Data Warehouse Service

Best Practices

Issue 04

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Contents

1 Import and Export

1.1 Best Practices for Data Import

Importing Data from OBS in Parallel

- Splitting a data file into multiple files

  Importing a huge amount of data takes a long period of time and consumes many computing resources.

  To improve the performance of importing data from OBS, split a data file into multiple files as evenly as possible before importing it to OBS. The preferred number of split files is an integer multiple of the DN quantity.

- Verifying data files before and after an import

  When importing data from OBS, first import your files to your OBS bucket, and then verify that the bucket contains all the correct files, and only those files.

  After the import is complete, run the **SELECT** statement to verify that the required files have been imported.

- Ensuring no Chinese characters are contained in paths used for importing data to or exporting data from OBS.

Using GDS to Import Data

- Data skew causes the query performance to deteriorate. Before importing all the data from a table containing over 10 million records, you are advised to import some of the data and check whether there is data skew and whether the distribution keys need to be changed. Troubleshoot the data skew if any. It is costly to address data skew and change the distribution keys after a large amount of data has been imported. For details, see **Checking for Data Skew**.
- To speed up the import, you are advised to split files and use multiple Gauss Data Service (GDS) tools to import data in parallel. An import task can be split into multiple concurrent import tasks. If multiple import tasks use the same GDS, you can specify the **-t** parameter to enable GDS multi-thread concurrent import. To prevent physical I/O and network bottleneck, you are advised to mount GDSs to different physical disks and NICs.

- If the GDS I/O and NICs do not reach their physical bottlenecks, you can enable SMP on GaussDB(DWS) for acceleration. SMP will multiply the pressure on GDSs. Note that SMP adaptation is implemented based on the GaussDB(DWS) CPU pressure rather than the GDS pressure. For more information about SMP, see **Suggestions for SMP Parameter Settings**.
- For the proper communication between GDSs and GaussDB(DWS), you are advised to use 10GE networks. 1GE networks cannot bear the high-speed data transmission, and, as a result, cannot ensure proper communication between GDSs and GaussDB(DWS). To maximize the import rate of a single file, ensure that a 10GE network is used and the data disk group I/O rate is greater than the upper limit of the GDS single-core processing capability (about 400 MB/s).
- Similar to the single-table import, ensure that the I/O rate is greater than the maximum network throughput in the concurrent import.
- It is recommended that the ratio of GDS quantity to DN quantity be in the range of 1:3 to 1:6.
- To improve the efficiency of importing data in batches to column-store partitioned tables, the data is buffered before being written into a disk. You can specify the number of buffers and the buffer size by setting **partition_mem_batch** and **partition_max_cache_size**, respectively. Smaller values indicate the slower the batch import to column-store partitioned tables. The larger the values, the higher the memory consumption.

Using INSERT to Insert Multiple Rows

If the **COPY** statement cannot be used and you require SQL inserts, use a multi-row insert whenever possible. Data compression is inefficient when you add data of only one row or a few rows at a time.

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

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

```
INSERT INTO customer_t1 VALUES
(6885, 'maps', 'Joes'),
(4321, 'tpcds', 'Lily'),
(9527, 'world', 'James');
```

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

Using the COPY Statement to Import Data

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

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

Using a gsql Meta-Command to Import Data

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

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

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

NOTE

\copy only applies to small-batch data import with uniform formats but poor error tolerance capability. GDS or **COPY** is preferred for data import.

1.2 GDS Practice Guide

- Before installing GDS, ensure that the system parameters of the server where GDS is deployed are consistent with those of the database cluster.
- Ensure the physical network works properly for communication between GDS and GaussDB(DWS). A 10GE network is recommended. The 1GE network cannot guarantee smooth communication between GDS and GaussDB(DWS), because it cannot bear the high-speed data transmission pressure and is prone to disconnection. To maximize the import rate of a single file, ensure that a 10GE network is used and the data disk group I/O rate is greater than the upper limit of the GDS single-core processing capability (about 400 MB/s).
- Plan service deployment in advance. It is recommended that one or two GDSs be deployed on a RAID of a data server. It is recommended that the ratio of GDS quantity to DN quantity be in the range of 1:3 to 1:6. Do not deploy too many GDS processes on a loader. Deploy only one GDS process if an 1GE NIC is used, and no more than four GDS processes if a 10GE NIC is used.
- Hierarchically divide the data directories for data imported and exported by GDS in advance. Do not put too many files under a data directory, and delete expired files in a timely manner.
- Properly plan the character set of the target database. You are advised to use UTF8 instead of the SQL_ASCII characters which can easily incur mixed encoding. When exporting data using GDS, ensure that the character set of the foreign table is the same as that of the client. When importing data, ensure that the client and data file content use the same encoding method.
- If the character set of the database, client, or foreign table cannot be changed, run the **iconv** command to manually change the character set.

  ```
  #Note: -f indicates the character set of the source file, and -t indicates the target character set.
  iconv -f utf8 -t gbk utf8.txt -o gbk.txt
  ```
- For details about GDS import practices, see **Using GDS to Import Data**.
- GDS supports CSV, TEXT, and FIXED formats. The default format is TEXT. The binary format is not supported. However, the encode/decode function can be used to process data of the binary type. Example:

  Export a binary table.

  ```
  -- Create a table.
  CREATE TABLE blob_type_t1
  ```

```
(
    BT_COL BYTEA
) DISTRIBUTE BY REPLICATION;
-- Create a foreign table.
CREATE FOREIGN TABLE f_blob_type_t1( BT_COL  text ) SERVER gsmpp_server OPTIONS (LOCATION
'gsfs://127.0.0.1:7789/', FORMAT 'text', DELIMITER E'\x08',  NULL '', EOL '0x0a' ) WRITE ONLY;
INSERT INTO blob_type_t1 VALUES(E'\\xDEADBEEF');
INSERT INTO blob_type_t1 VALUES(E'\\xDEADBEEF');
INSERT INTO blob_type_t1 VALUES(E'\\xDEADBEEF');
INSERT INTO blob_type_t1 VALUES(E'\\xDEADBEEF');
INSERT INTO f_blob_type_t1 select encode(BT_COL,'base64') from blob_type_t1;
```

