WST**, and **CST**.

IntervalStyle

Parameter description: Specifies the display format for interval values.

Type: USERSET

Value range: enumerated values

- **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 the output result that matches the numtodsinterval function in the Oracle database. For details, see numtodsinterval.

NOTICE

The **IntervalStyle** parameter also affects the interpretation of ambiguous interval input.

Default value: **postgres**

TimeZone

Parameter description: Specifies the time zone for displaying and interpreting time stamps.

Type: USERSET

Value range: a string. You can obtain it by querying the **pg_timezone_names** view.

Default value: **UTC**

NOTE

gs_initdb will set a time zone value that is consistent with the system environment.

timezone_abbreviations

Parameter description: Specifies the time zone abbreviations that will be accepted by the server.

Type: USERSET

Value range: a string. You can obtain it by querying the pg_timezone_names view.

Default value: **Default**

NOTE

Default indicates an abbreviation that works 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: Specifies 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).

Type: USERSET

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 type (character set).

Set this parameter as needed. Try to keep the client code and server code consistent to improve efficiency.

Type: USERSET

Value range: encoding compatible with PostgreSQL. **UTF8** indicates that the database encoding is used.

NOTE

- You can run the **locale -a** command to check and set the system-supported zone and the corresponding encoding format.
- 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 a cluster, you are advised to 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**

lc_messages

Parameter description: Specifies the language in which messages are displayed.

Valid values depend on the current system. On some systems, this zone 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.

Type: SUSET

Value range: a string

NOTE

- You can run the **locale -a** command to check and set the system-supported zone and the corresponding encoding format.
- 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. Valid values depend on the current system.

Type: USERSET

Value range: a string

NOTE

- You can run the **locale -a** command to check and set the system-supported zone and the corresponding encoding format.
- 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_numeric

Parameter description: Specifies the display format of numbers. It affects the output of functions such as to_char. Valid values depend on the current system.

Type: USERSET

Value range: a string

NOTE

- You can run the **locale -a** command to check and set the system-supported zone and the corresponding encoding format.
- 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_time

Parameter description: Specifies the display format of time and zones. It affects the output of functions such as to_char. Valid values depend on the current system.

Type: USERSET

Value range: a string

NOTE

- You can run the **locale -a** command to check and set the system-supported zone and the corresponding encoding format.
- 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**

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.

Type: USERSET

Value range: a string

NOTE

GaussDB(DWS) supports the following two configurations: pg_catalog.english and pg_catalog.simple.

Default value: **pg_catalog.english**

17.15.3 Other Default Parameters

This section describes the default database loading parameters of the database system.

dynamic_library_path

Parameter description: Specifies the path for saving the shared database files that are dynamically loaded for data searching. When a dynamically loaded 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.

The value of **dynamic_library_path** must be a list of absolute paths separated by colons (:) or by semi-colons (;) on the Windows OS. The special variable **$libdir** in the beginning of a path will be replaced with the module installation directory provided by GaussDB(DWS). Example:

```
dynamic_library_path = '/usr/local/lib/postgresql:/opt/testgs/lib:$libdir'
```

Type: SUSET

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.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX. The value **0** indicates no limit.

Default value: **0**

17.16 Lock Management

In GaussDB(DWS), concurrent transactions may cause single-node deadlocks or distributed deadlocks due to resource competition. This section describes parameters used for managing transaction lock mechanisms.

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.

- 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 released before the waiter decides to check for deadlocks will be reduced.
- When **log_lock_waits** is set, this parameter also determines the duration you need to wait before a log message about the lock wait is issued. If you are trying to investigate locking delays, you need to set this parameter to a value smaller than normal **deadlock_timeout**.

Type: SUSET

Value range: an integer ranging from 1 to 2147483647. The unit is millisecond (ms).

Default value: **1s**

ddl_lock_timeout

Parameter description: Indicates the number of seconds a DDL command should wait for the locks to become available. If the time spent in waiting for a lock exceeds the specified time, an error is reported. This parameter is supported only by clusters of version 8.1.3.200 or later.

Type: SUSET

Value range: an integer ranging from 0 to INT_MAX. The unit is millisecond (ms).

- If the value of this parameter is 0, this parameter does not take effect.
- If the value of this parameter is greater than 0, the lock wait time of DDL statements is the value of this parameter, and the lock wait time of other locks is the value of **lockwait_timeout**.

Default value: **0**

NOTE

This parameter has a higher priority than **lockwait_timeout** and takes effect only for **AccessExclusiveLock**.

ddl_select_concurrent_mode

Parameter description: Specifies the concurrency mode of DDL and **SELECT** statements. This parameter is supported only by clusters of version 8.1.3.320, 8.2.1, or later.

Type: SUSET

Value range: enumerated values

- **none**: DDL and select statements cannot be executed concurrently. Waiting statements are in the lock wait state.
- **truncate**: When a **TRUNCATE** statement is blocked by a **SELECT** statement, the **TRUNCATE** statement interrupts the **SELECT** statement and is executed first. Other DDL statements and **SELECT** statements remain in the lock wait state.
- **exchange**: When an **EXCHANGE** statement is blocked by a **SELECT** statement, the **EXCHANGE** statement interrupts the **SELECT** statement and is executed first. Other DDL statements and **SELECT** statements remain in the lock wait state.
- **truncate**, **exchange**: When a **TRUNCATE** and an **EXCHANGE** statement are blocked by the **SELECT** statement, the **SELECT** statement is interrupted and the **TRUNCATE** and **EXCHANGE** statement are executed first.

Default value: **none**

NOTE

- To reserve time for the **SELECT** statement to respond to signals, if the value of **ddl_lock_timeout** is less than 1 second in the current version, 1 second is used.
- Concurrency is not supported when there are conflicts with locks of higher levels (more than one level). For example, **autoanalyze** is triggered by **SELECT** when **autoanalyze_mode** is set to **normal**.

lockwait_timeout

Parameter description: Specifies the longest time to wait before a single lock times out. If the time you wait before acquiring a lock exceeds the specified time, an error is reported.

Type: SUSET

Value range: an integer ranging from 0 to INT_MAX. The unit is millisecond (ms).

Default value: **20 min**

update_lockwait_timeout

Parameter description: sets 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 you wait before acquiring a lock exceeds the specified time, an error is reported.

Type: SUSET

Value range: an integer ranging from 0 to INT_MAX. The unit is millisecond (ms).

Default value: **2min**

max_locks_per_transaction

Parameter description: Controls 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 that do not exceed the preset number can be locked simultaneously at any time. You may need to increase this value when you modify many different tables in a single transaction. This parameter can only be set at database start.
- If this parameter is set to a large value, GaussDB(DWS) may require more System V shared memory than the default setting.
- 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.

Type: POSTMASTER

Value range: an integer ranging from 10 to INT_MAX

Default value: **256**

max_pred_locks_per_transaction

Parameter description: Controls the average number of predicated locks allocated for each transaction.

- The size of the shared and predicated 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 that do not exceed the preset number can be locked simultaneously at any time. You may need to increase this value when you modify many different tables in a single transaction. This parameter can only be set at server start.
- If this parameter is set to a large value, GaussDB(DWS) may require more System V shared memory than the default setting.

Type: POSTMASTER

Value range: an integer ranging from 10 to INT_MAX

Default value: **64**

partition_lock_upgrade_timeout

Parameter description: Specifies the time to wait before the attempt of a lock upgrade from ExclusiveLock to AccessExclusiveLock times out on partitions.

- 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, ExclusiveLock is acquired for the partitions during data rearrangement and AccessExclusiveLock is acquired during file exchange.
- Generally, a partition waits until it acquires a lock, or a timeout occurs if the partition waits for a period of time longer than specified by the **lockwait_timeout** parameter.
- When doing MERGE PARTITION or CLUSTER PARTITION on a partitioned table, you need to acquire AccessExclusiveLock during file exchange. If the

lock fails to be acquired, the acquisition is retried in 50 ms. This 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.

Type: USERSET

Value range: an integer ranging from -1 to 3000. The unit is second (s).

Default value: **1800**

enable_release_scan_lock

Parameter description: Specifies whether a SELECT statement releases a level-1 lock after the statement execution is complete. This parameter reduces DDL conflicts with SELECT locks within transaction blocks. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: Boolean

- **on** indicates that DDL operations will be blocked to wait for the release of cluster locks. The SELECT statement releases the level-1 lock after it finishes, not when the transaction commits.
- **off** indicates that DDL operations will not be blocked.

Default value: **off**

17.17 Version and Platform Compatibility

17.17.1 Compatibility with Earlier Versions

This section describes the parameter control of the downward compatibility and external compatibility features of GaussDB(DWS). Backward compatibility of the database system provides support for the application of databases of earlier versions. This section describes parameters used for controlling backward compatibility of a database.

array_nulls

Parameter description: Determines whether the array input parser recognizes unquoted NULL as a null array element.

Type: USERSET

Value range: Boolean

- **on** indicates that null values can be entered in arrays.
- **off** indicates backward compatibility with the old behavior. Arrays containing **NULL** values can still be created when this parameter is set to **off**.

Default value: **on**

backslash_quote

Parameter description: Determines whether a single quotation mark can be represented by \' in a string text.

Type: USERSET

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'...').

Value range: 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: Determines whether **CREATE TABLE** and **CREATE TABLE AS** include an **OID** field in newly-created tables if neither **WITH OIDS** nor **WITHOUT 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.

Type: USERSET

Value range: Boolean

- **on** indicates **CREATE TABLE** and **CREATE TABLE AS** can include an **OID** field in newly-created tables.
- **off** indicates **CREATE TABLE** and **CREATE TABLE AS** cannot include any **OID** field in newly-created tables.

Default value: **off**

escape_string_warning

Parameter description: Specifies a warning on directly using a backslash (\) 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 is now to treat the backslash as an ordinary character in each SQL standard.

- This variable can be enabled to help locate codes that need to be changed.

Type: USERSET

Value range: Boolean

Default value: **on**

lo_compat_privileges

Parameter description: Determines whether to enable backward compatibility for the privilege check of large objects.

Type: SUSET

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.

Default value: **off**

quote_all_identifiers

Parameter description: When the database generates SQL, this parameter forcibly quotes all identifiers even if they are not keywords. This will affect the output of EXPLAIN as well as the results of functions, such as pg_get_viewdef. For details, see the **--quote-all-identifiers** parameter of **gs_dump**.

Type: USERSET

Value range: Boolean

- **on** indicates the forcible quotation function is enabled.
- **off** indicates the forcible quotation function is disabled.

Default value: **off**

sql_inheritance

Parameter description: Determines whether to inherit semantics.

Type: USERSET

Value range: Boolean

off indicates that child tables cannot be accessed by various commands. That is, an ONLY keyword is used by default. This setting is compatible with versions earlier than PostgreSQL 7.1.

Default value: **on**

standard_conforming_strings

Parameter description: Determines 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'...').

Type: USERSET

Value range: Boolean

- **on** indicates that the function is enabled.
- **off** indicates that the function is disabled.

Default value: **on**

synchronize_seqscans

Parameter description: Controls sequential scans of tables to synchronize with each other. Concurrent scans read the same data block about at the same time and share the I/O workload.

Type: USERSET

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: Controls whether certain limited features, such as GDS table join, are available. These features are not explicitly prohibited in earlier versions, but are not recommended due to their limitations in certain scenarios.

Type: USERSET

Value range: Boolean

- **on** indicates that the features are enabled and forward compatible, but may incur errors in certain scenarios.
- **off** indicates that the features are disabled.

Default value: **off**

17.17.2 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: Determines whether expressions of the form expr = NULL (or NULL = expr) are treated as expr IS NULL. They return true if expr evaluates to **NULL**, 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.

Type: USERSET

Value range: Boolean

- **on** indicates expressions of the form expr = NULL (or NULL = expr) are treated as expr IS NULL.
- **off** indicates expr = NULL always returns NULL.

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.

td_compatible_truncation

Parameter description: Determines 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 (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.

Type: USERSET

Value range: Boolean

- **on** indicates overlong strings are truncated.
- **off** indicates overlong strings are not truncated.

Default value: **off**

behavior_compat_options

Parameter description: Specifies database compatibility behavior. Multiple items are separated by commas (,).

Type: USERSET

Value range: a string

Default value: In upgrade scenarios, the default value of this parameter is the same as that in the cluster before the upgrade. When a new cluster is installed, the default value of this parameter is **check_function_conflicts** to prevent serious problems caused by incorrect function attributes defined by users.

NOTE

- Currently, only **Table 17-4** is supported.
- When multiple compatibility configuration items are configured, adjacent configuration items are separated by commas (,). For example:
  ```
  set behavior_compat_options='end_month_calculate,display_leading_zero';
  ```
- **strict_concat_functions** and **strict_text_concat_td** are mutually exclusive.

Table 17-4 Compatibility configuration items

Configuration Item	Behavior	Applicable Compatibility Mode

display_leading_zero	Specifies how floating point numbers are displayed.
	• 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**.
	• 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**.
	For example, during data migration, if this parameter is not set during data import, when floating numbers are displayed or converted to strings, the leading zeros of the floating point numbers are omitted, causing an error message like this:
	`ERROR: xxx invalid input syntax for type xxx`
	`DETAIL: Token "." is invalid`
		ORA
		TD

Configuration Item	Behavior	Applicable Compatibility Mode

end_month_calculate	Specifies the calculation logic of the add_months function.
	Assume that the two parameters of the add_months function are **param1** and **param2**, and that the sum of **param1** and **param2** is **result**.
	● 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:
	`select add_months('2018-02-28',3) from dual;`
	`add_months`
	`---------------------`
	`2018-05-28 00:00:00`
	`(1 row)`
	● 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:
	`select add_months('2018-02-28',3) from dual;`
	`add_months`
	`---------------------`
	`2018-05-31 00:00:00`
	`(1 row)`
		ORA
		TD

compat_analyze_sample	Specifies the sampling behavior of the ANALYZE operation. 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.	ORA TD MySQL
bind_schema_tablespace	Binds a schema with the tablespace with the same name. 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*.	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode
bind_procedure_searchpath	Specifies the search path of the database object for which no schema name is specified. If no schema name is specified for a stored procedure, the search is performed in the schema to which the stored procedure belongs. If the stored procedure is not found, the following operations are performed: ● If this item is not specified, the system reports an error and exits. ● 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.	ORA TD MySQL
correct_to_number	Controls the compatibility of the to_number() result. If this item is specified, the result of the **to_number()** function is the same as that of PG11. Otherwise, the result is the same as that of Oracle.	ORA

unbind_divide_bound	Controls the range check on the result of integer division.
	● If this item is not specified, the division result is checked. If the result is out of the range, an error is reported. In the following example, an out-of-range error is reported because the value of **INT_MIN/(-1)** is greater than the value of **INT_MAX**.
	`SELECT (-2147483648)::int / (-1)::int;`
	`ERROR:  integer out of range`
	● If this item is specified, the range of the division result does not need to be checked. In the following example, **INT_MIN/(-1)** can be used to obtain the output result **INT_MAX+1**.
	`SELECT (-2147483648)::int / (-1)::int;`
	` ?column?`
	`------------`
	` 2147483648`
	`(1 row)`
		ORA
		TD

merge_update_multi	Specifies whether to perform an update when **MERGE INTO** is executed to match multiple rows. If this item is specified, no error is reported when multiple rows are matched. Otherwise, an error is reported (same as Oracle).	ORA TD

Configuration Item	Behavior	Applicable Compatibility Mode
disable_row_update_multi	Specifies whether to perform an update when multiple rows of a row-store table are matched. If this item is specified, an error is reported when multiple rows are matched. Otherwise, multiple rows can be matched and updated by default.	ORA TD

return_null_string	Specifies how to display the empty result (empty string '') of the lpad(), rpad(), repeat(), regexp_split_to_table(), and split_part() functions.
	● If this item is not specified, the empty string is displayed as **NULL**.
	`select length(lpad('123',0,'*')) from dual;`
	`length`
	`--------`
	`(1 row)`
	● If this item is specified, the empty string is displayed as single quotation marks (''').
	`select length(lpad('123',0,'*')) from dual;`
	`length`
	`--------`
	`0`
	`(1 row)`
		ORA

compat_concat_variadic	Specifies the compatibility of variadic results of the concat() and concat_ws() functions. 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.	ORA TD