Import a binary table.

```
-- Create a table.
CREATE TABLE blob_type_t2
(
    BT_COL BYTEA
) DISTRIBUTE BY REPLICATION;
-- Create a foreign table.
CREATE FOREIGN TABLE f_blob_type_t2( BT_COL  text ) SERVER gsmpp_server OPTIONS (LOCATION
'gsfs://127.0.0.1:7789/f_blob_type_t1.dat.0', FORMAT 'text', DELIMITER E'\x08',  NULL '', EOL '0x0a' );
insert into  blob_type_t2 select decode(BT_COL,'base64') from f_blob_type_t2;
SELECT * FROM blob_type_t2;
   bt_col
------------
 \xdeadbeef
 \xdeadbeef
 \xdeadbeef
 \xdeadbeef
(4 rows)
```

- Do not repeatedly export data from the same foreign table. Otherwise, the previously exported file will be overwritten.
- If you are not sure whether the file is in the standard CSV format, you are advised to set **quote** parameter to invisible characters such as **0x07**, **0x08**, or **0x1b** to import and export data using GDS. This prevents task failures caused by incorrect file format.

```
CREATE FOREIGN TABLE foreign_HR_staffS_ft1
(
  MANAGER_ID     NUMBER(6),
  section_ID     NUMBER(4)
) SERVER gsmpp_server OPTIONS (location 'file:///input_data/*', format 'csv', mode 'private', quote
'0x07', delimiter ',') WITH err_HR_staffS_ft1;
```

- GDS supports concurrent import and export. The **gds -t** parameter is used to set the size of the thread pool and control the maximum number of concurrent working threads. But it does not accelerate a single SQL task. The default value of **gds -t** is **8**, and the upper limit is **200**. When using the pipe function to import and export data, ensure that the value of **-t** is greater than or equal to the number of concurrent services.
- If the delimiter of a GDS foreign table consists of multiple characters, do not use the same characters in the TEXT format, for example **---**.
- GDS imports a single file through multiple tables in parallel to improve data import performance. (Only CSV and TXT files can be imported.)

```
-- Create a target table.
CREATE TABLE pipegds_widetb_1 (city integer, tel_num varchar(16), card_code  varchar(15),
phone_code vcreate table pipegds_widetb_3 (city integer, tel_num varchar(16), card_code varchar(15),
phone_code varchar(16), region_code varchar(6), station_id varchar(10), tmsi varchar(20), rec_date
integer(6), rec_time integer(6), rec_type numeric(2), switch_id  varchar(15), attach_city varchar(6),
opc varchar(20), dpc varchar(20));

-- Create a foreign table that contains the file_sequence column.
CREATE FOREIGN TABLE gds_pip_csv_r_1( like pipegds_widetb_1) SERVER gsmpp_server  OPTIONS
(LOCATION 'gsfs://127.0.0.1:8781/wide_tb.txt', FORMAT 'text', DELIMITER E'|+|', NULL '', file_sequence
'5-1');
```

```
CREATE FOREIGN TABLE gds_pip_csv_r_2( like pipegds_widetb_1) SERVER gsmpp_server  OPTIONS
(LOCATION 'gsfs://127.0.0.1:8781/wide_tb.txt', FORMAT 'text', DELIMITER E'|+|', NULL '', file_sequence
'5-2');

CREATE FOREIGN TABLE gds_pip_csv_r_3( like pipegds_widetb_1) SERVER gsmpp_server  OPTIONS
(LOCATION 'gsfs://127.0.0.1:8781/wide_tb.txt', FORMAT 'text', DELIMITER E'|+|', NULL '', file_sequence
'5-3');

CREATE FOREIGN TABLE gds_pip_csv_r_4( like pipegds_widetb_1) SERVER gsmpp_server  OPTIONS
(LOCATION 'gsfs://127.0.0.1:8781/wide_tb.txt', FORMAT 'text', DELIMITER E'|+|', NULL '', file_sequence
'5-4');

CREATE FOREIGN TABLE gds_pip_csv_r_5( like pipegds_widetb_1) SERVER gsmpp_server  OPTIONS
(LOCATION 'gsfs://127.0.0.1:8781/wide_tb.txt', FORMAT 'text', DELIMITER E'|+|', NULL '', file_sequence
'5-5');

-- Import the wide_tb.txt file to the pipegds_widetb_1 table in parallel.
\parallel on
INSERT INTO pipegds_widetb_1 SELECT * FROM gds_pip_csv_r_1;
INSERT INTO pipegds_widetb_1 SELECT * FROM gds_pip_csv_r_2;
INSERT INTO pipegds_widetb_1 SELECT * FROM gds_pip_csv_r_3;
INSERT INTO pipegds_widetb_1 SELECT * FROM gds_pip_csv_r_4;
INSERT INTO pipegds_widetb_1 SELECT * FROM gds_pip_csv_r_5;
\parallel off
```

For details about **file_sequence**, see **CREATE FOREIGN TABLE (for GDS Import and Export)**.

1.3 Tutorial: Importing Data from OBS to a Cluster

Overview

This practice demonstrates how to upload sample data to OBS and import OBS data to the target table on GaussDB(DWS), helping you quickly learn how to import data from OBS to a GaussDB(DWS) cluster.

You can import data in TXT, CSV, ORC, PARQUET, CARBONDATA, or JSON format from OBS to a GaussDB(DWS) cluster for query.

This tutorial uses the CSV format as an example to describe how to perform the following operations:

- Generate data files in CSV format.
- Create an OBS bucket in the same region as the GaussDB(DWS) cluster, and upload data files to the OBS bucket.
- Create a foreign table to import data from the OBS bucket to GaussDB(DWS) clusters.
- Start GaussDB(DWS), create a table, and import data from OBS to the table.
- Analyze import errors based on the information in the error table and correct these errors.

Estimated time: 30 minutes

Preparing Source Data Files

- Data file **product_info0.csv**

```
100,XHDK-A,2017-09-01,A,2017 Shirt Women,red,M,328,2017-09-04,715,good!
205,KDKE-B,2017-09-01,A,2017 T-shirt Women,pink,L,584,2017-09-05,40,very good!
300,JODL-X,2017-09-01,A,2017 T-shirt men,red,XL,15,2017-09-03,502,Bad.
```

```
310,QQPX-R,2017-09-02,B,2017 jacket women,red,L,411,2017-09-05,436,It's nice.
150,ABEF-C,2017-09-03,B,2017 Jeans Women,blue,M,123,2017-09-06,120,good.
```

- Data file **product_info1.csv**

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

- Data file **product_info2.csv**

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

Step 1 Create a text file, open it using a local editing tool (for example, Visual Studio Code), and copy the sample data to the text file.