Configuration Item	Behavior	Applicable Compatibility Mode
convert_string_digit_to_numeric	Specifies the type casting priority for binary BOOL operations on the CHAR type and INT type. ● If this item is not specified, the type casting priority is the same as that of PG9.6. ● After this item is configured, all binary BOOL operations of the CHAR type and INT type are forcibly converted to the NUMERIC type for computation. After this configuration item is set, the CHAR types that are affected include BPCHAR, VARCHAR, NVARCHAR2, and TEXT, and the INT types that are affected include INT1, INT2, INT4, and INT8. **CAUTION** This configuration item is valid only for binary BOOL operation, for example, **INT2>TEXT** and **INT4=BPCHAR**. Non-BOOL operation is not affected. This configuration item does not support conversion of UNKNOWN operations such as **INT>'1.1'**. After this configuration item is enabled, all BOOL operations of the CHAR and INT types are preferentially converted to the NUMERIC type for computation, which affects the computation performance of the database. When the JOIN column is a combination of affected types, the execution plan is affected.	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode
check_function_conflicts	Controls the check of the custom **plpgsql/SQL** function attributes. • If this parameter is not specified, the **IMMUTABLE/STABLE/VOLATILE** attributes of a custom function are not checked. • If this parameter is specified, the IMMUTABLE attribute of a custom function is checked. If the function contains a table or the STABLE/VOLATILE function, an error is reported during the function execution. In a custom function, a table or the STABLE/VOLATILE function conflicts with the IMMUTABLE attribute, thus function behaviors are not IMMUTABLE in this case. For example, when this parameter is specified, an error is reported in the following scenarios: CREATE OR replace FUNCTION sql_immutable (INTEGER) RETURNS INTEGER AS 'SELECT a+$1 from shipping_schema.t4 where a=1;' LANGUAGE SQL IMMUTABLE RETURNS NULL ON NULL INPUT; select sql_immutable(1); ERROR: IMMUTABLE function cannot contain SQL statements with relation or Non-IMMUTABLE function. CONTEXT: SQL function "sql_immutable" during startup referenced column: sql_immutable	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode

varray_verification	Indicates whether to verify the array length and array type length. Compatible with GaussDB(DWS) versions earlier than 8.1.0.
	If this parameter is specified, the array length and array type length are not verified.
	Scenario 1
	CREATE OR REPLACE PROCEDURE varray_verification
	AS
	TYPE org_varray_type IS varray(5) OF VARCHAR2(2);
	v_org_varray org_varray_type;
	BEGIN
	v_org_varray(1) := '111'; --If the value exceeds the limit of **VARCHAR2(2)**, the setting will be consistent with that in the historical version and no verification is performed after configuring this option.
	END;
	/
	Scenario 2
	CREATE OR REPLACE PROCEDURE varray_verification_i3_1
	AS
	TYPE org_varray_type IS varray(2) OF NUMBER(2);
	v_org_varray org_varray_type;
	BEGIN
	v_org_varray(3) := 1; --If the value exceeds the limit of **varray(2)** specified for array length, the setting will be consistent with that in the historical version and no verification is performed after configuring this option.
	END;
	/
		ORA
		TD

Configuration Item	Behavior	Applicable Compatibility Mode

strict_concat_functions	Indicates whether the **textanycat()** and **anytextcat()** functions are compatible with the return value if there are null parameters. This parameter and **strict_text_concat_td** are mutually exclusive.
	In MySQL-compatible mode, this parameter has no impact.
	● If this configuration item is not specified, the returned values of the **textanycat()** and **anytextcat()** functions are the same as those in the Oracle database.
	● When this configuration item is specified, if there are null parameters in the **textanycat()** and **anytextcat()** functions, the returned value is also null. Different result formats in Oracle and Teradata are retained.
	If this configuration item is not specified, the returned values of the **textanycat()** and **anytextcat()** functions are the same as those in the Oracle database.
	`SELECT textanycat('gauss', cast(NULL as BOOLEAN));`
	` textanycat`
	`------------`
	` gauss`
	`(1 row)`
	
	`SELECT 'gauss' || cast(NULL as BOOLEAN); -- In this case, the || operator is converted to the **textanycat** function.`
	` ?column?`
	`----------`
	` gauss`
	`(1 row)`
	When setting this configuration item, retain the results that are different from those in Oracle and Teradata:
	`SELECT textanycat('gauss', cast(NULL as BOOLEAN));`
	` textanycat`
	`------------`
	
	`(1 row)`
	
	`SELECT 'gauss' || cast(NULL as BOOLEAN); -- In this case, the || operator is converted to the **textanycat** function.`
	` ?column?`
	`----------`
	
	`(1 row)`
		ORA
		TD

Configuration Item	Behavior	Applicable Compatibility Mode

strict_text_concat_td	In Teradata compatible mode, whether the **textcat()**, **textanycat()** and **anytextcat()** functions are compatible with the return value if there are null parameters. This parameter and **strict_concat_functions** are mutually exclusive.
	● If this parameter is not specified, the return values of the **textcat()**, **textanycat()**, and **anytextcat()** functions in Teradata-compatible mode are the same as those in GaussDB(DWS).
	● When this parameter is specified, if the **textcat()**, **textanycat()**, and **anytextcat()** functions contain any null parameter values, the return value is null in the Teradata-compatible mode.
	If this parameter is not specified, the returned values of the **textcat()**, **textanycat()**, and **anytextcat()** functions are the same as those in the GaussDB(DWS).
	td_compatibility_db=# SELECT textcat('abc', NULL);
	textcat
	--------- 	
	abc
	(1 row)
	td_compatibility_db=# SELECT 'abc' || NULL; -- In this case, the operator **||** is converted to the **textcat()** function.
	?column?
	---------- 	
	abc
	(1 row)
	When this parameter is specified, **NULL** is returned if any of the **textcat()**, **textanycat()**, and **anytextcat()** functions returns a null value.
	td_compatibility_db=# SELECT textcat('abc', NULL);
	textcat
	--------- 	
	
	(1 row)
	td_compatibility_db=# SELECT 'abc' || NULL;
	?column?
	---------- 	
	
	(1 row)
		TD

Configuration Item	Behavior	Applicable Compatibility Mode
compat_display_ref_table	Sets the column display format in the view. ● If this parameter is not specified, the prefix is used by default, in the **tab.col** format. ● Specify this parameter to the same original definition. It is displayed only when the original definition contains a prefix. SET behavior_compat_options='compat_display_ref_table'; CREATE OR REPLACE VIEW viewtest2 AS SELECT a.c1, **c2**, a.c3, 0 AS c4 FROM viewtest_tbl a; SELECT pg_get_viewdef('viewtest2'); pg_get_viewdef ---------- SELECT a.c1, **c2**, a.c3, 0 AS c4 FROM viewtest_tbl a; (1 row)	ORA TD
para_support_set_func	Whether the input parameters of the **COALESCE()**, **NVL()**, **GREATEST()**, and **LEAST()** functions in a column-store table support multiple result set expressions. ● If this item is not specified and the input parameter contains multiple result set expressions, an error is reported, indicating that the function is not supported. SELECT COALESCE(regexp_split_to_table(c3,'#'), regexp_split_to_table(c3,'#')) FROM regexp_ext2_tb1 ORDER BY 1 LIMIT 5; ERROR: set-valued function called in context that cannot accept a set ● When this configuration item is specified, the function input parameter can contain multiple result set expressions. SELECT COALESCE(regexp_split_to_table(c3,'#'), regexp_split_to_table(c3,'#')) FROM regexp_ext2_tb1 ORDER BY 1 LIMIT 5; coalesce ---------- a a a a a (5 rows)	ORA TD

Configuration Item	Behavior	Applicable Compatibility Mode
disable_select_truncate_parallel	Controls the DDL lock level such as TRUNCATE in a partitioned table. • If this item is specified, the concurrent execution of TRUNCATE and DML operations (such as SELECT) on different partitions is forbidden, and the fast query shipping (FQS) of the SELECT operation on the partitioned table is allowed. You can set this parameter in the OLTP database, where there are many simple queries on partitioned tables, and there is no requirement for concurrent TRUNCATE and DML operations on different partitions. • If this item is not specified, SELECT and TRUNCATE operations can be concurrently performed on different partitions in a partitioned table, and the FQS of the partitioned table is disabled to avoid possible inconsistency.	ORA TD MySQL

bpchar_text_without_rtrim	In Teradata-compatible mode, controls the space to be retained on the right during the character conversion from **bpchar** to **text**. If the actual length is less than the length specified by **bpchar**, spaces are added to the value to be compatible with the Teradata style of the **bpchar** character string.
	Currently, ignoring spaces at the end of a string for comparison is not supported. If the concatenated string contains spaces at the end, the comparison is space-sensitive.
	The following is an example:
	`td_compatibility_db=# select length('a'::char(10)::text);`
	`length`
	`--------`
	`10`
	`(1 row)`
	
	`td_compatibility_db=# select length('a'||'a'::char(10));`
	`length`
	`--------`
	`11`
	`(1 row)`
		TD

Configuration Item	Behavior	Applicable Compatibility Mode

convert_empty_str_to_null_td	In Teradata-compatible mode, controls the **to_date**, **to_timestamp**, and **to_number** type conversion functions to return **null** when they encounter empty strings, and controls the format of the return value when the **to_char** function encounters an input parameter of the date type.
	For example:
	If this parameter is not specified:
	`td_compatibility_db=# select to_number('');`
	` to_number`
	`-----------`
	`  0`
	`(1 row)`
	
	`td_compatibility_db=# select to_date('');`
	`ERROR:  the format is not correct`
	`DETAIL:  invalid date length "0", must between 8 and 10.`
	`CONTEXT:  referenced column: to_date`
	
	`td_compatibility_db=# select to_timestamp('');`
	`  to_timestamp`
	`------------------------`
	` 0001-01-01 00:00:00 BC`
	`(1 row)`
	
	`td_compatibility_db=# select to_char(date '2020-11-16');`
	`  to_char`
	`------------------------`
	` 2020-11-16 00:00:00+08`
	`(1 row)`
	If this parameter is specified, and parameters of **to_number**, **to_date**, and **to_timestamp** functions contain empty strings:
	`td_compatibility_db=# select to_number('');`
	` to_number`
	`-----------`
	
	`(1 row)`
	
	`td_compatibility_db=# select to_date('');`
	` to_date`
	`---------`
	
	`(1 row)`
	
	`td_compatibility_db=# select to_timestamp('');`
	` to_timestamp`
	`--------------`
	
	`(1 row)`
		TD

Configuration Item	Behavior	Applicable Compatibility Mode
	td_compatibility_db=# select to_char(date '2020-11-16'); to_char ------------ 2020/11/16 (1 row)	
disable_case_specific	Determines whether to ignore case sensitivity during character type match. This parameter is valid only in Teradata-compatible mode. ● If this item is not specified, characters are case sensitive during character type match. ● If this item is specified, characters are case insensitive during character type match. After being specified, this item will affect five character types (**CHAR**, **TEXT**, **BPCHAR**, **VARCHAR**, and **NVARCHAR**), 12 operators (**<**, **>**, **=**, **>=**, **<=**, **!=**, **<>**, **!=**, **like**, **not like**, **in**, and **not in**), and expressions **case when** and **decode**. **CAUTION** After this item is enabled, the **UPPER** function is added before the character type, which affects the estimation logic. Therefore, an enhanced estimation model is required. (Suggested settings: **cost_param=16**, **cost_model_version = 1**, **join_num_distinct=-20**, and **qual_num_distinct=200**)	TD
enable_interval_to_text	Controls the implicit conversion from the **interval** type to the **text** type. ● When this option is enabled, the implicit conversion from the **interval** type to the **text** type is supported. SELECT TO_DATE('20200923', 'yyyymmdd') - TO_DATE('20200920', 'yyyymmdd') = '3'::text; ?column? ---------- f (1 row) ● When this option is disabled, the implicit conversion from the **interval** type to the **text** type is not supported. SELECT TO_DATE('20200923', 'yyyymmdd') - TO_DATE('20200920', 'yyyymmdd') = '3'::text; ?column? ---------- t (1 row)	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode

case_insensitive	In MySQL-compatible mode, configure this parameter to specify the case-insensitive input parameters of the **locate**, **strpos**, and **instr** string functions.
	Currently, this parameter is not configured by default. That is, the input parameter is case-sensitive.
	For example:
	● If this parameter is not configured, the input parameter is case-sensitive.
	`mysql_compatibility_db=# SELECT LOCATE('sub', 'Substr');`
	` locate`
	`--------`
	`  0`
	`(1 row)`
	● If this parameter is configured, the input parameter is case-insensitive.
	`mysql_compatibility_db=# SELECT LOCATE('sub', 'Substr');`
	` locate`
	`--------`
	`  1`
	`(1 row)`
		MySQL

inherit_not_null_strict_func	Controls the original **strict** attribute of a function. A function with one parameter can transfer the **NOT NULL** attribute. **func(x)** is used an example. If **func()** is the **strict** attribute and x contains the **NOT NULL** constraint, func(x) also contains the **NOT NULL** constraint. The compatible configuration item is effective in some optimization scenarios, for example, **NOT IN** and **COUNT(DISTINCT)** optimization. However, the optimization results may be incorrect in specific scenarios. Currently, this parameter is not configured by default to ensure that the result is correct. However, the performance may be rolled back. If an error occurs, you can set this parameter to roll back to the historical version.	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode
disable_compat_minmax_expr_mysql	Specifies the method for processing the input parameter **null** in the **greatest**/**least** expression in MySQL-compatible mode. You can configure this parameter to roll back to a historical version. ● If this parameter is not configured and the input parameter is **null**, **null** is returned. mysql_compatibility_db=# SELECT greatest(1, 2, null), least(1, 2, null); greatest | least ----------+------- | (1 row) ● If this parameter is configured, the maximum or minimum value of non-null parameters is returned. mysql_compatibility_db=# SELECT greatest(1, 2, null), least(1, 2, null); greatest | least ----------+------- 2 | 1 (1 row)	MySQL

Configuration Item	Behavior	Applicable Compatibility Mode

disable_compat_substr_mysql	Specifies the behavior of the **substr**/**substring** function when the start position pos is ≤ 0 in MySQL-compatible mode.
	You can configure this parameter to roll back to a historical version.
	● If this parameter is not configured, that is, an empty string is returned when pos = 0. When pos < 0, **TRUNCATE** starts from the last |*pos*| character on.
	mysql_compatibility_db=# SELECT substr('helloworld',0);
	substr
	-------- 	
	
	(1 row)
	mysql_compatibility_db=# SELECT substring('helloworld',0),substring('helloworld',-2,4);
	substring | substring
	-----------+-----------
	| ld
	(1 row)
	● If this parameter is configured and pos is ≤ 0, characters are truncated from the left.
	mysql_compatibility_db=# SELECT substr('helloworld',0);
	substr
	------------ 	
	helloworld
	(1 row)
	mysql_compatibility_db=# SELECT substring('helloworld',0),substring('helloworld',-2,4);
	substring | substring
	------------+-----------
	helloworld | h
	(1 row)
		MySQL

Configuration Item	Behavior	Applicable Compatibility Mode
disable_compat_trim_mysql	Specifies the method for processing the input parameter in the **trim**/**ltrim**/**rtrim** function in MySQL-compatible mode. You can configure this parameter to roll back to a historical version. ● If this parameter is not configured, the entire substring is matched. `mysql_compatibility_db=# SELECT trim('{}{name}{}','{}'),trim('xyznamezyx','xyz');` ` btrim	btrim` `---------+---------` ` {name}	namezyx` `(1 row)` ● If this parameter is configured, a single character in the character set is matched. `mysql_compatibility_db=# SELECT trim('{}{name}{}','{}'),trim('xyznamezyx','xyz');` ` btrim	btrim` `--------+-------` ` name	name` `(1 row)`	MySQL
light_object_mtime	Specifies whether the **mtime** column in the **pg_object** system catalog records object operations. ● If this parameter is configured, the **GRANT**, **REVOKE**, and **TRUNCATE** operations are not recorded by **mtime**, that is, the **mtime** column is not updated. ● If this parameter is not configured (by default), the **ALTER**, **COMMENT**, **GRANT**, **REVOKE**, and **TRUNCATE** operations are recorded by **mtime**, that is, the **mtime** column is updated.	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode

disable_including_all_mysql	In MySQL-compatible mode, this parameter controls whether the **CREATE TABLE...LIKE** syntax is **INCLUDING_ALL**.
	By default, this parameter is not set. That is, in MySQL compatibility mode, **CREATE TABLE... LIKE** syntax is **INCLUDING_ALL**.
	You can set this parameter to roll back to a historical version.
	● If this parameter is not set, in MySQL-compatible mode, the **CREATE TABLE... LIKE** syntax is in **INCLUDING_ALL**.
	mysql_compatibility_db=# CREATE TABLE mysql_like(id int, name varchar(10), score int) DISTRIBUTE BY hash(id) COMMENT 'mysql_like';
	CREATE TABLE
	mysql_compatibility_db=# CREATE INDEX index_like ON mysql_like(name);
	CREATE INDEX
	mysql_compatibility_db=# \d+ mysql_like;
	Table "public.mysql_like"
	Column | Type | Modifiers | Storage | Stats target | Description
	--------+-----------------------+-----------+----------+--------------+-------------
	id | integer | | plain | |
	name | character varying(10) | | extended | |
	score | integer | | plain | |
	Indexes:
	"index_like" btree (name) TABLESPACE pg_default
	Has OIDs: no
	Distribute By: HASH(id)
	Location Nodes: ALL DATANODES
	Options: orientation=row, compression=no
	
	mysql_compatibility_db=# CREATE TABLE copy_like like mysql_like;
	CREATE TABLE
	mysql_compatibility_db=# \d+ copy_like;
	Table "public.copy_like"
	Column | Type | Modifiers | Storage | Stats target | Description
	--------+-----------------------+-----------+----------+--------------+-------------
	id | integer | | plain | |
	name | character varying(10) | | extended | |
	score | integer | | plain | |
	Indexes:
	"copy_like_name_idx" btree (name) TABLESPACE pg_default
	Has OIDs: no
	Distribute By: HASH(id)
	Location Nodes: ALL DATANODES
	Options: orientation=row, compression=no
		MySQL

Configuration Item	Behavior	Applicable Compatibility Mode

	• If this parameter is set, in MySQL-compatible mode, the **CREATE TABLE... LIKE** syntax is empty.
	mysql_compatibility_db=# SET behavior_compat_options = 'disable_including_all_mysql';
	SET
	mysql_compatibility_db=# CREATE TABLE mysql_copy LIKE mysql_like;
	NOTICE: The 'DISTRIBUTE BY' clause is not specified. Using round-robin as the distribution mode by default.
	HINT: Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
	CREATE TABLE
	mysql_db=# \d+ mysql_copy;
	Table "public.mysql_copy"
	Column | Type | Modifiers | Storage | Stats target | Description
	--------+-----------------------+-----------+----------+--------------+-------------
	id | integer | | plain | |
	name | character varying(10) | | extended | |
	score | integer | | plain | |
	Has OIDs: no
	Distribute By: ROUND ROBIN
	Location Nodes: ALL DATANODES
	Options: orientation=row, compression=no	

cte_onetime_inline	Indicates whether to execute **inline** for non-stream plans. • When this parameter is set, the CTE that is not in a stream plan and is referenced only once executes **inline**. • If this parameter is not set, the CTE that is not in a stream plan and is referenced only once does not execute **inline**.	ORA TD MyS QL

Configuration Item	Behavior	Applicable Compatibility Mode
skip_first_after_mysql	Controls whether to ignore the **FIRST/AFTER colname** syntax in **ALTER TABLE ADD/MODIFY/CHANGE COLUMN** in MySQL compatibility mode. ● If this parameter is set, the **FIRST/AFTER colname** syntax is ignored and executing this syntax does not cause errors mysql_compatibility_db=# SET behavior_compat_options = 'skip_first_after_mysql'; mysql_compatibility_db=# ALTER TABLE t1 ADD COLUMN b text after a; ALTER TABLE ● If this parameter is not set, the **FIRST/AFTER colname** syntax is not supported, and executing this syntax causes error. mysql_compatibility_db=# SET behavior_compat_options = ''; mysql_compatibility_db=# ALTER TABLE t1 ADD COLUMN b text after a; ERROR: FIRST/AFTER is not yet supported.	MySQL

enable_division_by_zero_mysql	Specifies whether to report an error when the divisor is 0 in MySQL compatibility mode. (This configuration item is supported only by clusters of 8.1.3.110 and later versions.)
	● If this parameter is set, NULL is returned if the divisor is 0 in a division or modulo operation.
	compatible_mysql_db=# SET behavior_compat_options = 'enable_division_by_zero_mysql';
	SET
	compatible_mysql_db=# SELECT 1/0 AS test;
	test
	---------- 	
	
	(1 row)
	● If this parameter is not set, an error is returned if the divisor is 0 in a division or modulo operation.
	compatible_mysql_db=# SELECT 1/0;
	ERROR: division by zero
		MySQL

Configuration Item	Behavior	Applicable Compatibility Mode
normal_session_id	Indicates whether to generate a session ID in normal format. • If this option is set, a session ID in normal format will be generated, which is compatible with session IDs in 8.1.3 and earlier cluster versions. SET behavior_compat_options='normal_session_id'; SELECT pg_current_sessionid(); pg_current_sessionid ---------- 1660268184.140594655524608 (1 row) • If this parameter is not set, a session ID in pretty format will be generated. SET behavior_compat_options=''; SELECT pg_current_sessionid(); pg_current_sessionid ---------- 1660268184.140594655524608.coordinator1 (1 row)	ORA TD MySQL
disable_jsonb_exact_match	Specifies whether to check the jsonb type during fuzzy match for binary operators. (This parameter is supported by version 8.2.0 or later clusters.) • If this parameter is specified, operators search for matched items within the entire search scope (including the jsonb type) during fuzzy match. This setting is compatible with the match rules of cluster versions 8.1.1 to 8.1.3. SET behavior_compat_options='disable_jsonb_exact_match'; select '2022' - '2'::text; ERROR: cannot delete from scalar • If this parameter is not specified, fuzzy match is performed within the search scope, except for the jsonb type. This setting is compatible with the match rules of cluster versions earlier than 8.1.1. SET behavior_compat_options=''; select '2022' - '2'::text; ?column? ---------- 2020 (1 row)	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode
merge_into_with_trigger	Controls whether the MERGE INTO operation can be performed on tables with triggers. (This parameter is supported only by clusters of version 8.1.3.200 or later.) ● When this option is set, the MERGE INTO operation can be performed on tables with triggers. When the MERGE INTO operation is performed, the trigger on the table is not activated. ● If this option is not set, an error is reported when the MERGE INTO operation is performed on a table with triggers.	ORA TD MySQL
add_column_default_v_func	Controls whether **expression** in **alter table add column default expression** supports volatile functions. (This parameter is supported only by clusters of version 8.1.3.200 or later.) ● If this option is selected, **expression** in **alter table add column default expression** supports volatile functions. ● If this option is not selected, **expression** in **alter table add column default expression** does not support volatile functions. If **expression** contains volatile functions, an error will be reported during statement execution.	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode

disable_full_group_by_mysql	Specifies whether to display non-aggregation function query columns after **GROUP BY** in a query. (This parameter is supported by clusters in version 8.2.0.101 or later.)
	• If this option is specified, the query does not display any non-aggregation function query columns after **GROUP BY**.
	`SET behavior_compat_options='disable_full_group_by_mysql';`
	`SELECT a,b FROM t1 GROUP BY a;`
	` a | b`
	`---+---`
	` 1 | 1`
	` 2 | 2`
	`(2 rows)`
	• If this option is not specified, the query must display all non-aggregate function query columns after **GROUP BY**, or an error will be reported.
	`SET behavior_compat_options='';`
	`SELECT a,b FROM t1 GROUP BY a;`
	`ERROR:  column "t1.b" must appear in the GROUP BY clause or be used in an aggregate function`
	`LINE 1: SELECT a,b FROM t1 GROUP BY a;`
	CAUTION
	This parameter must be used together with **full_group_by_mode**. For details, see **full_group_by_mode**.
	After this configuration item is set, if **full_group_by_mode** is set to **notpadding**, ensure that the data of non-aggregation query fields after grouping is consistent. Otherwise, the column is a random value.
		MySQL

Configuration Item	Behavior	Applicable Compatibility Mode

disable_gc_fdw_filter_partial_pushdown	Controls whether filter criteria are pushed down when filter criteria are used to query data in a collaborative analysis foreign table (type: gc_fdw). (This parameter is supported only by clusters of version 8.2.1 or later.)
	• When this option is selected, if the filter criteria contain elements (such as non-immutable functions) that do not meet the pushdown conditions, all filter criteria are not pushed down to ensure the normal generation of the result set document. This behavior is compatible with the behavior in versions earlier than 8.2.1.
	`-- Create a table in the source cluster.`
	`CREATE TABLE t1(c1 INT, c2 INT, c3 INT) DISTRIBUTE BY HASH(c1);`
	`-- Create a foreign table with the same structure in the local cluster.`
	`CREATE SERVER server_remote FOREIGN DATA WRAPPER gc_fdw options(ADDRESS 'address', DBNAME 'dbname', USERNAME 'username', PASSWORD 'password');`
	`CREATE FOREIGN TABLE t1(c1 INT, c2 INT, c3 INT) SERVER server_remote;`
	`-- Enable the parameter and see the pushdown behavior.`
	`SET behavior_compat_options = 'disable_gc_fdw_filter_partial_pushdown';`
	`EXPLAIN (verbose on,costs off) SELECt * FROM t1 WHERE c1>3 AND c2 <100 AND now() - '20230101' < c3;`
	`QUERY PLAN`
	`----------`
	`Streaming (type: GATHER)`
	`Output: c1, c2, c3`
	`Node/s: All datanodes`
	`-> Foreign Scan on ca_schema.t1`
	`Output: c1, c2, c3`
	`Filter: ((t1.c1 > 3) AND (t1.c2 < 100) AND ((now() - '2023-01-01 00:00:00-08'::timestamp with time zone) < (t1.c3)::interval))`
	`Remote SQL: SELECT c1, c2, c3 FROM ca_schema.t1`
	`(7 rows)`
	• If this parameter is not set, the filter criteria that can be pushed down are executed in the source cluster, and the filter criteria that cannot be pushed down are executed in the local cluster. This improves the query efficiency of foreign tables.
	`-- Disable this parameter and see the pushdown behavior.`
	`SET behavior_compat_options = '';`
	`EXPLAIN (verbose on,costs off) SELECT * FROM t1 WHERE c1>3 AND c2 <100 AND now() - '20230101' < c3;`
	`QUERY PLAN`
	`----------`
		ORA
		TD
		MySQL

Configuration Item	Behavior	Applicable Compatibility Mode

	``
	------------------------ 	
	Streaming (type: GATHER)
	  Output: c1, c2, c3
	  Node/s: All datanodes
	  -> Foreign Scan on ca_schema.t1
	        Output: c1, c2, c3
	        Filter: ((now() - '2023-01-01 00:00:00-08'::timestamp with time zone) < (t1.c3)::interval)
	        Remote SQL: SELECT c1, c2, c3 FROM ca_schema.t1 WHERE ((c1 > 3)) AND ((c2 < 100))
	(7 rows)
	``	

ignore_unshipped_concurrent_update	Determines whether to ignore new tuples when the **UPDATE** or **DELETE** statement is executed in the current session if the statement is not pushed down and the tuples are updated by other sessions. By default, new tuples are not processed. (This parameter is supported only by clusters of version 8.2.1 or later.) • If this parameter is specified, new tuples are ignored when the **UPDATE** or **DELETE** statement is executed in the current session. If the **UPDATE** or **DELETE** statement is successfully executed, data inconsistency occurs in concurrent update scenarios. This behavior is compatible with the behavior in versions earlier than 8.2.1. • If this parameter is not set and the **UPDATE** or **DELETE** statement executed in the current session detects that tuples have been updated, the **UPDATE** or **DELETE** statement of the current session will be re-executed to ensure data consistency. The number of statement execution retries is controlled by the **max_query_retry_times** parameter.	ORA TD MySQL

Configuration Item	Behavior	Applicable Compatibility Mode
disable_set_global_var_on_datanode	Controls whether the **set_config** function can be used to set global variables on DNs. (This parameter is supported only by clusters of version 8.2.1 or later.) ● When this parameter is set, the **set_config** function cannot be used to set global variables on DNs. By default, this behavior is compatible with the behavior in versions earlier than 8.2.1. ● If this parameter is not set, the **set_config** function can set global variables on DNs. As a result, the global variable values on CNs and DNs are inconsistent, and errors may occur when the **read_global_var** function is pushed down.	ORA TD MySQL

variadic_null_check	Whether **variadic** can transfer the **NULL** parameter. This function is disabled by default. (This parameter is supported only by clusters of version 8.2.1.300 or later.)
	● When this parameter is set, the **NULL** parameter cannot be transferred to **variadic**. Otherwise, an error is reported.
	`SET behavior_compat_options = 'variadic_null_check';`
	`SELECT format ( 'array', VARIADIC NULL);`
	`ERROR:  VARIADIC parameter must be an array`
	NOTE
	To be compatible with MySQL, enabling **compat_concat_variadic** does not take effect for the **concat** and **concat_ws** functions, and the **NULL** parameter can still be transferred.
	● If this parameter is not set, the **NULL** parameter can be transferred to **variadic**.
	`SET behavior_compat_options = '';`
	`SELECT format ( 'array', VARIADIC NULL);`
	` format`
	`--------`
	` array`
	`(1 row)`
		ORA
		TD
		MySQL

Configuration Item	Behavior	Applicable Compatibility Mode
enable_use_syscol_in_replicate_table	Whether **oid**, **ctid**, **tableoid**, or **xc_node_id** can be used as filter, join, or having conditions when the **INSERT**, **UPDATE**, **MERGE INTO**, and **DELETE** statements are executed on replication tables. This parameter is not set by default. This parameter is supported only by clusters of version 8.2.1.200 or later. ● If this parameter is not set and **oid**, **ctid**, **tableoid**, or **xc_node_id** is used as filter, join, or having conditions when the **INSERT**, **UPDATE**, **MERGE INTO**, or **DELETE** statement is executed on replication tables, the following error is reported: `ERROR: Can not use system column oid/ctid/tableoid/xc_node_id in Replication Table.` ● When this parameter is set, the **INSERT**, **UPDATE**, **MERGE INTO**, and **DELETE** statement can be executed on replication tables using the system columns **id**, **ctid**, **tableoid**, or **xc_node_id**. **CAUTION** If **oid**, **ctid**, **tableoid**, or **xc_node_id** is used as filter, join, and having conditions when the **INSERT**, **UPDATE**, **MERGE INTO**, or **DELETE** statement is executed on partition tables, the statement may cause cluster core dumps. In this case, exercise caution when setting this parameter.	ORA TD MYSQL
enable_force_add_batch	Determines whether GaussDB(DWS) receives U packets in addbatch mode when **support_batch_bind** is set to **on** and **enable_fast_query_shipping** and **enable_light_proxy** are both set to **off**. This parameter is not set by default. This parameter is supported only by clusters of version 8.2.1.200 or later. ● If this parameter is not set, **support_batch_bind** is set to **on**, and **enable_fast_query_shipping** and **enable_light_proxy** are both set to **off**, GaussDB(DWS) does not receive U packets in addbatch mode. ● If this parameter is set, **support_batch_bind** is set to **on**, and **enable_fast_query_shipping** and **enable_light_proxy** are both set to **off**, GaussDB(DWS) receives U packets in addbatch mode. However, packets are imported to the database slowly, which may cause insufficient memory. So, exercise caution when setting this parameter.	ORA TD MYSQL

Configuration Item	Behavior	Applicable Compatibility Mode
disable_mergesort_without_material	Controls whether the current stream segment contains materialized operators. If it is, **merge sort** is used. This parameter is supported only by clusters of version 8.2.1.100 or later. ● If this parameter is set and the current stream segment contains materialized operators (material, sort, agg, and CteScan), **merge sort** can be used. Otherwise, merge sort cannot be used. ● If this parameter is not set, whether to use **merge sort** does not need to check whether the current stream segment contains materialized operators.	ORA TD MYSQL
enable_pushdown_groupingset_subquery	If a subquery contains grouping sets, this parameter determines whether to push only the conditions related to the subquery in the outer query to the subquery. This parameter is supported only by clusters of version 8.2.1.100 or later. ● If the subquery contains grouping sets and this parameter is set, the conditions in the outer query cannot be pushed down to the subquery. ● If the subquery contains grouping sets and this parameter is not set, the conditions in the outer query can be pushed down to the subquery.	ORA TD MYSQL

Configuration Item	Behavior	Applicable Compatibility Mode
enable_whole_row_var	This parameter: 1. Specifies whether you can use tables or views in SQL expressions, such as in the query's target list or GROUP BY list. 2. Specifies whether you can use non-table records in SQL expressions. This option is supported only by clusters of version 8.3.0 or later. ● When this option is enabled, tables or views are allowed to appear in SQL expressions. SET behavior_compat_options = 'enable_whole_row_var'; SELECT a1 FROM t a1; a1 ---- (0 rows) SELECT t FROM (SELECT 1) as t; t ----- (1) (1 rows) ● If this option is disabled, tables or views are not allowed to appear in SQL expressions. SET behavior_compat_options = ''; SELECT a1 FROM t a1; ERROR: Table or view cannot appear in expression. Table/view name: t, alias: a1. Please check targetList, groupClause etc. SELECT t FROM (SELECT 1) as t; ERROR: Non-table records cannot appear in expression. alias: t. Please check targetList, groupClause etc.	ORA TD MYSQL
enable_unknown_datatype	Specifies whether tables containing unknown columns can be created. This option is supported only by clusters of version 8.3.0 or later. ● When this option is enabled, tables containing unknown columns can be created. SET behavior_compat_options = 'enable_unknown_datatype'; CREATE TABLE t(a unknown); WARNING: column "a" has type "unknown" DETAIL: Proceeding with relation creation anyway. CREATE TABLE ● If this parameter is disabled, tables containing unknown columns cannot be created. SET behavior_compat_options = ''; create table t(a unknown); ERROR: column "a" has type "unknown"	ORA TD MYSQL