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

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

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

----End

Uploading Data to OBS

Step 1 Store the three CSV source data files in the OBS bucket.

1. Log in to the OBS management console.

   Click **Service List** and choose **Object Storage Service** to open the OBS management console.

2. Create a bucket.

   For details about how to create an OBS bucket, see **Creating a Bucket** in Getting Started in Object Storage Service.

   For example, create two buckets named **mybucket** and **mybucket02**.

   NOTICE

   Ensure that the two buckets are in the same region as the GaussDB(DWS) cluster. This practice uses the EU-Dublin region as an example.

3. Create a folder.

   For details, see "Creating a Folder" in the *Object Storage Service Usage Guide*

   Examples:

   – Create a folder named **input_data** in the **mybucket** OBS bucket.

   - Create a folder named **input_data** in the **mybucket02** OBS bucket.

4. Upload the files.

   For details, see "Uploading a File" in the *Object Storage Service Usage Guide*.

   Examples:

   - Upload the following data files to the **input_data** folder in the **mybucket** OBS bucket:
     ```
     product_info0.csv
     product_info1.csv
     ```
   - Upload the following data file to the **input_data** folder in the **mybucket02** OBS bucket:
     ```
     product_info2.csv
     ```

Step 2 Grant the OBS bucket read permission for the user who will import data.

When importing data from OBS to a cluster, the user must have the read permission for the OBS buckets where the source data files are located. You can configure the ACL for the OBS buckets to grant the read permission to a specific user.

----End

Creating a Foreign Table

Step 1 Connect to the GaussDB(DWS) database.

Step 2 Create a foreign table.

NOTE

- ACCESS_KEY and SECRET_ACCESS_KEY

  These parameters specify the AK and SK used to access OBS by a user. Replace them with the actual AK and SK.

  To obtain an access key, log in to the management console, move the cursor to the username in the upper right corner, click **My Credential**, and click **Access Keys** in the navigation pane on the left. On the **Access Keys** page, you can view the existing access key IDs (AKs). To obtain both the AK and SK, click **Create Access Key** to create and download an access key.
- // Hard-coded or plaintext AK and SK are risky. For security purposes, encrypt your AK and SK and store them in the configuration file or environment variables.

```
DROP FOREIGN TABLE IF EXISTS product_info_ext;
CREATE FOREIGN TABLE product_info_ext
(
    product_price                integer        not null,
    product_id                   char(30)       not null,
    product_time                 date           ,
    product_level                char(10)       ,
    product_name                 varchar(200)   ,
    product_type1                varchar(20)    ,
    product_type2                char(10)       ,
    product_monthly_sales_cnt    integer        ,
    product_comment_time         date           ,
    product_comment_num          integer        ,
    product_comment_content      varchar(200)
)
SERVER gsmpp_server
OPTIONS(
LOCATION 'obs://mybucket/input_data/product_info | obs://mybucket02/input_data/product_info',
```

```
FORMAT 'CSV' ,
DELIMITER ',',
ENCODING 'utf8',
HEADER 'false',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
FILL_MISSING_FIELDS 'true',
IGNORE_EXTRA_DATA 'true'
)
READ ONLY
LOG INTO product_info_err
PER NODE REJECT LIMIT 'unlimited';
```

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

```
CREATE FOREIGN TABLE
```

----End

Importing Data

Step 1 Create a table named **product_info** in the GaussDB(DWS) database to store the data imported from OBS.

```
DROP TABLE IF EXISTS product_info;
CREATE TABLE product_info
(
    product_price                integer        not null,
    product_id                   char(30)       not null,
    product_time                 date           ,
    product_level                char(10)       ,
    product_name                 varchar(200)   ,
    product_type1                varchar(20)    ,
    product_type2                char(10)       ,
    product_monthly_sales_cnt    integer        ,
    product_comment_time         date           ,
    product_comment_num          integer        ,
    product_comment_content      varchar(200)
)
WITH (
orientation = column,
compression=middle
)
DISTRIBUTE BY hash (product_id);
```

Step 2 Run **INSERT** to import data from OBS to the target table **product_info** through the foreign table **product_info_ext**.

```
INSERT INTO product_info SELECT * FROM product_info_ext;
```

Step 3 Run **SELECT** to view the data imported from OBS to GaussDB(DWS).

```
SELECT * FROM product_info;
```

The following information is displayed at the end of the query result:

```
(20 rows)
```

Step 4 Run **VACUUM FULL** on the **product_info** table.

```
VACUUM FULL product_info;
```

Step 5 Update statistics of the **product_info** table.

```
ANALYZE product_info;
```

----End

Deleting Resources

Step 1 If you have performed queries after importing data, run the following statement to delete the target table:

```
DROP TABLE product_info;
```

If the following output is displayed, the foreign table has been deleted:

```
DROP TABLE
```

Step 2 Run the following statement to delete the foreign table:

```
DROP FOREIGN TABLE product_info_ext;
```

If the following output is displayed, the foreign table has been deleted:

```
DROP FOREIGN TABLE
```

----End

1.4 Tutorial: Using GDS to Import Data from a Remote Server

Overview

This practice demonstrates how to use General Data Service (GDS) to import data from a remote server to GaussDB(DWS).

GaussDB(DWS) allows you to import data in TXT, CSV, or FIXED format.

In this tutorial, you will:

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

Preparing an ECS as the GDS Server

For details about how to purchase a Linux ECS, see section "Purchasing an ECS" in the *Elastic Cloud Server Getting Started*. After the purchase, log in to the ECS by referring to section "Logging In to a Linux ECS".

NOTE

- The ECS OS must be supported by the GDS package.
- The ECS and DWS are in the same region, VPC, and subnet.
- The ECS security group rule must allow access to the DWS cluster, that is, the inbound rule of the security group is as follows:
  - **Protocol**: **TCP**
  - **Port**: **5000**
  - **Source**: Select **IP Address** and enter the IP address of the GaussDB(DWS) cluster, for example, **192.168.0.10/32**.
- If the firewall is enabled in the ECS, ensure that the listening port of GDS is enabled on the firewall:

  ```
  iptables  -I INPUT -p tcp -m tcp --dport <gds_port> -j ACCEPT
  ```

Downloading the GDS Package

Step 1 Log in to the GaussDB(DWS) console.