Configuration Item	Behavior	Applicable Compatibility Mode
alter_distribute_key_by_partition	Specifies whether **INSERT INTO** is executed by partition when **ALTER TABLE** is used to modify the distribution column of a partitioned table. ● If this option is enabled, **INSERT INTO** is executed by partition. The memory usage decreases but the performance deteriorates. ● If this option is disabled, **INSERT INTO** is performed on the entire partitioned table. The performance is good but the memory usage is high.	ORA TD MYSQL
disable_update_returning_check	Specifies whether to prevent multiple joins when a replication table is updated with the returning statement. This option is supported only by clusters of version 8.3.0 or later. ● If this option is disabled and there are multiple joins when a replication table is updated with the returning statement, the following error is reported: `ERROR: Unsupported FOR UPDATE replicated table joined with other table.` ● If this option is enabled for forward compatibility, but it may cause data inconsistency when updating a replicated table with multiple joins.	ORA TD MYSQL

Configuration Item	Behavior	Applicable Compatibility Mode

check_function_shippable	Controls the check of the custom **plpgsql/SQL** function attributes. This option is supported only by clusters of version 8.3.0 or later.
	• If this parameter is not specified, the **IMMUTABLE/STABLE/VOLATILE** attributes of a custom function are not checked.
	• If this parameter is specified, the **IMMUTABLE/STABLE/VOLATILE** attributes of user-defined functions are checked based on the following principles:
	– Whitelist: For the three functions in **DBMS_OUTPUT**, skip the **check_function_shippable** check.
	– If a user-defined function contains DML statements and the outer layer is **IMMUTABLE** or **SHIPPABLE**, the function is pushed down. As a result, an error is reported.
	– If the outer layer of a user-defined function is **SHIPPABLE** and the inner layer is **IMMUTABLE**, the function passes the check.
	– If the outer layer of a user-defined function is **SHIPPABLE**, the inner layer is **SHIPPABLE** and not **IMMUTABLE**, the function passes the check.
	– If the outer layer of a user-defined function is **SHIPPABLE** but the inner layer is not none of the above, an error is reported.
	For example, when this parameter is specified, an error is reported in the following scenarios:
	`CREATE OR replace function func_ship(a int)`
	`returns int`
	`LANGUAGE plpgsql`
	`NOT FENCED  SHIPPABLE`
	`AS $function$`
	`begin`
	`perform test_ship();`
	`return a;`
	`EXCEPTION WHEN OTHERS THEN`
	`return a;`
	`end $function$;`
	`select func_ship(a) from tt3;`
	`ERROR:  parent function is shippable but child is not immutable or shippable.`
		ORA
		TD
		MYSQL

Configuration Item	Behavior	Applicable Compatibility Mode
enable_full_string_agg	Specifies how **string_agg(a, delimeter) over (partition by b order by c)** behaves in different situations, such as using full or incremental aggregation in the window. This parameter is supported only by clusters of version 8.3.0 or later. If this parameter is not set, incremental aggregation is used. If this parameter is set, full aggregation is used. By default, this parameter is not set. CREATE TABLE string_agg_dn_col(c1 int, c2 text) WITH(orientation = column) distribute by hash(c1); INSERT INTO string_agg_dn_col values(1, 'test'); INSERT INTO string_agg_dn_col values(1, 'haidian'); INSERT INTO string_agg_dn_col values(1, 'nanjing'); SELECT t.c1 AS c1, string_agg(t.c2, ',') OVER(PARTITION BY t.c1 ORDER BY t.c2) AS c2 FROM string_agg_dn_col t ORDER BY c2; c1 | c2 ----+---------------------- 1 | haidian 1 | haidian,nanjing 1 | haidian,nanjing,test (3 rows) SET behavior_compat_options='enable_full_string_agg'; SELECT t.c1 AS c1, string_agg(t.c2, ',') OVER(PARTITION BY t.c1 ORDER BY t.c2) AS c2 FROM string_agg_dn_col t ORDER BY c2; c1 | c2 ----+---------------------- 1 | haidian,nanjing,test 1 | haidian,nanjing,test 1 | haidian,nanjing,test (3 rows)	ORA TD MYSQL

Configuration Item	Behavior	Applicable Compatibility Mode

enable_banker_round	Specifies how numeric types round their values, using either the rounding or the banker method. This option is supported only by clusters of version 8.3.0 or later.
	Behaviors controlled by parameters include:
	● Type conversion working when **INSERT INTO** and **::xxx** specify a type, such as integer types (int1, int2, int4, int8), any precision types (decimal, numeric, number), or money types.
	● Rounding and conversion functions for the numeric type: **round(xxx.xx,s)**, **cast('xxx.xx',numeric)**, or **to_char(xxx.xx,'xxx')**.
	● Mathematical calculation of the numeric type.
	NOTE
	This is how the banker algorithm rounds numbers: If the next digit is more than 5, round up. If the next digit is less than 5, round down. If the next digit is 5, round to the closest even number.
	● If this parameter is set, the rounding uses the banker method.
	`SET behavior_compat_options = enable_banker_round;`
	`SELECT 1.5::int1,1.5::int2,1.5::int4,1.5::int8,1.5::numeric(10,0),1.115::money;`
	` int1 | int2 | int4 | int8 | numeric | money`
	`------+------+------+------+---------+-------`
	` 2 | 2 | 2 | 2 | 2 | $1.12`
	`SELECT 0.5::int1,0.5::int2,0.5::int4,0.5::int8,0.5::numeric(10,0),1.105::money;`
	` int1 | int2 | int4 | int8 | numeric | money`
	`------+------+------+------+---------+-------`
	` 0 | 0 | 0 | 0 | 0 | $1.10`
	`SELECT round(1.05,1),round(1.15,1),cast('1.05',numeric(10,1)),cast('1.15',numeric(10,1)),to_char(1.05,'9D9'),to_char(1.15,'9D9');`
	` round | round | numeric | numeric | to_char | to_char`
	`-------+-------+---------+---------+---------+---------`
	`  1.0 | 1.2 | 1.0 | 1.2 | 1.0 | 1.2`
	● If this parameter is set, the rounding uses round-off method.
	`SET behavior_compat_options = '';`
	`SELECT 1.5::int1,1.5::int2,1.5::int4,1.5::int8,1.5::numeric(10,0),1.115::money;`
	` int1 | int2 | int4 | int8 | numeric | money`
	`------+------+------+------+---------+-------`
	` 2 | 2 | 2 | 2 | 2 | $1.12`
	`SELECT 0.5::int1,0.5::int2,0.5::int4,0.5::int8,0.5::numeric(10,0),1.105::money;`
	` int1 | int2 | int4 | int8 | numeric | money`
	`------+------+------+------+---------+-------`
	` 1 | 1 | 1 | 1 | 1 | $1.11`
	`SELECT round(1.05,1),round(1.15,1),cast('1.05',numeric(10,1)),cast('1.15',numeric(1`
		ORA
		TD
		MYSQL

Configuration Item	Behavior	Applicable Compatibility Mode
	0,1)),to_char(1.05,'9D9'),to_char(1.15,'9D9'); round | round | numeric | numeric | to_char | to_char -------+-------+---------+---------+---------+--------- 1.1 | 1.2 | 1.1 | 1.2 | 1.1 | 1.2	
unsupported_set_function_case	Indicates whether the case when condition can contain the function that returns multiple result sets. This option is supported only by clusters of version 8.3.0.100 or later. ● If this option is selected, column storage does not support the case when condition containing the function that returns multiple result sets. CREATE TABLE t1(id int, c1 text) with(orientation=column); INSERT INTO t1 values(1, 'a#1'); SET behavior_compat_options = 'unsupported_set_function_case'; SELECT CASE split_part(regexp_split_to_table(c1, E'\,'),'#',1) when 'a' then c1 else null end from t1; ERROR: set-valued function called in context that cannot accept a set ● If this parameter is not set, the case when condition in column storage supports the function that returns multiple result sets. SET behavior_compat_options = ''; SELECT CASE split_part(regexp_split_to_table(c1, E'\,'),'#',1) when 'a' then c1 else null end from t1; case ------ a#1 (1 row)	ORA TD MYSQL

17.18 Fault Tolerance

This section describes parameters used for controlling the methods that the server processes an error occurring in the database system.

exit_on_error

Parameter description: Specifies whether to terminate the current session.

Type: SUSET

Value range: Boolean

- **on** indicates that any error will terminate the current session.
- **off** indicates that only a FATAL error will terminate the current session.

Default value: **off**

omit_encoding_error

Parameter description: This parameter determines how to handle character code errors that occur when converting a database to UTF-8. If set to true, it replaces the invalid characters with question marks (?).

Type: USERSET

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**

max_query_retry_times

Parameter description: Specifies the maximum number of times that an **SQL** statement with errors can be re-executed. **SQL** statements with the following types of errors can be re-executed: **Connection reset by peer**, **Lock wait timeout**, and **Connection timed out**. If this parameter is set to **0**, the re-execution function is disabled.

Type: USERSET

Value range: an integer ranging from 0 to 20

Default value: **6**

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.

Type: SIGHUP

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 retry.

Type: USERSET

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 CG003 CG004 F0011 F0012 45003 42P30

17.19 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.

min_pool_size

Parameter description: Specifies the minimum number of connections between a CN's connection pool and another CN/DN.

Type: POSTMASTER

Value range: an integer ranging from 1 to 65535

Default value: **1**

max_pool_size

Parameter description: Specifies the maximum number of connections between a CN's connection pool and another CN/DN.

Type: POSTMASTER

Value range: an integer ranging from 1 to 65535

Default value: **800** for CNs and **5000** for DNs

persistent_datanode_connections

Parameter description: Specifies whether to release the connection for the current session.

Type: USERSET

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 function is enabled, 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**

cache_connection

Parameter description: Specifies whether to reclaim the connections of a connection pool.

Type: USERSET

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.

Type: USERSET

Value range: Boolean

- **on** indicates that the new connection is forcibly used.
- **off** indicates that the current connection is used.

Default value: **off**

enable_pooler_parallel

Parameter description: Specifies whether a CN's connection pool can be connected in parallel mode.

Type: SIGHUP

Value range: Boolean

- **on** indicates that a CN's connection pool can be connected in parallel mode.
- **off** indicates that a CN's connection pool cannot be connected in parallel mode.

Default value: **on**

17.20 Cluster Transaction Parameters

This section describes the settings and value ranges of cluster transaction parameters.

transaction_isolation

Parameter description: Specifies the isolation level of the current transaction.

Type: USERSET

Value range:

- **READ COMMITTED**: Only committed data is read. This is the default.
- **READ UNCOMMITTED**: GaussDB(DWS) does not support **READ UNCOMMITTED**. If **READ UNCOMMITTED** is set, **READ COMMITTED** is executed instead.
- **REPEATABLE READ**: Only the data committed before transaction start is read. Uncommitted data or data committed in other concurrent transactions cannot be read.
- **SERIALIZABLE**: GaussDB(DWS) does not support **SERIALIZABLE**. If **SERIALIZABLE** is set, **REPEATABLE READ** is executed instead.

Default value: **READ COMMITTED**

transaction_read_only

Parameter description: Specifies that the current transaction is a read-only transaction.

Type: USERSET

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** for CNs and **on** for DNs

xc_maintenance_mode

Parameter description: Specifies whether the system is in maintenance mode.

Type: SUSET

Value range: Boolean

- **on** indicates that maintenance mode is enabled.
- **off** indicates that the maintenance mode is disabled.

Default value: **off**

NOTICE

Enable the maintenance mode with caution to avoid cluster data inconsistencies.

allow_concurrent_tuple_update

Parameter description: Specifies whether to allow concurrent update.

Type: USERSET

Value range: Boolean

- **on** indicates it is enabled.
- **off** indicates it is disabled.

Default value: **on**

gtm_backup_barrier

Parameter description: Specifies whether to create a restoration point for the GTM starting point.

Type: SUSET

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 CN to check whether the connection between the local thread and the primary GTM is normal.

Type: SIGHUP

Value range: an integer ranging from 0 to INT_MAX/1000. The unit is second.

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. Currently, this parameter is not used in GaussDB(DWS). Similar to this parameter, the **default_transaction_deferrable** parameter is used to specify whether to allow delayed execution of a transaction.

Type: USERSET

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**

enforce_two_phase_commit

Parameter description: This parameter is reserved for compatibility with earlier versions. This parameter is invalid in the current version.

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/true**, all versions of tuples in the table are displayed.

Type: USERSET

Value range: Boolean

- **on/true** indicates that all versions of tuples in the table are displayed.
- **off/false** indicates that no versions of tuples in the table are displayed.

Default value: **off**

gtm_connect_retries

Parameter description: Specifies the number of GTM reconnection attempts.

Type: SIGHUP

Value range: an integer ranging from 1 to 2,147,483,647

Default value: **30**

idle_in_transaction_timeout

Parameter description: duration during which a transaction is allowed to be in the idle state. When a transaction is in the idle state for a period specified by this parameter, the transaction is terminated. This function takes effect only for client connections that are directly connected to CNs and does not take effect for direct DNs or internal connections. This parameter is supported only by clusters of version 8.2.1.100 or later.

Type: USERSET

Value range: 0 to 86400, in second.

Default value: **0**, indicating that the function is disabled.

17.21 Developer Operations

enable_light_colupdate

Parameter description: Specifies whether to enable the lightweight column-store update.

Type: USERSET

Value range: Boolean

- **on** indicates that the lightweight column-store update is enabled.
- **off** indicates that the lightweight column-store update is disabled.

Default value: **off**

NOTE

There is a low probability that an error is reported when lightweight **UPDATE** and backend column-store **AUTOVACUUM** coexist. You can run **ALTER TABLE** to set the table-level parameter **enable_column_autovacuum_garbage** to **off** to avoid this issue. If the table-level parameter **enable_column_autovacuum_garbage** is set to **off**, the backend column-store **AUTOVACUUM** of the table is disabled.

enable_fast_query_shipping

Parameter description: Specifies whether to use the distributed framework for a query planner.

Type: USERSET

Value range: Boolean

- **on** indicates that 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.

Default value: **on**

enable_trigger_shipping

Parameter description: Specifies whether the trigger can be pushed to DNs for execution.

Type: USERSET

Value range: Boolean

- **on** indicates that the trigger can be pushed to DNs for execution.
- **off** indicates that the trigger cannot be pushed to DNs. It must be executed on the CN.

Default value: **on**

enable_remotejoin

Parameter description: Specifies whether JOIN operation plans can be delivered to DNs for execution.

Type: USERSET

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.

Type: USERSET

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 pushed down to DNs for execution.

Type: USERSET

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_limit_stop

Parameter description: whether to enable the **early stop** optimization for **LIMIT** statements. For a **LIMIT n** statement, if **early stop** is enabled, the CN requests the DN to end the execution after receiving n pieces of data. This method is applicable to complex queries with **LIMIT**. This parameter is supported only by clusters of version 8.1.3.320 or later.

Type: USERSET

Value range: Boolean

- **on** indicates that **early stop** is enabled for LIMIT statements.
- **off** indicates that **early stop** is disabled for LIMIT statements.

Default value: **on**

enable_remotesort

Parameter description: Specifies whether the execution plan of the ORDER BY clause can be delivered to DNs for execution.

Type: USERSET

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_join_pseudoconst

Parameter description: Specifies whether joining with the pseudo constant is allowed. A pseudo constant indicates that the variables on both sides of a join are identical to the same constant.

Type: USERSET

Value range: Boolean

- **on** indicates that joining with the pseudo constant is allowed.
- **off** indicates that joining with the pseudo constant is not allowed.

Default value: **off**

cost_model_version

Parameter description: Specifies the model used for cost estimation in the application scenario. This parameter affects the distinct estimation of the expression, HashJoin cost model, estimation of the number of rows, distribution key selection during redistribution, and estimation of the number of aggregate rows.

Type: USERSET

Value range: **0**, **1**, **2**, **3**, or **4**

- **0** indicates that the original cost estimation model is used.
- **1** indicates that the enhanced distinct estimation of the expression, HashJoin cost estimation model, estimation of the number of rows, distribution key selection during redistribution, and estimation of the number of aggregate rows are used on the basis of **0**.
- **2** indicates that the ANALYZE sampling algorithm with better randomicity is used on the basis of **1** to improve the accuracy of statistics collection.
- **3** indicates that the broadcast cost estimation in large cluster scenarios is optimized based on **2** so that the optimizer can select a better plan. This option is supported only by clusters of version 8.3.0 or later.
- 4 indicates that the cost estimation of hashjoin parallelization, skew, and column-store index order cost and the number of rows in coalesce expressions are optimized based on 3. In addition, skew optimization identification is supported when constant output columns of subqueries are joined.

Default value: **1**

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(DWS) compilation.

Type: USERSET

Value range: Boolean

- **on** indicates that various assertion checks are enabled.
- **off** indicates that various assertion checks are disabled.

NOTE

This parameter is set to **on** by default if GaussDB(DWS) is compiled with various assertion checks enabled.

Default value: **off**

distribute_test_param

Parameter description: Specifies whether the embedded test stubs for testing the distribution framework take effect. In most cases, developers embed some test stubs in the code during fault injection tests. Each test stub is identified by a unique name. The value of this parameter is a triplet that includes three values: thread level, test stub name, and error level of the injected fault. The three values are separated by commas (,).

Type: USERSET

Value range: a string indicating the name of any embedded test stub.

Default value: **-1, default, default**

enable_crc_check

Parameter description: Specifies whether to enable data checks. Check information is generated when table data is written and is checked when the data is read. You are not advised to modify the settings.

Type: POSTMASTER

Value range: Boolean

- **on** indicates that data checks are enabled.
- **off** indicates that data checks are disabled.

Default value: **on**

NOTICE

If CRC is enabled, all data on a page must be written to WALs when hint bits of tuples on the page are modified for the first time after a checkpoint. This deteriorates the performance of the first query after the checkpoint.

ignore_checksum_failure

Parameter description: Sets whether to ignore check failures (but still generates an alarm) and continues reading data. This parameter is valid only if **enable_crc_check** is set to **on**. Continuing reading data may result in breakdown, damaged data being transferred or hidden, failure of data recovery from remote nodes, or other serious problems. You are not advised to modify the settings.

Type: SUSET

Value range: Boolean

- **on** indicates that data check errors are ignored.
- **off** indicates that data check errors are reported.

Default value: **off**

default_orientation

Parameter description: Specifies the type of the table to be created if no storage method is specified during table creation. The value for each node must be the same.

Type: SUSET

Value range: **row**, **column**, **column enabledelta**

- **row**: creates a row-store table.
- **column**: creates a column-store table.
- **column enabledelta**: creates a column-store table with delta tables enabled.

Default value: **row**

default_table_behavior

Parameter description: behavior type of the default table. This parameter is supported only by clusters of version 8.2.1 or later.

Type: USERSET

Value range: **column_btree_index**

- **column_btree_index** indicates that the default index for creating a column-store table is **btree**.

Default value: an empty string

enable_colstore

Parameter description: Specifies whether to create a table as a column-store table by default when no storage method is specified. The value for each node must be the same. This parameter is used for tests. Users are not allowed to enable it.

Type: SUSET

Value range: Boolean

Default value: **off**

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. When **enable_force_vector_engine** is enabled, no matter it is a row-store table, column-store table, or hybrid row-column store table, if the plantree does not contain scenarios that do not support vectorization, the vectorized executor is forcibly used.

Type: USERSET

Value range: Boolean

Default value: **off**

enable_csqual_pushdown

Parameter description: Specifies whether to deliver filter criteria for a rough check during query.

Type: USERSET

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: Specifies the name of a CSV file exported when **explain_perf_mode** is set to **run**.

Type: USERSET

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: **NULL**

explain_perf_mode

Parameter description: Specifies the display format of the **explain** command.

Type: USERSET

Value range: **normal**, **pretty**, **summary**, and **run**

- **normal** indicates that the default printing format is used.
- **pretty** indicates that the optimized display mode of GaussDB(DWS) is used. A new format contains a plan node ID, directly and effectively analyzing performance.

- **summary** indicates that the analysis result based on such 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.

Default value: **pretty**

join_num_distinct

Parameter description: Controls the default distinct value of the join column or expression in application scenarios.

Type: USERSET

Value range: a double-precision floating point number greater than or equal to **-100**. Decimals may be truncated when displayed on clients.

- If the value is greater than **0**, the value is used as the default distinct value.
- If the value is greater than or equal to **-100** and less than **0**, it means the percentage used to estimate the default distinct value.
- If the value is **0**, the default distinct value is **200**.

Default value: **-20**

outer_join_max_rows_multipler

Parameter description: Specifies the maximum number of estimated rows for outer joins.

Type: USERSET

Value range: **0** or a double-precision floating point number greater than or equal to **1**. Decimals may be truncated when displayed on clients.

- If the value is **0**, the estimated number of rows for outer joins is not limited.
- If the value is greater than or equal to **1**, the estimated number of rows cannot exceed a multiple of the number of rows in the foreign table in the outer join.

Default value: **-20**

qual_num_distinct

Parameter description: Controls the default distinct value of the filter column or expression in application scenarios.

Type: USERSET

Value range: a double-precision floating point number greater than or equal to **-100**. Decimals may be truncated when displayed on clients.

- If the value is greater than **0**, the value is used as the default distinct value.
- If the value is greater than or equal to **-100** and less than **0**, it means the percentage used to estimate the default distinct value.

- If the value is **0**, the default distinct value is **200**.

Default value: **200**

trace_notify

Parameter description: Specifies whether to generate a large amount of debugging output for the **LISTEN** and **NOTIFY** commands. **client_min_messages** or **log_min_messages** must be **DEBUG1** or lower so that such output can be recorded in the logs on the client or server separately.

Type: USERSET

Value range: Boolean

- **on** indicates that the function is enabled.
- **off** indicates that the function is disabled.

Default value: **off**

trace_sort

Parameter description: Specifies whether to display information about resource usage during sorting operations in logs. This parameter is available only when the macro TRACE_SORT is defined during the GaussDB(DWS) compilation. However, TRACE_SORT is currently defined by default.

Type: USERSET

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(DWS) to report an error, aborting the current transaction.

Type: SUSET

Value range: Boolean

- **on** indicates that the function is enabled.
- **off** indicates that the function is disabled.

NOTE

- Setting this parameter to **on** causes the system to report a warning, pad the damaged page with zeros, and then continue with subsequent processing. This behavior will damage data, that is, all rows on the damaged page. However, it allows you to bypass the error and retrieve rows from any undamaged pages that are present in the table. Therefore, it is useful for restoring data that is damaged due to a hardware or software error. In most cases, you are not advised to set this parameter to **on** unless you do not want to restore data from the damaged pages of a table.
- For a column-store table, the system will skip the entire CU and then continue processing. The supported scenarios include the CRC check failure, magic check failure, and incorrect CU length.

Default value: **off**

replication_test

Parameter description: Specifies whether to enable internal testing on the data replication function.

Type: USERSET

Value range: Boolean

- **on** indicates that internal testing on the data replication function is enabled.
- **off** indicates that internal testing on the data replication function is disabled.

Default value: **off**

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 (&) operations on the bit for each method. A method is selected if its value is not **0**.

If **cost_param & 1** is not set to **0**, an improvement mechanism is selected for calculating a non-equi join selection rate, which is more accurate in estimation of self-join (join between two same tables). In V300R002C00 and later, **cost_param & 1=0** is not used. That is, an optimized 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.

When **cost_param & 16** is not **0**, the model between fully correlated and fully uncorrelated models is used to calculate the comprehensive selection rate of two or more filtering conditions or join conditions. If there are many filtering conditions, the strongly-correlated model is preferred.

Type: USERSET

Value range: an integer ranging from 1 to INT_MAX

Default value: **16**

convert_string_to_digit

Parameter description: Specifies the implicit conversion priority, which determines whether to preferentially convert strings into numbers.

Type: USERSET

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

Modify this parameter only when absolutely necessary because the modification will change the rule for converting internal data types and may cause unexpected results.

nls_timestamp_format

Parameter description: Specifies the default timestamp format.

Type: USERSET

Value range: a string

Default value: **DD-Mon-YYYY HH:MI:SS.FF AM**

enable_partitionwise

Parameter description: Specifies whether to select an intelligent algorithm for joining partitioned tables.

Type: USERSET

Value range: Boolean

- **on** indicates that an intelligent algorithm is selected.
- **off** indicates that an intelligent algorithm is not selected.

Default value: **off**

enable_partition_dynamic_pruning

Parameter description: Specifies whether dynamic pruning is enabled during partition table scanning.

Type: USERSET

Value range: Boolean

- **on**: enable
- **off**: disable

Default value: **on**

max_user_defined_exception

Parameter description: Specifies the maximum number of exceptions. The default value cannot be changed.

Type: USERSET

Value range: an integer

Default value: **1000**

datanode_strong_sync

Parameter description: This parameter no longer takes effect.

Type: USERSET

Value range: Boolean

- **on** indicates that forcible synchronization between stream nodes is enabled.
- **off** indicates that forcible synchronization between stream nodes is disabled.

Default value: **off**

enable_global_stats

Parameter description: Specifies the current statistics mode. This parameter is used to compare global statistics generation plans and the statistics generation plans for a single DN. This parameter is used for tests. Users are not allowed to enable it.

Type: SUSET

Value range: Boolean

- **on** or **true** indicates the global statistics mode.
- **off** or **false** indicates the single-DN statistics mode.

Default value: **on**

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.

Type: USERSET

Value range: Boolean

- **on/true** indicates that optimization for numeric data calculation is enabled.

- **off/false** indicates that optimization for numeric data calculation is disabled.

Default value: **on**

enable_row_fast_numeric

Parameter description: Specifies the format in which numeric data in a row-store table is spilled to disks.

Type: USERSET

Value range: Boolean

- **on/true** indicates that numeric data in a row-store table is spilled to disks in bigint format.
- **off/false** indicates that numeric data in a row-store table is spilled to disks in the original format.

NOTICE

If this parameter is set to **on**, you are advised to enable **enable_force_vector_engine** to improve the query performance of large data sets. However, compared with the original format, there is a high probability that the bigint format occupies more disk space. For example, the TPC-H test set occupies about 7% more space (reference value, may vary depending on the environment).

Default value: **off**

rewrite_rule

Parameter description: Specifies the rewriting rule for enabled optional queries. Some query rewriting rules are optional. Enabling them cannot always improve query efficiency. In a specific customer scenario, you can set the query rewriting rules through the 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. To set the parameters, you can perform the following operations:

```
set rewrite_rule=rule1;          --Enable query rewriting rule rule1.
set rewrite_rule=rule2,rule3;    --Enable query rewriting rules rule2 and rule3.
set rewrite_rule=none;           --Disable all optional query rewriting rules.
```

Type: USERSET

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 rule (to push down conditions from the main query to pulled up sublinks).
- **uniquecheck**: Uses the Unique Check rewriting rule. (The scenario where the target column does not contain the expression sublink of the aggregate

function can be improved. The function can be enabled only when the value of the target column is unique after the sublink is aggregated based on the associated column. This function is recommended to be used by optimization engineers.)

- **disablerep**: Uses the function that prohibits pulling up sublinks of the replication table. (Disables sublink pull-up for the replication table.)
- **projection_pushdown**: the Projection Pushdown rewriting rule (Removes columns that are not used by the parent query from the subquery).
- **or_conversion**: the OR conversion rewriting rule (eliminates the association OR conditions that are inefficient to execute).
- **plain_lazyagg**: the **Plain Lazy Agg** query rewriting rule (eliminates aggregation operations in a single subquery). This option is supported only by clusters of version 8.1.3.100 or later.
- **eager_magicset**: Uses the **eager_magicset** query rewriting rule (to push down conditions from the main query to subqueries). This option is supported only by clusters of version 8.2.0 or later.
- casewhen_simplification: rewriting rule for rewriting the casewhen statement. After this function is enabled, the (case when xxx then const1 else const2)=const1 scenario is rewritten. This option is supported only by clusters of version 8.3.0 or later.
- outer_join_quality_imply: The expression filter conditions (non-equivalent and equivalent filter conditions are supported) of foreign tables in outer joins can be transferred and pushed down to internal tables through equivalent join conditions, reducing the amount of data returned after internal table scanning. This option is supported only by clusters of version 8.3.0 or later.
- inlist_merge: uses inlist_or_inlist to query rewriting rules. OR statements of the same column in the base table can be combined. After this function is enabled, (where a in (list1) or a in (list2)) is combined and rewritten. After the combination, inlist2join is supported. This option is supported only by clusters of version 8.3.0 or later.

Default value: **magicset**, **or_conversion**, **projection_pushdown**, and **plain_lazyagg**

mv_rewrite_rule

Parameter description: whether to enable the rewriting rule for the materialized view. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: a string

- **none**: No materialized view rewriting rule is used.
- **text**: materialized view rewriting rule that uses text matching.

Default value: **text**

enable_compress_spill

Parameter description: Specifies whether to enable the compression function of writing data to a disk.

Type: USERSET

Value range: Boolean

- **on/true** indicates that optimization for writing data to a disk is enabled.
- **off/false** indicates that optimization for writing data to a disk is disabled.

Default value: **on**

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.

Type: USERSET

Value range: a string

- **LLVM_COMPILE** indicates that the codegen compilation time of each thread is displayed on the explain performance page.
- **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.
- TURBO_DATA_CHECK indicates that the data context of the ScalarVector and VectorBatch operators of Turbo is verified. This option is supported only by clusters of 8.3.0.100 or later.

Default value: **off(ALL)**, which indicates that no location function is enabled.

resource_track_log

Parameter description: Specifies the log level of self-diagnosis. Currently, this parameter takes effect only in multi-column statistics.

Type: USERSET

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**

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/$2^{log2m*1/2}$]

Type: USERSET

Value range: an integer ranging from 10 to 16

Default value: **11**

hll_default_regwidth

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. For details, see **Table 17-5**.

Type: USERSET

Value range: an integer ranging from 1 to 5

Default value: **5**

Table 17-5 Maximum number of calculated distinct values determined by hll_default_log2m and hll_default_regwidth

log2m	regwidth = 1	regwidth = 2	regwidth = 3	regwidth = 4	regwidth = 5
10	7.4e+02	3.0e+03	4.7e+04	1.2e+07	7.9e+11
11	1.5e+03	5.9e+03	9.5e+04	2.4e+07	1.6e+12
12	3.0e+03	1.2e+04	1.9e+05	4.8e+07	3.2e+12
13	5.9e+03	2.4e+04	3.8e+05	9.7e+07	6.3e+12
14	1.2e+04	4.7e+04	7.6e+05	1.9e+08	1.3e+13
15	2.4e+04	9.5e+04	1.5e+06	3.9e+08	2.5e+13

hll_default_expthresh

Parameter description: Specifies the default threshold for switching from the **explicit** mode to the **sparse** mode.

Type: USERSET

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

Parameter description: Specifies whether to enable the **sparse** mode by default.

Type: USERSET

Valid value: **0** and **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

Parameter description: Specifies the size of **max_sparse**.

Type: USERSET

Value range: an integer ranging from –1 to **INT_MAX**

Default value: **–1**

enable_compress_hll

Parameter description: Specifies whether to enable memory optimization for HLL.

Type: USERSET

Value range: Boolean

- **on** or **true** indicates that memory optimization is enabled.
- **off** or **false** indicates that memory optimization is disabled.

Default value: **off**

approx_count_distinct_precision

Parameter description: Specifies the number of buckets in the HyperLogLog++ (HLL++) algorithm. This parameter can be used to adjust the error rate of the **approx_count_distinct** aggregate function. The number of buckets affects the precision of estimating the distinct value. More bacukets make the estimation more accurate. The deviation range is as follows: $[-1.04/2^{log2m*1/2}, +1.04/2^{log2m*1/2}]$ This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: an integer ranging from 10 to 20.

Default value: 17

udf_memory_limit

Parameter description: Controls the maximum physical memory that can be used when each CN or DN executes UDFs.

Type: POSTMASTER

Value range: an integer ranging from 200 x 1024 to the value of **max_process_memory** and the unit is KB.

Default value: **0.05 x max_process_memory**

FencedUDFMemoryLimit

Parameter description: Controls the virtual memory used by each fenced udf worker process.

Type: USERSET

Suggestion: You are not advised to set this parameter. You can set **udf_memory_limit** instead.

Value range: an integer. The unit can be KB, MB, or GB. **0** indicates that the memory is not limited.

Default value: **0**

UDFWorkerMemHardLimit

Parameter description: Specifies the maximum value of **fencedUDFMemoryLimit**.

Type: POSTMASTER

Suggestion: You are not advised to set this parameter. You can set **udf_memory_limit** instead.

Value range: an integer. The unit can be KB, MB, or GB.

Default value: **1 GB**

enable_pbe_optimization

Parameter description: Specifies whether the optimizer optimizes the query plan for statements executed in Parse Bind Execute (PBE) mode.

Type: USERSET

Value range: Boolean

- **on** indicates that the optimizer optimizes the query plan.
- **off** indicates that the optimization does not optimize the query plan.

Default value: **on**

enable_light_proxy

Parameter description: Specifies whether the optimizer optimizes the execution of simple queries on CNs.

Type: USERSET

Value range: Boolean

- **on** indicates that the optimizer optimizes the execution.
- **off** indicates that the optimization does not optimize the execution.

Default value: **on**

checkpoint_flush_after

Parameter description: Specifies the number of consecutive disk pages that the checkpointer writer thread writes before asynchronous flush. In GaussDB(DWS), the size of a disk page is 8 KB.

Type: SIGHUP

Value range: an integer ranging from 0 to 256. **0** indicates that the asynchronous flush function is disabled. 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: **32**

enable_parallel_ddl

Parameter description: Controls whether multiple CNs can concurrently perform DDL operations on the same database object.