Step 2 In the navigation tree on the left, click **Connections**.

Step 3 Select the GDS client of the corresponding version from the drop-down list of **CLI Client**.

Select a version based on the cluster version and the OS where the client is installed.

NOTE

The CPU architecture of the client must be the same as that of the cluster. If the cluster uses the x86 specifications, select the x86 client.

Step 4 Click **Download**.

----End

Preparing Source Data Files

- Data file **product_info0.csv**

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

- Data file **product_info1.csv**

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

- Data file **product_info2.csv**

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

```
70,"HWNB-P",2017-09-27,"B","2017 jacket women","red","L",30,2017-09-30,55,"I like it so much"
80,"JKHU-Q",2017-09-29,"C","2017 T-shirt","red","M",90,2017-10-02,82,"very good."
```

Step 1 Create a text file, open it using a local editing tool (for example, Visual Studio Code), and copy the sample data to the text file.

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

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

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

Step 5 Log in to the GDS server as user **root**.

Step 6 Create the **/input_data** directory for storing the data file.

```
mkdir -p /input_data
```

Step 7 Use MobaXterm to upload source data files to the created directory.

----End

Installing and Starting GDS

Step 1 Log in to the GDS server as user **root** and create the **/opt/bin/dws** directory for storing the GDS package.

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

Step 2 Upload the GDS package to the created directory.

For example, upload the **dws_client_8.1.*x*_redhat_x64.zip** package to the created directory.

Step 3 Go to the directory and decompress the package.

```
cd /opt/bin/dws
unzip dws_client_8.1.x_redhat_x64.zip
```

Step 4 Create a user (**gds_user**) and the user group (**gdsgrp**) to which the user belongs. This user is used to start GDS and must have the permission to read the source data file directory.

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

Step 5 Change the owner of the GDS package and source data file directory to **gds_user** and change the user group to **gdsgrp**.

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

Step 6 Switch to user **gds_user**.

```
su - gds_user
```

If the current cluster version is 8.0.*x* or earlier, skip **Step 7** and go to **Step 8**.

If the current cluster version is 8.1.*x* or later, go to the next step.

Step 7 Execute the script on which the environment depends (applicable only to 8.1.*x*).

```
cd /opt/bin/dws/gds/bin
source gds_env
```

Step 8 Start GDS.

```
/opt/bin/dws/gds/bin/gds -d /input_data/ -p 192.168.0.90:5000 -H 10.10.0.1/24 -l /opt/bin/dws/gds/
gds_log.txt -D
```

Replace the italic parts as required.

- **-d** *dir*: directory for storing data files that contain data to be imported. This practice uses **/input_data/** as an example.
- **-p** *ip:port*: listening IP address and port for GDS. The default value is **127.0.0.1**. Replace it with the IP address of a 10GE network that can communicate with GaussDB(DWS). The port number ranges from 1024 to 65535. The default value is **8098**. This practice uses **192.168.0.90:5000** as an example.
- **-H** *address_string*: hosts that are allowed to connect to and use GDS. The value must be in CIDR format. Set this parameter to enable a GaussDB(DWS) cluster to access GDS for data import. Ensure that the network segment covers all hosts in a GaussDB(DWS) cluster.
- **-l** *log_file*: GDS log directory and log file name. This practice uses **/opt/bin/dws/gds/gds_log.txt** as an example.
- **-D**: GDS in daemon mode. This parameter is used only in Linux.

----End

Creating a Foreign Table

Step 1 Use an SQL client to connect to the GaussDB(DWS) database.

Step 2 Create the following foreign table:

⚠ CAUTION

LOCATION: Replace it with the actual GDS address and port number.

```
DROP FOREIGN TABLE IF EXISTS product_info_ext;
CREATE FOREIGN TABLE product_info_ext
(
    product_price                integer        not null,
    product_id                   char(30)       not null,
    product_time                 date           ,
    product_level                char(10)       ,
    product_name                 varchar(200)   ,
    product_type1                varchar(20)    ,
    product_type2                char(10)       ,
    product_monthly_sales_cnt    integer        ,
    product_comment_time         date           ,
    product_comment_num          integer        ,
    product_comment_content      varchar(200)
)
SERVER gsmpp_server
OPTIONS(
LOCATION 'gsfs://192.168.0.90:5000/*',
FORMAT 'CSV' ,
DELIMITER ',',
ENCODING 'utf8',
HEADER 'false',
FILL_MISSING_FIELDS 'true',
IGNORE_EXTRA_DATA 'true'
)
READ ONLY
LOG INTO product_info_err
PER NODE REJECT LIMIT 'unlimited';
```

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

```
CREATE FOREIGN TABLE
```

----End

Importing Data

Step 1 Run the following statements to create the **product_info** table in GaussDB(DWS) to store imported data:

```
DROP TABLE IF EXISTS product_info;
CREATE TABLE product_info
(
    product_price                integer        not null,
    product_id                   char(30)       not null,
    product_time                 date           ,
    product_level                char(10)       ,
    product_name                 varchar(200)   ,
    product_type1                varchar(20)    ,
    product_type2                char(10)       ,
    product_monthly_sales_cnt    integer        ,
    product_comment_time         date           ,
    product_comment_num          integer        ,
    product_comment_content      varchar(200)
)
WITH (
orientation = column,
compression=middle
)
DISTRIBUTE BY hash (product_id);
```

Step 2 Import data from source data files to the **product_info** table through the foreign table **product_info_ext**.

```
INSERT INTO product_info SELECT * FROM product_info_ext ;
```

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

```
INSERT 0 20
```

Step 3 Run the **SELECT** statement to view the data imported to GaussDB(DWS).

```
SELECT count(*) FROM product_info；
```

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

```
count
-------
     20
(1 row)
```

Step 4 Run **VACUUM FULL** on the **product_info** table.

```
VACUUM FULL product_info
```

Step 5 Update statistics of the **product_info** table.

```
ANALYZE product_info;
```

----End

Stopping GDS

Step 1 Log in to the data server where GDS is installed as user **gds_user**.