Type: USERSET

Value range: Boolean

- **on** indicates that DDL operations can be performed safely and that no distributed deadlock occurs.
- **off** indicates that DDL operations cannot be performed safely and that distributed deadlocks may occur.

Default value: **on**

gc_fdw_verify_option

Parameter description: Specifies whether to enable the logic for verifying the number of rows in a result set in the collaborative analysis. This parameter is supported only by clusters of version 8.1.3.310 or later.

Type: USERSET

Value range: Boolean

- **on** indicates that the logic for verifying the number of rows in the result set is enabled. The **SELECT COUNT** statement is used to obtain the expected number of rows and compare it with the actual number of rows.
- **off** indicates that the logic for verifying the number of rows in the result set is disabled and only the required result set is obtained.

Default value: **on**

NOTE

- If this parameter is enabled, the performance deteriorates slightly. In performance-sensitive scenarios, you can disable this parameter to improve the performance.
- If an exception is thrown during the result set row verification. You can set **log_min_messages=debug1** and **logging_module='on(COOP_ANALYZE)'** to obtain the collaborative analysis logs.

show_acce_estimate_detail

Parameter description: When the GaussDB(DWS) cluster is accelerated (**acceleration_with_compute_pool** is set to **on**), specifies whether the **EXPLAIN** statement displays the evaluation information about execution plan pushdown to computing Node Groups. 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.

Type: USERSET

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**

support_batch_bind

Parameter description: Specifies whether to batch bind and execute PBE statements through interfaces such as JDBC, ODBC, and Libpq.

Type: SIGHUP

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**

full_group_by_mode

Parameter description: This parameter is used together with **disable_full_group_by_mysql** to control the two different behaviors after the **disable_full_group_by_mysql** syntax feature is disabled. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: a string

- **nullpadding** indicates that NULL values in a non-aggregation column are replaced with values and non-null values in the column are used. The result set may contain different rows.
- **notpadding** indicates that NULL values are not processed for non-aggregation columns and the entire row of data is obtained. The result set of non-aggregation columns is a random row.

Default value: **notpadding**

NOTICE

This parameter takes effect only when **disable_full_group_by_mysql** is enabled in the MySQL compatibility library and non-aggregation columns exist in the query. The two behaviors of this parameter also take effect only for non-aggregation columns in the query.

17.22 Auditing

17.22.1 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.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the auditing function is enabled.
- **off** indicates that the auditing function is disabled.

Default value: **on**

audit_space_limit

Parameter description: Specifies the total disk space occupied by audit files.

Type: SIGHUP

Value range: an integer ranging from **1024** to **1073741824**. The unit is KB.

Default value: **1GB**

audit_object_name_format

Parameter description: Specifies the format of the object name displayed in the **object_name** field of audit logs.

Type: USERSET

Value range: enumerated values

- **single** indicates that the **object_name** field displays a single object name, which is the name of the target object.
- **all** indicates that the **object_name** field displays multiple object names.

Default value: single

NOTE

If the default value is set to **all**, multiple object names will be displayed for SELECT, DELETE, UPDATE, INSERT, MERGE, CREATE TABLE AS and CREATE VIEW AS.

audit_object_details

Parameter description: whether to record the **object_details** field in audit logs. This field indicates the table name, column name, and column type in the audit statement. This parameter is supported only by clusters of version 8.2.1.100 or later.

Type: USERSET

Value range: Boolean

- **on** indicates that the **object_details** field is recorded during the audit.
- **off** indicates that the **object_details** field is not recorded during the audit.

Default value: **off**

NOTE

- If this parameter is set to **on**, the table name, column name, and column type in the statement will be audited, which may affect the performance. So, exercise caution when setting this parameter to **on**.
- If this parameter is set to **on**, the **object_details** field records the following statements: **SELECT**, **DELETE**, **UPDATE**, **INSERT**, **MERGE**, **CREATE TABLE AS SELECT**, **GRANT**, and **DECLARE CURSOR**. **GRANT** statements that fail to be executed are not recorded.

17.22.2 Operation Audit

audit_operation_exec

Parameter description: Specifies whether to audit successful operations in GaussDB(DWS). Set this parameter as required.

Type: SIGHUP

Value range: a string

- **none**: indicates that no audit item is configured. If any audit item is configured, **none** becomes invalid.
- **all**: indicates that all successful operations are audited. This value overwrites the concurrent configuration of any other audit items. Note that even if this parameter is set to **all**, not all DDL operations are audited. You need to control the object level of DDL operations by referring to **audit_system_object**.
- **login**: indicates that successful logins are audited.
- **logout**: indicates that user logouts are audited.
- **database_process**: indicates that database startup, stop, switchover, and recovery operations are audited.
- **user_lock**: indicates that successful locking and unlocking operations are audited.

- **grant_revoke**: indicates that successful granting and reclaiming of a user's permission are audited.
- **ddl**: indicates that successful DDL operations are audited. DDL operations are controlled at a fine granularity based on operation objects. Therefore, **audit_system_object** is used to control the objects whose DDL operations are to be audited. (The audit function takes effect as long as **audit_system_object** is configured, no matter whether **ddl** is set.)
- **select**: indicates that successful SELECT operations are audited.
- **copy**: indicates that successful COPY operations are audited.
- **userfunc**: indicates that successful operations for user-defined functions, stored procedures, and anonymous blocks are audited.
- **set**: indicates that successful SET operations are audited.
- **transaction**: indicates that successful transaction operations are audited.
- **vacuum**: indicates that successful VACUUM operations are audited.
- **analyze**: indicates that successful ANALYZE operations are audited.
- **explain**: indicates that successful EXPLAIN operations are audited.
- **specialfunc**: indicates that successful calls to special functions are audited. Special functions include **pg_terminate_backend** and **pg_cancel_backend**.
- **insert**: indicates that successful INSERT operations are audited.
- **update**: indicates that successful UPDATE operations are audited.
- **delete**: indicates that successful DELETE operations are audited.
- **merge**: indicates that successful MERGE operations are audited.
- **show**: indicates that successful SHOW operations are audited.
- **checkpoint**: indicates that successful CHECKPOINT operations are audited.
- **barrier**: indicates that successful BARRIER operations are audited.
- **cluster**: indicates that successful CLUSTER operations are audited.
- **comment**: indicates that successful COMMENT operations are audited.
- **cleanconn**: indicates that successful CLEANCONNECTION operations are audited.
- **prepare**: indicates that successful PREPARE, EXECUTE, and DEALLOCATE operations are audited.
- **constraints**: indicates that successful CONSTRAINTS operations are audited.
- **cursor**: indicates that successful cursor operations are audited.
- **discard** indicates that the successful executions related to global temporary tables in the current session are audited.

Default value: **login**, **logout**, **database_process**, **user_lock**, **grant_revoke**, **set**, **transaction**, and **cursor**

NOTICE

- You are advised to reserve **transaction**. Otherwise, statements in a transaction will not be audited.
- You are advised to reserve **cursor**. Otherwise, the **SELECT** statements in a cursor will not be audited.
- The Data Studio client automatically encapsulates **SELECT** statements using **CURSOR**.
- If a user-defined function or stored procedure contains a **FETCH** statement, the **common_text** field records the corresponding CURSOR content when the **FETCH** statement is audited.

audit_operation_error

Parameter description: Specifies whether to audit failed operations in GaussDB(DWS). Set this parameter as required.

Type: SIGHUP

Value range: a string

- **none**: indicates that no audit item is configured. If any audit item is configured, **none** becomes invalid.
- **syn_success**: synchronizes the **audit_operation_exec** configuration. To be specific, if the audit of a successful operation is configured, the corresponding failed operation is also audited. Note that even after **syn_success** is configured, you can continue to configure the audit of other failed operations. If **audit_operation_exec** is set to **all**, all failed operations are audited. If **audit_operation_exec** is set to **none**, **syn_success** is equivalent to **none**, that is, no audit item is configured.
- **parse**: indicates that the failed command parsing is audited, including the timeout of waiting for a command execution.
- **login**: indicates that failed logins are audited.
- **user_lock**: indicates that failed locking and unlocking operations are audited.
- **violation**: indicates that a user's access violation operations are audited.
- **grant_revoke**: indicates that failed granting and reclaiming of a user's permission are audited.
- **ddl**: indicates that failed DDL operations are audited. DDL operations are controlled at a fine granularity based on operation objects and configuration of **audit_system_object**. Therefore, failed DDL operations of the type specified in **audit_system_object** will be audited after **ddl** is configured.
- **select**: indicates that failed SELECT operations are audited.
- **copy**: indicates that failed COPY operations are audited.
- **userfunc**: indicates that failed operations for user-defined functions, stored procedures, and anonymous blocks are audited.
- **set**: indicates that failed SET operations are audited.
- **transaction**: indicates that failed transaction operations are audited.
- **vacuum**: indicates that failed VACUUM operations are audited.

- **analyze**: indicates that failed ANALYZE operations are audited.
- **explain**: indicates that failed EXPLAIN operations are audited.
- **specialfunc**: indicates that failed calls to special functions are audited. Special functions include **pg_terminate_backend** and **pg_cancel_backend**.
- **insert**: indicates that failed INSERT operations are audited.
- **update**: indicates that failed UPDATE operations are audited.
- **delete**: indicates that failed DELETE operations are audited.
- **merge**: indicates that failed MERGE operations are audited.
- **show**: indicates that failed SHOW operations are audited.
- **checkpoint**: indicates that failed CHECKPOINT operations are audited.
- **barrier**: indicates that failed BARRIER operations are audited.
- **cluster**: indicates that failed CLUSTER operations are audited.
- **comment**: indicates that failed COMMENT operations are audited.
- **cleanconn**: indicates that failed CLEANCONNECTION operations are audited.
- **prepare**: indicates that failed PREPARE, EXECUTE, and DEALLOCATE operations are audited.
- **constraints**: indicates that failed CONSTRAINTS operations are audited.
- **cursor**: indicates that failed cursor operations are audited.
- **blacklist**: indicates that the blacklist execution failure is audited.
- **discard** indicates that the execution failures related to global temporary tables in the current session are audited.

Default value: **login**

audit_inner_tool

Parameter description: Specifies whether to audit the operations of the internal maintenance tool in GaussDB(DWS).

Type: SIGHUP

Value range: Boolean

- **on**: indicates that all operations of the internal maintenance tool are audited.
- **off**: indicates that all operations of the internal maintenance tool are not audited.

Default value: **off**

audit_system_object

Parameter description: Specifies whether to audit the CREATE, DROP, and ALTER operations on the GaussDB(DWS) database object. The GaussDB(DWS) database objects include databases, users, schemas, and tables. The operations on the database object can be audited by changing the value of this parameter.

Type: SIGHUP

Value range: an integer ranging from 0 to 4194303

- **0** indicates that the function of auditing the CREATE, DROP, and ALTER operations on the GaussDB(DWS) database object can be disabled.
- Other values indicate that the CREATE, DROP, and ALTER operations on a certain or some GaussDB(DWS) database objects are audited.

Value description:

The value of this parameter is calculated by 22 binary bits. The 22 binary bits represent 22 types of GaussDB(DWS) database 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 content represented by these 22 binary bits, see **Table 17-6**.

Default value: **12303**

Table 17-6 Meaning of each value for the **audit_system_object** parameter

Binary Bit	Meaning	Value Description
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. • **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. • **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.	• **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited. • **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. • **1** indicates that the CREATE, DROP, ALTER, and TRUNCATE operations on these objects are audited.

Binary Bit	Meaning	Value Description
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. • **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited.
Bit 5	Whether to audit the CREATE, DROP, and ALTER operations on views.	• **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited. • **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited.
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. • **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/ functions.	• **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited. • **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. • **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. • **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. • **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited.

Binary Bit	Meaning	Value Description
Bit 11	Whether to audit the CREATE, DROP, and ALTER operations on SERVER FOR HADOOP objects.	• **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited. • **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited.
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. • **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited.
Bit 13	Whether to audit the CREATE, DROP, and ALTER operations on Node Groups.	• **0** indicates that the CREATE, DROP, and ALTER operations on these objects are not audited. • **1** indicates that the CREATE, DROP, and ALTER operations on these objects are audited.
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. • **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. • **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 (configurations and dictionaries)	• **0** indicates that the CREATE, DROP, and ALTER operations on text search objects are not audited. • **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. • **1** indicates that the CREATE, DROP, and ALTER operations on directories are audited.

Binary Bit	Meaning	Value Description
Bit 18	Whether to audit the CREATE, DROP, and ALTER operations on workloads.	• **0** indicates that the CREATE, DROP, and ALTER operations on types are not audited. • **1** indicates that the CREATE, DROP, and ALTER operations on types are audited.
Bit 19	Whether to audit the CREATE, DROP, and ALTER operations on redaction policies.	• **0** indicates that the CREATE, DROP, and ALTER operations on redaction policies are not audited. • **1** indicates that the CREATE, DROP, and ALTER operations on redaction policies are audited.
Bit 20	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. • **1** indicates that the CREATE, DROP, and ALTER operations on sequences are audited.
Bit 21	Whether to audit the CREATE, DROP, and ALTER operations on nodes.	• **0** indicates that the CREATE, DROP, and ALTER operations on nodes are not audited. • **1** indicates that the CREATE, DROP, and ALTER operations on nodes are audited.

enableSeparationOfDuty

Parameter description: Specifies whether the separation of permissions is enabled.

Type: POSTMASTER

Value range: Boolean

- **on** indicates that the separation of permissions is enabled.
- **off** indicates that the separation of permissions is disabled.

Default value: **off**

security_enable_options

Parameter description: Specifies whether **grant_to_public**, **grant_with_grant_option**, and **foreign_table_options** can be used in security mode. This parameter is supported by version 8.2.0 or later clusters.

Type: SIGHUP

Value range: a string

- **on** indicates that **grant to public** can be used in security mode.
- **on** indicates that **with grant option** can be used in security mode.
- **foreign_table_options** allows users to perform operations on foreign tables in security mode without explicitly granting the **useft** permission to users.

Default value: empty

NOTE

- In a newly installed cluster, this parameter is left blank by default, indicating that none of **grant_to_public**, **grant_with_grant_option**, and **foreign_table_options** can be used in security mode.
- In upgrade scenarios, the default value of this parameter is forward compatible. If the default values of **enable_grant_public** and **enable_grant_option** are **ON** before the upgrade, the default value of **security_enable_options** is **grant_to_public, grant_with_grant_option** after the upgrade.

17.23 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 the 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.

Type: USERSET

Value range: an integer. The minimum value is **0**. The unit is second.

Default value: **5s**

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 the 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).

Type: USERSET

Value range: an integer. The minimum value is **0**. The unit is second.

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 a DN.

17.24 GTM Parameters

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.

Type: SUSET

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 17-3**.

Default value: **warning**

enable_alarm

Parameter description: Specifies whether to enable the alarm detection thread to detect the fault scenarios that may occur in the database.

Type: POSTMASTER

Value range: Boolean

- **on**: Alarm detection thread is enabled.
- **off**: Alarm detection thread is disabled.

Default value: **on**

17.25 Miscellaneous Parameters

enable_cluster_resize

Parameter description: Indicates whether the current session is a scale-out redistribution session. This parameter applies only to scale-out redistribution sessions. Do not set this parameter for other service sessions.

Type: SUSET

Value range: Boolean

- **on** indicates that the current session is a scale-out redistribution session and redistribution SQL statements can be executed.
- **off** indicates that the current session is a non-scale-out redistribution session and redistribution SQL statements cannot be executed.

Default value: **off**

NOTE

This parameter is used for internal O&M. Do not set it to **on** unless absolutely necessary.

dfs_partition_directory_length

Parameter description: Specifies the largest directory name length for the partition directory of a table partitioned by VALUE in the HDFS.

Type: USERSET

Value range: 92 to 7999

Default value: **512**

enable_hadoop_env

Parameter description: Sets whether local row- and column-store tables can be created in a database while the Hadoop feature is used. In the GaussDB(DWS) cluster, it is set to **off** by default to support local row- and column- based storage and cross-cluster access to Hadoop. You are not advised to change the value of this parameter.

Type: USERSET

Value range: Boolean

- **on** or **true**, indicating that local row- and column-store tables cannot be created in a database while the Hadoop feature is used.
- **off** or **false**, indicating that local row- and column-based tables can be created in a database while the Hadoop feature is used.

Default value: **off**

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 avoided when update and delete operations are performed at the same time.

Type: USERSET

Value range: Boolean

- If this parameter is set to **on**, the delta merge operation internally increases the lock level. In this way, when any two of the **DELTAMERGE**, **UPDATE**, and **DELETE** operations are concurrently performed, an operation can be performed only after the previous one is complete.
- If this parameter is set to **off**, and any two of the **DELTAMERGE**, **UPDATE**, and **DELETE** operations are concurrently performed to data in a row in the delta table of the HDFS table, errors will be reported during the later operation, and the operation will stop.

Default value: **off**

job_queue_processes

Parameter description: Specifies the number of jobs that can be concurrently executed.

Type: POSTMASTER

Value range: 0 to 1000

Functions:

- Setting **job_queue_processes** to **0** indicates that the scheduled task function is disabled and that no job will be executed. (Enabling scheduled tasks 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 task function is enabled and this value is the maximum number of tasks that can be concurrently processed.

After the scheduled task function is enabled, the **job_scheduler** thread at a scheduled interval polls the **pg_jobs** system catalog. The scheduled task check is performed every second by default.

Too many concurrent tasks consume many system resources, so you need to set the number of concurrent tasks to be processed. If the current number of concurrent tasks reaches **job_queue_processes** and some of them expire, these tasks 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 task to avoid the problem that tasks in the next polling period cannot be properly processed because overlong task execution time.

Note: If the number of parallel 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.

Default value: **10**

job_queue_naptime

Parameter description: Specifies how often to check the scheduling tasks and how long to wait for a task thread to start. This parameter is supported only by clusters of version 8.3.0 or later.

Type: SIGHUP

Value range: 0 ~ 2147483, in seconds.

Default value: **1**

job_retention_time

Parameter description: Specifies the maximum number of days for storing **pg_job** execution results. This parameter is supported only by clusters of version 8.3.0 or later.

Type: SIGHUP

Value range: 0-3650 (unit: day)

Default value: **30**

ngram_gram_size

Parameter description: Specifies the length of the ngram parser segmentation.

Type: USERSET

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.

Type: USERSET

Value range: Boolean

- **on**: Ignores graphical characters.
- **off**: Does not ignore graphical characters.

Default value: **off**

ngram_punctuation_ignore

Parameter description: Specifies whether the ngram parser ignores punctuations.

Type: USERSET

Value range: Boolean

- **on**: Ignores punctuations.
- **off**: Does not ignore punctuations.

Default value: **on**

zhparser_dict_in_memory

Parameter description: Specifies whether Zhparser adds a dictionary to memory.

Type: POSTMASTER

Value range: Boolean

- **on**: Adds the dictionary to memory.
- **off**: Does not add the dictionary to memory.

Default value: **on**

zhparser_multi_duality

Parameter description: Specifies whether Zhparser aggregates segments in long words with duality.

Type: USERSET

Value range: Boolean

- **on**: Aggregates segments in long words with duality.
- **off**: Does not aggregate segments in long words with duality.

Default value: **off**

zhparser_multi_short

Parameter description: Specifies whether Zhparser executes long words composite divide.

Type: USERSET

Value range: Boolean

- **on**: Performs compound segmentation for long words.
- **off**: Does not perform compound segmentation for long words.

Default value: **on**

zhparser_multi_zall

Parameter description: Specifies whether Zhparser displays all single words individually.

Type: USERSET

Value range: Boolean

- **on**: Displays all single words separately.
- **off**: Does not display all single words separately.

Default value: **off**

zhparser_multi_zmain

Parameter description: Specifies whether Zhparser displays important single words separately.

Type: USERSET

Value range: Boolean

- **on**: Displays important single words separately.
- **off**: Does not display important single words separately.

Default value: **off**

zhparser_punctuation_ignore

Parameter description: Specifies whether the Zhparser segmentation result ignores special characters including punctuations (\r and \n will not be ignored).

Type: USERSET

Value range: Boolean

- **on**: Ignores all the special characters including punctuations.
- **off**: Does not ignore all the special characters including punctuations.

Default value: **on**

zhparser_seg_with_duality

Parameter description: Specifies whether Zhparser aggregates segments in long words with duality.

Type: USERSET

Value range: Boolean

- **on**: Aggregates segments in long words with duality.
- **off**: Does not aggregate segments in long words with duality.

Default value: **off**

acceleration_with_compute_pool

Parameter description: Specifies whether to use the computing resource pool for acceleration when OBS is queried.

Type: USERSET

Value range: Boolean

- **on** indicates that the query covering OBS is accelerated based on the cost when the computing resource pool is available.
- **off** indicates that no query is accelerated using the computing resource pool.

Default value: **off**

redact_compat_options

Parameter description: Specifies the compatibility option for calculation using masked data. This parameter is supported only by clusters of version 8.1.3.310 or later.

Type: USERSET

Value range: a string

- **none** indicates that compatibility options are specified.
- **disable_comparison_operator_mask** indicates that comparison operators that do not expose raw data can bypass the data masking check and generate the actual calculation result.

Default value: **none**

table_skewness_warning_threshold

Parameter description: Specifies the threshold for triggering a table skew alarm.

Type: SUSET

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.

Type: SUSET

Value range: an integer ranging from **0** to **INT_MAX**

Default value: **100000**

auto_process_residualfile

Parameter description: Specifies whether to enable the residual file recording function.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the residual file recording function is enabled.
- **off** indicates that the residual file recording function is disabled.

Default value: **off**

enable_view_update

Parameter description: Enables the view update function or not.

Type: POSTMASTER

Value range: Boolean

- **on** indicates that the view update function is enabled.
- **off** indicates that the view update function is disabled.

Default value: **off**

view_independent

Parameter description: Decouples views from tables, functions, and synonyms or not. After the base table is restored, automatic association and re-creation are supported.

Type: SIGHUP

Value range: Boolean

- **on** indicates that the view decoupling function is enabled. Tables, functions, synonyms, and other views on which views depend can be deleted separately (except temporary tables and temporary views). Associated views are reserved but unavailable.
- **off** indicates that the view decoupling function is disabled. Tables, functions, synonyms, and other views on which views depend cannot be deleted separately. You can only delete them in the cascade mode.

Default value: **off**

bulkload_report_threshold

Parameter description: Sets the threshold for reporting import and export statistics.

Type: SIGHUP

Value range: an integer ranging from **0** to **INT_MAX**

Default value: **50**

assign_abort_xid

Parameter description: Determines the transaction to be aborted based on the specified XID in a query.

Type: USERSET

Value range: a character string with the specified XID

CAUTION

This parameter is used only for quick restoration if a user deletes data by mistake (DELETE operation). Do not use this parameter in other scenarios. Otherwise, visible transaction errors may occur.

default_distribution_mode

Parameter description: Specifies the default distribution mode of a table. This feature is supported only in 8.1.2 or later.

Type: USERSET

Value range: enumerated values

- **roundrobin**: If the distribution mode is not specified during table creation, the default distribution mode is selected according to the following rules:
  a. If the primary key or unique constraint is included during table creation, hash distribution is selected. The distribution column is the column corresponding to the primary key or unique constraint.
  b. If the primary key or unique constraint is not included during table creation, round-robin distribution is selected.
- **hash**: If the distribution mode is not specified during table creation, the default distribution mode is selected according to the following rules:
  a. If the primary key or unique constraint is included during table creation, hash distribution is selected. The distribution column is the column corresponding to the primary key or unique constraint.
  b. If the primary key or unique constraint is not included during table creation but there are columns whose data types can be used as distribution columns, hash distribution is selected. The distribution column is the first column whose data type can be used as a distribution column.
  c. If the primary key or unique constraint is not included during table creation and no column whose data type can be used as a distribution column exists, round-robin distribution is selected.

Default value: **roundrobin**

NOTE

The default value of this parameter is **roundrobin** for a new GaussDB(DWS) 8.1.2 cluster and is **hash** for an upgrade to GaussDB(DWS) 8.1.2.

max_volatile_tables

Parameter description: Specifies the maximum number of volatile tables created for each session, including volatile tables and their auxiliary tables. This parameter is supported by version 8.2.0 or later clusters.

Type: USERSET

Value range: an integer ranging from 0 to INT_MAX

Default value: **300**

enable_matview

Parameter description: Controls whether **CREATE MATERIALIZED VIEW** can be used to create materialized views. This parameter is supported only by clusters of version 8.3.0 or later.

Type: SIGHUP

Value range: Boolean

- **on** indicates that **CREATE MATERIALIZED VIEW** can be used to create materialized views.

- **off** indicates that **CREATE MATERIALIZED VIEW** cannot be used to create materialized views.

Default value: **off**

query_cache_refresh_time

Parameter description: Specifies the cache refresh interval for queries that take effect using enable_accelerate_select. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: a floating vertex number ranging from 0 to 10000.0 (unit: s)

Default value: 60.0

vector_engine_strategy

Parameter description: Specifies the vectorization enhancement policy. This parameter is supported only by clusters of version 8.3.0 or later.

Type: USERSET

Value range: enumerated values

- **force** specifies that the vectorization-enhanced plan is forcibly rolled back to the row storage plan when there are scenarios that do not support vectorization.
- **improve** specifies that vectorization enhancement is enabled even when there are scenarios that do not support vectorization.

Default value: **improve**

18 Glossary

Term	Description
A – E	
ACID	Atomicity, Consistency, Isolation, and Durability (ACID). These are a set of properties of database transactions in a DBMS.
cluster ring	A cluster ring consists of several physical servers. The primary-standby-secondary relationships among its DNs do not involve external DNs. That is, none of the primary, standby, or secondary counterparts of DNs belonging to the ring are deployed in other rings. A ring is the smallest unit used for scaling.
Bgwriter	A background write thread created when the database starts. The thread pushes dirty pages in the database to a permanent device (such as a disk).
bit	The smallest unit of information handled by a computer. One bit is expressed as a 1 or a 0 in a binary numeral, or as a true or a false logical condition. A bit is physically represented by an element such as high or low voltage at one point in a circuit, or a small spot on a disk that is magnetized in one way or the other. A single bit conveys little information a human would consider meaningful. A group of eight bits, however, makes up a byte, which can be used to represent many types of information, such as a letter of the alphabet, a decimal digit, or other character.
Bloom filter	Bloom filter is a space-efficient binary vectorized data structure, conceived by Burton Howard Bloom in 1970, that is used to test whether an element is a member of a set. False positive matches are possible, but false negatives are not, in other words, a query returns either "possibly in set (possible error)" or "definitely not in set". In the cases, Bloom filter sacrificed the accuracy for time and space.

Term	Description
CCN	The Central Coordinator (CCN) is a node responsible for determining, queuing, and scheduling complex operations in each CN to enable the dynamic load management of GaussDB(DWS).
CIDR	Classless Inter-Domain Routing (CIDR). CIDR abandons the traditional class-based (class A: 8; class B: 16; and class C: 24) address allocation mode and allows the use of address prefixes of any length, effectively improving the utilization of address space. A CIDR address is in the format of *IP address*/*Number of bits in a network ID*. For example, in **192.168.23.35/21**, **21** indicates that the first 21 bits are the network prefix and others are the host ID.
Cgroups	A control group (Cgroup), also called a priority group (PG) in GaussDB(DWS). The Cgroup is a kernel feature of SUSE Linux and Red Hat that can limit, account for, and isolate the resource usage of a collection of processes.
CLI	Command-line interface (CLI). Users use the CLI to interact with applications. Its input and output are based on texts. Commands are entered through keyboards or similar devices and are compiled and executed by applications. The results are displayed in text or graphic forms on the terminal interface.
CM	Cluster Manager (CM) manages and monitors the running status of functional units and physical resources in the distributed system, ensuring stable running of the entire system.
CMS	The Cluster Management Service (CMS) component manages the cluster status.
CN	The Coordinator (CN) stores database metadata, splits query tasks and supports their execution, and aggregates the query results returned from DNs.
CU	Compression Unit (CU) is the smallest storage unit in a column-storage table.
core file	A file that is created when memory overwriting, assertion failures, or access to invalid memory occurs in a process, causing it to fail. This file is then used for further analysis. A core file contains a memory dump, in an all-binary and port-specific format. The name of a core file consists of the word "core" and the OS process ID. The core file is available regardless of the type of platform.

Term	Description
core dump	When a program stops abnormally, the core dump, memory dump, or system dump records the state of the working memory of the program at that point in time. In practice, other key pieces of program state are usually dumped at the same time, including the processor registers, which may include the program counter and stack pointer, memory management information, and other processor and OS flags and information. A core dump is often used to assist diagnosis and computer program debugging.
DBA	A database administrator (DBA) instructs or executes database maintenance operations.
DBLINK	An object defining the path from one database to another. A remote database object can be queried with DBLINK.
DBMS	Database Management System (DBMS) is a piece of system management software that allows users to access information in a database. This is a collection of programs that allows you to access, manage, and query data in a database. A DBMS can be classified as memory DBMS or disk DBMS based on the location of the data.
DCL	Data control language (DCL)
DDL	Data definition language (DDL)
DML	Data manipulation language (DML)
DN	Datanode performs table data storage and query operations.
ETCD	The Editable Text Configuration Daemon (ETCD) is a distributed key-value storage system used for configuration sharing and service discovery (registration and search).
ETL	Extract-Transform-Load (ETL) refers to the process of data transmission from the source to the target database.
Extension Connector	Extension Connector is provided by GaussDB(DWS) to process data across clusters. It can send SQL statements to Spark, and can return execution results to your database.
Backup	A backup, or the process of backing up, refers to the copying and archiving of computer data in case of data loss.
backup and restoration	A collection of concepts, procedures, and strategies to protect data loss caused by invalid media or misoperations.
standby server	A node in the GaussDB(DWS) HA solution. It functions as a backup of the primary server. If the primary server is behaving abnormally, the standby server is promoted to primary, ensuring data service continuity.

Term	Description
crash	A crash (or system crash) is an event in which a computer or a program (such as a software application or an OS) ceases to function properly. Often the program will exit after encountering this type of error. Sometimes the offending program may appear to freeze or hang until a crash reporting service documents details of the crash. If the program is a critical part of the OS kernel, the entire computer may crash (possibly resulting in a fatal system error).
encoding	Encoding is representing data and information using code so that it can be processed and analyzed by a computer. Characters, digits, and other objects can be converted into digital code, or information and data can be converted into the required electrical pulse signals based on predefined rules.
encoding technology	A technology that presents data using a specific set of characters, which can be identified by computer hardware and software.
table	A set of columns and rows. Each column is referred to as a field. The value in each field represents a data type. For example, if a table contains people's names, cities, and states, it has three columns: **Name**, **City**, and **State**. In every row in the table, the **Name** column contains a name, the **City** column contains a city, and the **State** column contains a state.
tablespace	A tablespace is a logical storage structure that contains tables, indexes, large objects, and long data. A tablespace provides an abstract layer between physical data and logical data, and provides storage space for all database objects. When you create a table, you can specify which tablespace it belongs to.
concurrency control	A DBMS service that ensures data integrity when multiple transactions are concurrently executed in a multi-user environment. In a multi-threaded environment, GaussDB(DWS) concurrency control ensures that database operations are safe and all database transactions remain consistent at any given time.
query	Specifies requests sent to the database, such as updating, modifying, querying, or deleting information.
query operator	An iterator or a query tree node, which is a basic unit for the execution of a query. Execution of a query can be split into one or more query operators. Common query operators include scan, join, and aggregation.
query fragment	Each query task can be split into one or more query fragments. Each query fragment consists of one or more query operators and can independently run on a node. Query fragments exchange data through data flow operators.

Term	Description
durability	One of the ACID features of database transactions. Durability indicates that transactions that have been committed will permanently survive and not be rolled back.
stored procedure	A group of SQL statements compiled into a single execution plan and stored in a large database system. Users can specify a name and parameters (if any) for a stored procedure to execute the procedure.
OS	An operating system (OS) is loaded by a bootstrap program to a computer to manage other programs in the computer. Other programs are applications or application programs.
secondary server	To ensure high cluster availability, the primary server synchronizes logs to the secondary server if data synchronization between the primary and standby servers fails. If the primary server suddenly breaks down, the standby server is promoted to primary and synchronizes logs from the secondary server for the duration of the breakdown.
BLOB	Binary large object (BLOB) is a collection of binary data stored in a database, such as videos, audio, and images.
dynamic load balancing	In GaussDB(DWS), dynamic load balancing automatically adjusts the number of concurrent jobs based on the usage of CPU, I/O, and memory to avoid service errors and to prevent the system from stop responding due to system overload.
segment	A segment in the database indicates a part containing one or more regions. Region is the smallest range of a database and consists of data blocks. One or more segments comprise a tablespace.
F – J	
failover	Automatic switchover from a faulty node to its standby node. Reversely, automatic switchback from the standby node to the primary node is called failback.
FDW	A foreign data wrapper (FDW) is a SQL interface provided by Postgres. It is used to access big data objects stored in remote data so that DBAs can integrate data from unrelated data sources and store them in public schema in the database.