Step 2 Perform the following operations to stop GDS:

1. Query the GDS process ID. The GDS process ID is 128954.

```
ps -ef|grep gds
gds_user 128954      1  0 15:03 ?        00:00:00 gds -d /input_data/ -p 192.168.0.90:5000 -
l /opt/bin/gds/gds_log.txt  -D
gds_user 129003 118723  0 15:04 pts/0    00:00:00 grep gds
```

2. Run the **kill** command to stop GDS. **128954** indicates the GDS process ID.

```
kill -9 128954
```

----End

Deleting Resources

Step 1 Run the following command to delete the target table **product_info**:

```
DROP TABLE product_info;
```

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

```
DROP TABLE
```

Step 2 Run the following command to delete the foreign table **product_info_ext**:

```
DROP FOREIGN TABLE product_info_ext;
```

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

```
DROP FOREIGN TABLE
```

----End

1.5 Tutorial: Importing Remote GaussDB(DWS) Data Sources

In the era of big data convergent analysis, GaussDB(DWS) clusters in the same region can communicate with each other. This practice demonstrates how to import data from a remote GaussDB(DWS) cluster to the local GaussDB(DWS) cluster using foreign tables.

The demonstration procedure is as follows: Install the gsql database client on an ECS, connect to GaussDB(DWS) using gsql, and import data from the remote GaussDB(DWS) using a foreign table.

General Procedure

This practice takes about 40 minutes. The basic process is as follows:

1. **Preparations**
2. **Creating an ECS**
3. **Creating a Cluster and Downloading the Tool Package**
4. **Importing Data Sources Using GDS**
5. **Importing Remote GaussDB(DWS) Data Using a Foreign Table**

Preparations

You have registered a Huawei account and enabled Huawei Cloud. The account cannot be in arrears or frozen.

Creating an ECS

For details about how to purchase a Linux ECS, see section "Purchasing an ECS" in the *Elastic Cloud Server Getting Started*. After the purchase, log in to the ECS by referring to section "Logging In to a Linux ECS".

NOTICE

When creating an ECS, ensure that the ECS and the GaussDB(DWS) clusters to be created are in the same VPC subnet and in the same region and AZ . The ECS OS is the same as that of the gsql client or GDS (CentOS 7.6 is used as an example), and the password is used for login.

Creating a Cluster and Downloading the Tool Package

Step 1 Log in to the Huawei Cloud management console.

Step 2 Choose **Service List** > **EI Enterprise IntelligenceAnalytics** > **Data Warehouse Service**. On the page that is displayed, click **Create Cluster** in the upper right corner.

Step 3 Configure the parameters according to **Table 1-1**.

Table 1-1 Software configuration

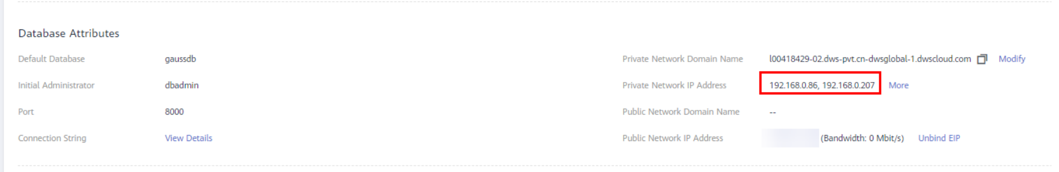
Parameter	Configuration
Region	Select EU-Dublin. **NOTE** ● EU-Dublin is used as an example. You can select other regions as required. Ensure that all operations are performed in the same region. ● Ensure that GaussDB(DWS) and the ECS are in the same region, AZ, and VPC subnet.
AZ	AZ2
Resource	Standard data warehouse
Compute Resource	ECS
Storage Type	Cloud SSD
CPU Architecture	x86
Node Flavor	dws2.m6.4xlarge.8 (16 vCPUs | 128 GB | 2000 GB SSD) **NOTE** If this flavor is sold out, select other AZs or flavors.
Hot Storage	100 GB/node

Parameter	Configuration
Nodes	3
Cluster Name	dws-demo01
Administrator Account	dbadmin
Administrator Password	User-defined password
Confirm Password	password
Database Port	8000
VPC	vpc-default
Subnet	subnet-default(192.168.0.0/24) **NOTICE** Ensure that the cluster and the ECS are in the same VPC subnet.
Security Group	Automatic creation
EIP	Buy now
Bandwidth	1 Mbit/s
Advanced Settings	Default

Step 4 Confirm the information, click **Next**, and then click **Submit**.

Step 5 Wait for about 10 minutes. After the cluster is created, click the cluster name to go to the **Basic Information** page. Choose **Network**, click a security group name, and verify that a security group rule has been added. In this example, the client IP address is 192.168.0.*x* (the private network IP address of the ECS where gsql is located is 192.168.0.90). Therefore, you need to add a security group rule in which the IP address is 192.168.0.0/24 and port number is 8000.

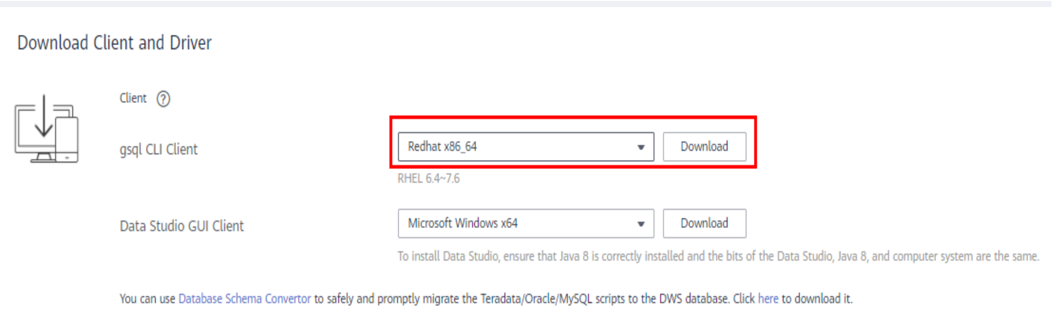
Step 6 Return to the **Basic Information** tab of the cluster and record the value of **Private Network IP Address**.



Database Attributes

Default Database	gaussdb	Private Network Domain Name	l00418429-02.dws-pvt.cn-dwsglobal-1.dwscloud.com Modify
Initial Administrator	dbadmin	Private Network IP Address	192.168.0.86, 192.168.0.207 More
Port	8000	Public Network Domain Name	--
Connection String	View Details	Public Network IP Address	[redacted] (Bandwidth: 0 Mbit/s) Unbind EIP

Step 7 Return to the homepage of the GaussDB(DWS) console. Choose **Connections** in the navigation pane on the left, select the ECS OS (for example, select **Redhat x86_64** for CentOS 7.6), and click **Download** to save the tool package to the local host. The tool package contains the gsql client and GDS.



Download Client and Driver

Client ?

gsql CLI Client: Redhat x86_64 ▾ Download

RHEL 6.4~7.6

Data Studio GUI Client: Microsoft Windows x64 ▾ Download

To install Data Studio, ensure that Java 8 is correctly installed and the bits of the Data Studio, Java 8, and computer system are the same.

You can use Database Schema Convertor to safely and promptly migrate the Teradata/Oracle/MySQL scripts to the DWS database. Click here to download it.

Step 8 Repeat **Step 1** to **Step 6** to create a second GaussDB(DWS) cluster and set its name to **dws-demo02**.

----End

Preparing Source Data

Step 1 Create the following three CSV files in the specified directory on the local PC:

- Data file **product_info0.csv**

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

- Data file **product_info1.csv**

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

- Data file **product_info2.csv**

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

Step 2 Log in to the created ECS as user **root** and run the following command to create a data source file directory:

mkdir -p /input_data

Step 3 Use a file transfer tool to upload the preceding data files to the **/input_data** directory of the ECS.

----End

Importing Data Sources Using GDS

Step 1 Log in to the ECS as user **root** and use a file transfer tool to upload the downloaded tool package in **Step 7** to the **/opt** directory.

Step 2 Decompress the tool package in the **/opt** directory.

cd /opt

unzip dws_client_8.1.x_redhat_x64.zip

Step 3 Create a GDS user and change the owners of the data source and GDS directories.

groupadd gdsgrp

useradd -g gdsgrp gds_user

chown -R gds_user:gdsgrp /opt/gds

chown -R gds_user:gdsgrp /input_data

Step 4 Switch to user **gds_user**.

su - gds_user

Step 5 Import the GDS environment variables.

NOTE

This step is required only for 8.1.*x* or later. For earlier versions, skip this step.

cd /opt/gds/bin

source gds_env

Step 6 Start GDS.

/opt/gds/bin/gds -d /input_data/ -p *192.168.0.90:5000* **-H** 192.168.0.0/24 **-l /opt/gds/gds_log.txt -D**

- **-d** *dir*: directory for storing data files that contain data to be imported. This practice uses **/input_data/** as an example.
- **-p** *ip:port*: listening IP address and port for GDS. Set this parameter to the private network IP address of the ECS where GDS is installed so that GDS can communicate with GaussDB(DWS). In this example, **192.168.0.90:5000** is used.
- **-H** *address_string*: hosts that are allowed to connect to and use GDS. The value must be in CIDR format. In this example, the network segment of the GaussDB(DWS) private network IP address is used.
- **-l** *log_file*: GDS log directory and log file name. In this example, **/opt/gds/gds_log.txt** is used.
- **-D**: GDS in daemon mode.

Step 7 Connect to the first GaussDB(DWS) cluster using gsql.

1. Run the **exit** command to switch to user **root**, go to the **/opt** directory of the ECS, and import the environment variables of gsql.

   exit

   cd /opt

source gsql_env.sh

2. Go to the **/opt/bin** directory and connect to the first GaussDB(DWS) cluster using gsql.

   cd /opt/bin

   gsql -d gaussdb -h 192.168.0.8 -p 8000 -U dbadmin -W *password* -r

   - **-d**: name of the connected database. In this example, the default database **gaussdb** is used.
   - **-h**: private network IP address of the connected GaussDB(DWS) database queried in **Step 6**. In this example, **192.168.0.8** is used.
   - **-p**: GaussDB(DWS) port. The value is **8000**.
   - **-U**: database administrator. The value defaults to **dbadmin**.
   - **-W**: administrator password, which is set during cluster creation in **Step 3**. In this example, replace *password* with your actual password.

Step 8 Create a common user **leo** and grant the user the permission for creating foreign tables.

```
CREATE USER leo WITH PASSWORD 'password';
ALTER USER leo USEFT;
```

Step 9 Switch to user **leo** and create a GDS foreign table.

NOTE

Set **LOCATION** to the GDS listening IP address and port number obtained in **Step 6**, for example, **gsfs://192.168.0.90:5000/***.

```
SET ROLE leo PASSWORD 'password';
DROP FOREIGN TABLE IF EXISTS product_info_ext;
CREATE FOREIGN TABLE product_info_ext
(
   product_price                integer        not null,
   product_id                   char(30)       not null,
   product_time                 date           ,
   product_level                char(10)       ,
   product_name                 varchar(200)   ,
   product_type1                varchar(20)    ,
   product_type2                char(10)       ,
   product_monthly_sales_cnt    integer        ,
   product_comment_time         date           ,
   product_comment_num          integer        ,
   product_comment_content      varchar(200)
)
SERVER gsmpp_server
OPTIONS(
LOCATION 'gsfs://192.168.0.90:5000/*',
FORMAT 'CSV' ,
DELIMITER ',',
ENCODING 'utf8',
HEADER 'false',
FILL_MISSING_FIELDS 'true',
IGNORE_EXTRA_DATA 'true'
)
READ ONLY
LOG INTO product_info_err
PER NODE REJECT LIMIT 'unlimited';
```

Step 10 Create a local table.

```
DROP TABLE IF EXISTS product_info;
CREATE TABLE product_info
(
   product_price                integer        not null,
   product_id                  char(30)       not null,
   product_time                 date           ,
   product_level               char(10)       ,
   product_name                  varchar(200)   ,
   product_type1                varchar(20)    ,
   product_type2                char(10)       ,
   product_monthly_sales_cnt    integer        ,
   product_comment_time         date           ,
   product_comment_num          integer        ,
   product_comment_content      varchar(200)
)
WITH (
orientation = column,
compression=middle
)
DISTRIBUTE BY hash (product_id);
```

Step 11 Import data from the GDS foreign table and check whether the data is successfully imported.

```
INSERT INTO product_info SELECT * FROM product_info_ext ;
SELECT count(*) FROM product_info;
```

----End

Importing Remote GaussDB(DWS) Data Using a Foreign Table

Step 1 Connect to the second cluster on the ECS by referring to **Step 7**. Change the connection address to the address of the second cluster. In this example, **192.168.0.86** is used.