Term	Description
freeze	An operation automatically performed by the AutoVacuum Worker process when transaction IDs are exhausted. GaussDB(DWS) records transaction IDs in row headings. When a transaction reads a row, the transaction ID in the row heading and the actual transaction ID are compared to determine whether this row is explicit. Transaction IDs are integers containing no symbols. If exhausted, transaction IDs are re-calculated outside of the integer range, causing the explicit rows to become implicit. To prevent such a problem, the freeze operation marks a transaction ID as a special ID. Rows marked with these special transaction IDs are explicit to all transactions.
GDB	As a GNU debugger, GDB allows you to see what is going on 'inside' another program while it executes or what another program was doing the moment that it crashed. GDB can perform four main kinds of things (make PDK functions stronger) to help you catch bugs in the act: • Starts your program, specifying anything that might affect its behavior. • Stops a program in a specific condition. • Checks what happens when a program stops. • Modifies the program content to rectify the fault and proceeds with the next one.
GDS	General Data Service (GDS). To import data to GaussDB(DWS), you need to deploy the tool on the server where the source data is stored so that DNs can use this tool to obtain data.
GIN index	Generalized inverted index (GIN) is used 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.
GNU	The GNU Project was publicly announced on September 27, 1983 by Richard Stallman, aiming at building an OS composed wholly of free software. GNU is a recursive acronym for "GNU's Not Unix!". Stallman announced that GNU should be pronounced as Guh-NOO. Technically, GNU is similar to Unix in design, a widely used commercial OS. However, GNU is free software and contains no Unix code.
gsql	GaussDB(DWS) interaction terminal. It enables you to interactively type in queries, issue them to GaussDB(DWS), and view the query results. Queries can also be entered from files. **gsql** supports many meta commands and shell-like commands, allowing you to conveniently compile scripts and automate tasks.
GTM	Global Transaction Manager (GTM) manages the status of transactions.

Term	Description
GUC	Grand unified configuration (GUC) includes parameters for running databases, the values of which determine database system behavior.
HA	High availability (HA) is a solution in which two modules operate in primary/standby mode to achieve high availability. This solution helps to minimize the duration of service interruptions caused by routine maintenance (planned) or sudden system breakdowns (unplanned), improving the system and application usability.
HBA	Host-based authentication (HBA) allows hosts to authenticate on behalf of all or some of the system users. It can apply to all users on a system or a subset using the **Match** directive. This type of authentication can be useful for managing computing clusters and other fairly homogenous pools of machines. In all, three files on the server and one on the client must be modified to prepare for host-based authentication.
HDFS	Hadoop Distributed File System (HDFS) is a subproject of Apache Hadoop. HDFS is highly fault tolerant and is designed to run on low-end hardware. The HDFS provides high-throughput access to large data sets and is ideal for applications having large data sets.
server	A combination of hardware and software designed for providing clients with services. This word alone refers to the computer running the server OS, or the software or dedicated hardware providing services.
advanced package	Logical and functional stored procedures and functions provided by GaussDB(DWS).
isolation	One of the ACID features of database transactions. Isolation means that the operations inside a transaction and data used are isolated from other concurrent transactions. The concurrent transactions do not affect each other.
relational database	A database created using a relational model. It processes data using methods of set algebra.
archive thread	A thread started when the archive function is enabled on a database. The thread archives database logs to a specified path.
failover	The automatic substitution of a functionally equivalent system component for a failed one. The system component can be a processor, server, network, or database.
environment variable	An environment variable defines the part of the environment in which a process runs. For example, it can define the part of the environment as the main directory, command search path, terminal that is in use, or the current time zone.

Term	Description
checkpoint	A mechanism that stores data in the database memory to disks at a certain time. GaussDB(DWS) periodically stores the data of committed and uncommitted transactions to disks. The data and redo logs can be used for database restoration if a database restarts or breaks down.
encryption	A function hiding information content during data transmission to prevent the unauthorized use of the information.
node	Cluster nodes (or nodes) are physical and virtual severs that make up the GaussDB(DWS) cluster environment.
error correction	A technique that automatically detects and corrects errors in software and data streams to improve system stability and reliability.
process	An instance of a computer program that is being executed. A process may be made up of multiple threads of execution. Other processes cannot use a thread occupied by the process.
PITR	Point-In-Time Recovery (PITR) is a backup and restoration feature of GaussDB(DWS). Data can be restored to a specified point in time if backup data and WAL logs are normal.
record	In a relational database, a record corresponds to data in each row of a table.
cluster	A cluster is an independent system consisting of servers and other resources, ensuring high availability. In certain conditions, clusters can implement load balancing and concurrent processing of transactions.
K – O	
LLVM	LLVM is short for Low Level Virtual Machine. Low Level Virtual Machine (LLVM) is a compiler framework written in C++ and is designed to optimize the compile-time, link-time, run-time, and idle-time of programs that are written in arbitrary programming languages. It is open to developers and compatible with existing scripts. GaussDB(DWS) LLVM dynamic compilation can be used to generate customized machine code for each query to replace original common functions. Query performance is improved by reducing redundant judgment conditions and virtual function invocation, and by making local data more accurate during actual queries.
LVS	Linux Virtual Server (LVS), a virtual server cluster system, is used for balancing the load of a cluster.
MPP	Massive Parallel Processing (MPP) refers to cluster architecture that consists of multiple machines. The architecture is also called a cluster system.

Term	Description
MVCC	Multi-Version Concurrency Control (MVCC) is a protocol that allows a tuple to have multiple versions, on which different query operations can be performed. A basic advantage is that read and write operations do not conflict.
NameNode	The NameNode is the centerpiece of a Hadoop file system, managing the namespace of the file system and client access to files.
OLAP	Online analytical processing (OLAP) is the most important application in the database warehouse system. It is dedicated to complex analytical operations, helps decision makers and executives to make decisions, and rapidly and flexibly processes complex queries involving a great amount of data based on analysts' requirements. In addition, the OLAP provides decision makers with query results that are easy to understand, allowing them to learn the operating status of the enterprise. These decision makers can then produce informed and accurate solutions based on the query results.
OM	Operations Management (OM) provides management interfaces and tools for routine maintenance and configuration management of the cluster.
ORC	Optimized Row Columnar (ORC) is a widely used file format for structured data in a Hadoop system. It was introduced from the Hadoop HIVE project.
client	A computer or program that accesses or requests services from another computer or program.
free space management	A mechanism for managing free space in a table. This mechanism enables the database system to record free space in each table and establish an easy-to-search data structure, accelerating operations (such as INSERT) performed on the free space.
cross-cluster	In GaussDB(DWS), users can access data in other DBMS through foreign tables or using an Extension Connector. Such access is cross-cluster.
junk tuple	A tuple that is deleted using the **DELETE** and **UPDATE** statements. When deleting a tuple, GaussDB(DWS) only marks the tuples that are to be cleared. The Vacuum thread will then periodically clear these junk tuples.
column	An equivalent concept of "field". A database table consists of one or more columns. Together they describe all attributes of a record in the table.
logical node	Multiple logical nodes can be installed on the same node. A logical node is a database instance.

Term	Description
schema	Collection of database objects, including logical structures, such as tables, views, sequences, stored procedures, synonyms, indexes, clusters, and database links.
schema file	A SQL file that determines the database structure.
P – T	
Page	Minimum memory unit for row storage in the GaussDB(DWS) relational object structure. The default size of a page is 8 KB.
PostgreSQL	An open-source DBMS developed by volunteers all over the world. PostgreSQL is not controlled by any companies or individuals. Its source code can be used for free.
Postgres-XC	Postgres-XC is an open source PostgreSQL cluster to provide write-scalable, synchronous, multi-master PostgreSQL cluster solution.
Postmaster	A thread started when the database service is started. It listens to connection requests from other nodes in the cluster or from clients. After receiving and accepting a connection request from the standby server, the primary server creates a WAL Sender thread to interact with the standby server.
RHEL	Red Hat Enterprise Linux (RHEL)
redo log	A log that contains information required for performing an operation again in a database. If a database is faulty, redo logs can be used to restore the database to its original state.
SCTP	The Stream Control Transmission Protocol (SCTP) is a transport-layer protocol defined by Internet Engineering Task Force (IETF) in 2000. The protocol ensures the reliability of datagram transport based on unreliable service transmission protocols by transferring SCN narrowband signaling over IP network.
savepoint	A savepoint marks the end of a sub-transaction (also known as a nested transaction) in a relational DBMS. The process of a long transaction can be divided into several parts. After a part is successfully executed, a savepoint will be created. If later execution fails, the transaction will be rolled back to the savepoint instead of being totally rolled back. This is helpful for recovering database applications from complicated errors. If an error occurs in a multi-statement transaction, the application can possibly recover by rolling back to the save point without terminating the entire transaction.
session	A task created by a database for a connection when an application attempts to connect to the database. Sessions are managed by the session manager. They execute initial tasks to perform all user operations.

Term	Description
shared-nothing architecture	A distributed computing architecture, in which none of the nodes share CPUs or storage resources. This architecture has good scalability.
SLES	SUSE Linux Enterprise Server (SLES) is an enterprise Linux OS provided by SUSE.
SMP	Symmetric multiprocessing (SMP) lets multiple CPUs run on a computer and share the same memory and bus. To ensure an SMP system achieves high performance, an OS must support multi-tasking and multi-thread processing. In databases, SMP means to concurrently execute queries using the multi-thread technology, efficiently using all CPU resources and improving query performance.
SQL	Structure Query Language (SQL) is a standard database query language. It consists of DDL, DML, and DCL.
SSL	Secure Socket Layer (SSL) is a network security protocol introduced by Netscape. SSL is a security protocol based on the TCP and IP communications protocols and uses the public key technology. SSL supports a wide range of networks and provides three basic security services, all of which use the public key technology. SSL ensures the security of service communication through the network by establishing a secure connection between the client and server and then sending data through this connection.
convergence ratio	Downlink to uplink bandwidth ratio of a switch. A high convergence ratio indicates a highly converged traffic environment and severe packet loss.
TCP	Transmission Control Protocol (TCP) sends and receives data through the IP protocol. It splits data into packets for sending, and checks and reassembles received package to obtain original information. TCP is a connection-oriented, reliable protocol that ensures information correctness in transmission.
trace	A way of logging to record information about the way a program is executed. This information is typically used by programmers for debugging purposes. System administrators and technical support can diagnose common problems by using software monitoring tools and based on this information.
full backup	Backup of the entire database cluster.
full synchronization	A data synchronization mechanism specified in the GaussDB(DWS) HA solution. Used to synchronize all data from the primary server to a standby server.
Log File	A file to which a computer system writes a record of its activities.

Term	Description
transaction	A logical unit of work performed within a DBMS against a database. A transaction consists of a limited database operation sequence, and must have ACID features.
data	A representation of facts or directives for manual or automatic communication, explanation, or processing. Data includes constants, variables, arrays, and strings.
data redistribution	A process whereby a data table is redistributed among nodes after users change the data distribution mode.
data distribution	A mode in which table data is split and stored on each database instance in a distributed system. Table data can be distributed in hash, replication, or random mode. In hash mode, a hash value is calculated based on the value of a specified column in a tuple, and then the target storage location of the tuple is determined based on the mapping between nodes and hash values. In replication mode, tuples are replicated to all nodes. In random mode, data is randomly distributed to the nodes.
data partitioning	A division of a logical database or its constituent elements into multiple parts (partitions) whose data does not overlap based on specified ranges. Data is mapped to storage locations based on the value ranges of specific columns in a tuple.
Database Name	A collection of data that is stored together and can be accessed, managed, and updated. Data in a view in the database can be classified into the following types: numerals, full text, digits, and images.
DB instance	A database instance consists of a process in GaussDB(DWS) and files controlled by the process. GaussDB(DWS) installs multiple database instances on one physical node. GTM, CM, CN, and DN installed on cluster nodes are all database instances. A database instance is also called a logical node.
database HA	GaussDB(DWS) provides a highly reliable HA solution. Every logical node in GaussDB(DWS) is identified as a primary or standby node. Only one GaussDB(DWS) node is identified as primary at a time. When the HA system is deployed for the first time, the primary server synchronizes all data from each standby server (full synchronization). The HA system then synchronizes only data that is new or has been modified from each standby server (incremental synchronization). When the HA system is running, the primary server can receive data read and write operation requests and the standby servers only synchronize logs.
database file	A binary file that stores user data and the data inside the database system.

Term	Description
data flow operator	An operator that exchanges data among query fragments. By their input/output relationships, data flows can be categorized into Gather flows, Broadcast flows, and Redistribution flows. **Gather** combines multiple query fragments of data into one. Broadcast forwards the data of one query fragment to multiple query fragments. **Redistribution** reorganizes the data of multiple query fragments and then redistributes the reorganized data to multiple query fragments.
data dictionary	A reserved table within a database which is used to store information about the database itself. The information includes database design information, stored procedure information, user rights, user statistics, database process information, database increase statistics, and database performance statistics.
deadlock	Unresolved contention for the use of resources.
index	An ordered data structure in the database management system. An index accelerates querying and the updating of data in database tables.
statistics	Information that is automatically collected by databases, including table-level information (number of tuples and number of pages) and column-level information (column value range distribution histogram). Statistics in databases are used to estimate the cost of execution plans to find the plan with the lowest cost.
stop word	In computing, stop words are words which are filtered out before or after processing of natural language data (text), saving storage space and improving search efficiency.
U – Z	
vacuum	A thread that is periodically started up by a database to clear junk tuples. Multiple Vacuum threads can be started concurrently by setting a parameter.
verbose	The VERBOSE option specifies the information to be displayed.
WAL	Write-ahead logging (WAL) is a standard method for logging a transaction. Corresponding logs must be written into a permanent device before a data file (carrier for a table and index) is modified.
WAL Receiver	A thread created by the standby server during database duplication. The thread is used to receive data and commands from the primary server and to tell the primary server that the data and commands have been acknowledged. Only one WAL receiver thread can run on one standby server.

Term	Description
WAL Sender	A thread created on the primary server when the primary server has received a connection request from a standby server during database replication. This thread is used to send data and commands to standby servers and to receive responses from the standby servers. Multiple WAL Sender threads may run on one primary server. Each WAL Sender thread corresponds to a connection request initiated by a standby server.
WAL Writer	A thread for writing redo logs that are created when a database is started. This thread is used to write logs in the memory to a permanent device, such as a disk.
WLM	The WorkLoad Manager (WLM) is a module for controlling and allocating system resources in GaussDB(DWS).
Xlog	A transaction log. A logical node can have only one Xlog file.
xDR	X detailed record. It refers to detailed records on the user and signaling plans and can be categorized into charging data records (CDRs), user flow data records (UFDRs), transaction detail records (TDRs), and data records (SDRs).
network backup	Network backup provides a comprehensive and flexible data protection solution to Microsoft Windows, UNIX, and Linux platforms. Network backup can back up, archive, and restore files, folders, directories, volumes, and partitions on a computer.
physical node	A physical machine or device.
system catalog	A table storing meta information about the database. The meta information includes user tables, indexes, columns, functions, and the data types in a database.
pushdown	GaussDB(DWS) is a distributed database, where CN can send a query plan to multiple DNs for parallel execution. This CN behavior is called pushdown. It achieves better query performance than extracting data to CN for query.
compression	Data compression, source coding, or bit-rate reduction involves encoding information that uses fewer bits than the original representation. Compression can be either lossy or lossless. Lossless compression reduces bits by identifying and eliminating statistical redundancy. No information is lost in lossless compression. Lossy compression reduces bits by identifying and removing unnecessary or unimportant information. The process of reducing the size of a data file is commonly referred as data compression, although its formal name is source coding (coding done at the source of the data, before it is stored or transmitted).

Term	Description
consistency	One of the ACID features of database transactions. Consistency is a database status. In such a status, data in the database must comply with integrity constraints.
metadata	Data that provides information about other data. Metadata describes the source, size, format, or other characteristics of data. In database columns, metadata explains the content of a data warehouse.
atomicity	One of the ACID features of database transactions. Atomicity means that a transaction is composed of an indivisible unit of work. All operations performed in a transaction must either be committed or uncommitted. If an error occurs during transaction execution, the transaction is rolled back to the state when it was not committed.
online scale-out	Online scale-out means that data can be saved to the database and query services are not interrupted during redistribution in GaussDB(DWS).
dirty page	A page that has been modified and is not written to a permanent device.
incremental backup	Incremental backup stores all files changed since the last valid backup.
incremental synchronization	A data synchronization mechanism in the GaussDB(DWS) HA solution. Only data modified since the last synchronization is synchronized to the standby server.
Host	A node that receives data read and write operations in the GaussDB(DWS) HA system and works with all standby servers. At any time, only one node in the HA system is identified as the primary server.
thesaurus	Standardized words or phrases that express document themes and are used for indexing and retrieval.
dump file	A specific type of the trace file. A dump is typically a one-time output of diagnostic data in response to an event, whereas a trace tends to be continuous output of diagnostic data.
resource pool	Resource pools used for allocating resources in GaussDB(DWS). By binding a user to a resource pool, you can limit the priority of the jobs executed by the user and resources available to the jobs.
tenant	A database service user who runs services using allocated computing (CPU, memory, and I/O) and storage resources. Service level agreements (SLAs) are met through resource management and isolation.

Term	Description
minimum restoration point	A method used by GaussDB(DWS) to ensure data consistency. During startup, GaussDB(DWS) checks consistency between the latest WAL logs and the minimum restoration point. If the record location of the minimum restoration point is greater than that of the latest WAL logs, the database fails to start.