Step 2 Create a common user **jim** and grant the user the permission for creating foreign tables and servers. The value of **FOREIGN DATA WRAPPER** is **gc_fdws**.

```
CREATE USER jim WITH PASSWORD 'password';
ALTER USER jim USEFT;
GRANT ALL ON FOREIGN DATA WRAPPER gc_fdw TO jim;
```

Step 3 Switch to user **jim** and create a server.

```
SET ROLE jim PASSWORD 'password';
CREATE SERVER server_remote FOREIGN DATA WRAPPER gc_fdw OPTIONS
   (address '192.168.0.8:8000,192.168.0.158:8000' ,
  dbname 'gaussdb',
  username 'leo',
  password 'password'
);
```

- **address**: private network IP addresses and port number of the first cluster obtained in **Step 6**. In this example, **192.168.0.8:8000** and **192.168.0.158:8000** are used.
- **dbname**: database name of the first connected cluster. In this example, **gaussdb** is used.
- **username**: username of the first connected cluster. In this example, **leo** is used.
- **password**: user password

Step 4 Create a foreign table.

NOTICE

The columns and constraints of the foreign table must be consistent with those of the table to be accessed.

```
CREATE FOREIGN TABLE region
(
    product_price                integer      ,
    product_id                   char(30)       ,
    product_time                 date           ,
    product_level                char(10)       ,
    product_name                 varchar(200)   ,
    product_type1                varchar(20)    ,
    product_type2                char(10)       ,
    product_monthly_sales_cnt    integer        ,
    product_comment_time         date           ,
    product_comment_num          integer        ,
    product_comment_content      varchar(200)
)
SERVER
    server_remote
OPTIONS
(
    schema_name 'leo',
    table_name 'product_info',
    encoding 'utf8'
);
```

- **SERVER**: name of the server created in the previous step. In this example, **server_remote** is used.
- **schema_name**: schema name of the first cluster to be accessed. In this example, **leo** is used.
- **table_name**: table name of the first cluster to be accessed obtained in **Step 10**. In this example, **product_info** is used.
- **encoding**: The value must be the same as that of the first cluster obtained in **Step 9**. In this example, **utf8** is used.

Step 5 View the created server and foreign table.

```
\des+ server_remote
\d+ region
```

Step 6 Create a local table.

NOTICE

The columns and constraints of the table must be consistent with those of the table to be accessed.

```
CREATE TABLE local_region
(
    product_price                integer        not null,
    product_id                   char(30)       not null,
    product_time                 date           ,
    product_level                char(10)       ,
    product_name                 varchar(200)   ,
    product_type1                varchar(20)    ,
    product_type2                char(10)       ,
    product_monthly_sales_cnt    integer        ,
    product_comment_time         date           ,
    product_comment_num          integer        ,
    product_comment_content      varchar(200)
)

WITH (
orientation = column,
compression=middle
)
DISTRIBUTE BY hash (product_id);
```

Step 7 Import data to the local table using the foreign table.

```
INSERT INTO local_region SELECT * FROM region;
SELECT * FROM local_region;
```

Step 8 Query the foreign table without importing data.

```
SELECT * FROM region;
```

----End

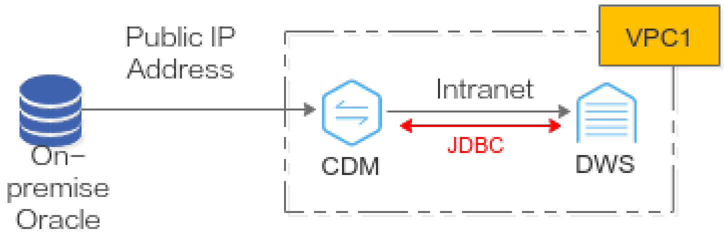
2 Data Migration

2.1 Migrating Data From Oracle to GaussDB(DWS)

2.1.1 Migration Process

This tutorial demonstrates how to migrate Oracle table data to GaussDB(DWS). **Figure 2-2** and **Table 2-1** show the migration process.

Figure 2-1 Migration scenario



NOTICE

- This practice describes how to migrate data in the **APEX2_DYNAMIC_ADD_REMAIN_TEST** table of user **db_user01** in the Oracle database.
- Network connection: In this practice, the Oracle database is deployed on-premises, so CDM is used to connect Oracle to GaussDB(DWS). CDM connects to Oracle via a public IP address. CDM and GaussDB(DWS) are in the same region and VPC and can communicate with each other. **Ensure that all the network is connected during the migration.**
- This practice is for reference only. The actual migration may be complex due to factors such as the network environment, service complexity, node scale, and data volume. It is better to perform the migration under the guidance of technical personnel.

Figure 2-2 Basic process of migrating data from Oracle to GaussDB(DWS)

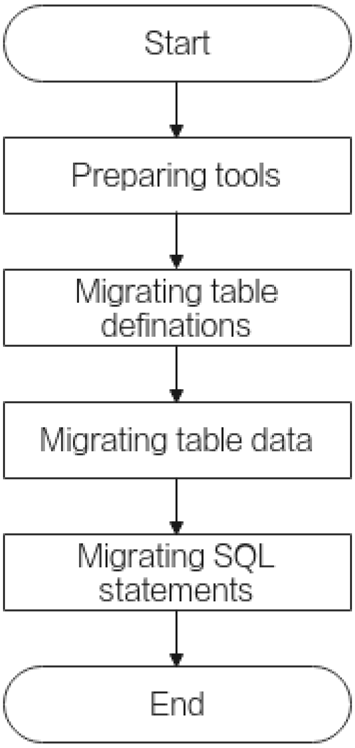


Table 2-1 Basic process of migrating data from Oracle to GaussDB(DWS)

Process	Description
Required Tools	Software tools to be prepared before the migration.
Migrating Table Definitions	Use the PL/SQL Developer to migrate table definitions.
Migrating Full Table Data	Use Huawei Cloud Data Migration Service (CDM) to migrate data.
Migrating SQL Statements	Use the DSC syntax migration tool to rewrite the syntax so that the Oracle service SQL statements can be adapted to GaussDB(DWS).

2.1.2 Required Tools

The tools required for the migration include PL/SQL Developer, Instant Client, and DSC. For details about how to download the tools, see **Table 2-2**.

Table 2-2 Required tools

Tool	Description	Download Address
PL/SQL Developer	Oracle visual development tool	**PL/SQL Developer download address**

Tool	Description	Download Address
Oracle Instant Client	Oracle client	Instant Client download address
DSC	Syntax migration tool for GaussDB(DWS)	DSC Download Address

2.1.3 Migrating Table Definitions

2.1.3.1 Installing the PL/SQL Developer on the Local Host

Procedure

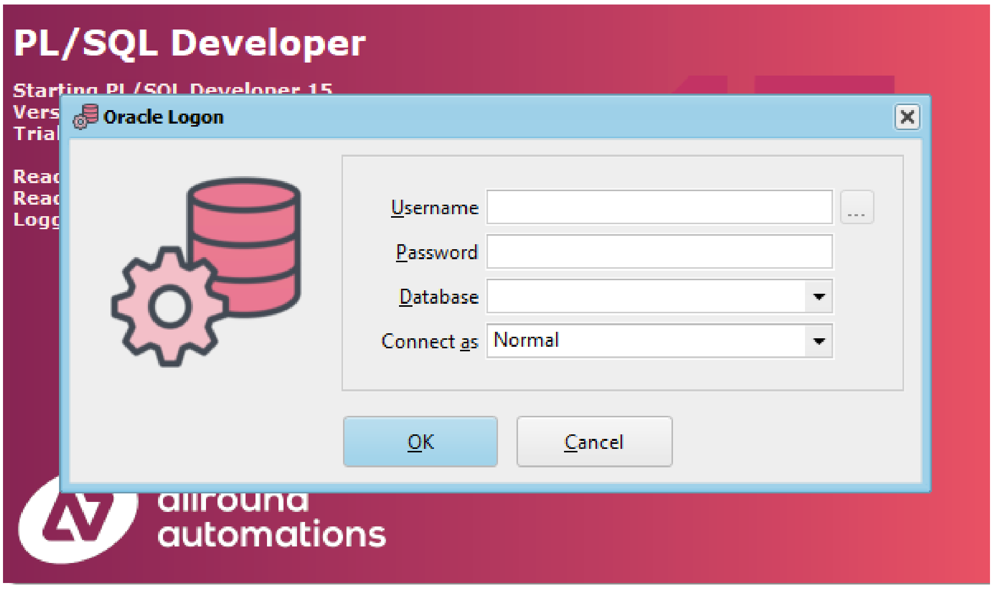
Step 1 Decompress the PL/SQL Developer, Instant Client, and DSC packages.

Step 2 Configure an Oracle home and OCL library for PL/SQL Developer.

NOTE

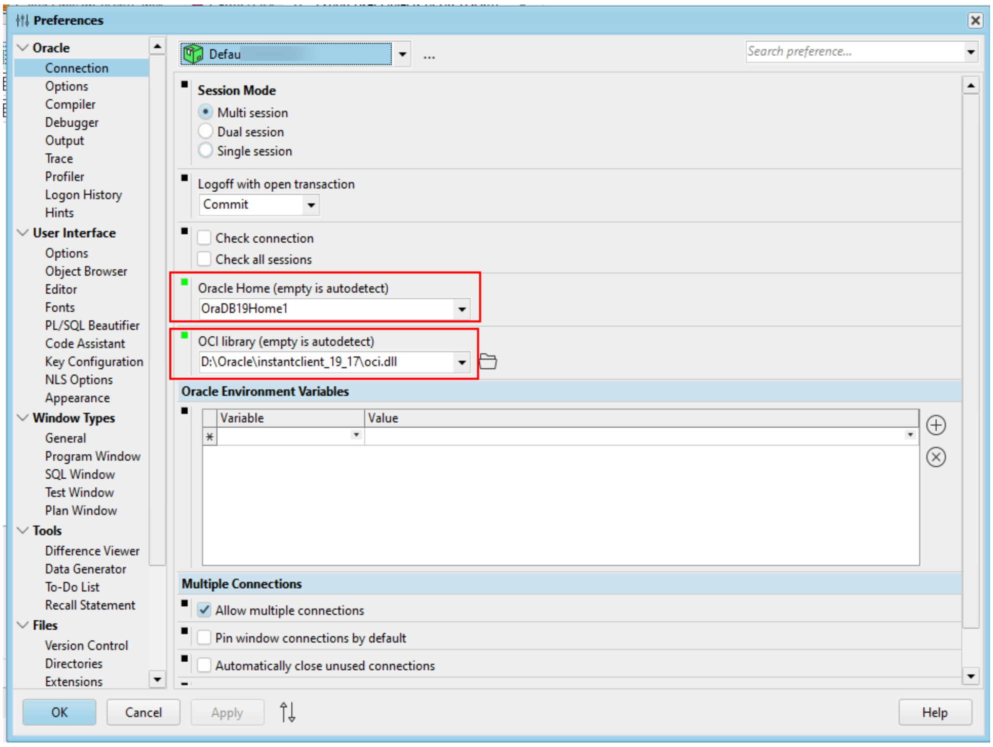
The following uses the PL/SQL Developer Trial Version as an example.

1. On the login page, click Cancel.



2. Choose **Configure** > **Preferences** > **Connection**, and add the Oracle Home and OCl library configurations.
3. Copy the instantclient path obtained from **Step 1** (for example, **D:\Oracle\instantclient_19_17\oci.dll**) to the home directory of the Oracle database.

   Copy the **oci.dll** file path (for example, **D:\Oracle\instantclient_19_17\oci.dll**) in the instantclient file to the OCI library.



Preferences

- Oracle
  - Connection
  - Options
  - Compiler
  - Debugger
  - Output
  - Trace
  - Profiler
  - Logon History
  - Hints
- User Interface
  - Options
  - Object Browser
  - Editor
  - Fonts
  - PL/SQL Beautifier
  - Code Assistant
  - Key Configuration
  - NLS Options
  - Appearance
- Window Types
  - General
  - Program Window
  - SQL Window
  - Test Window
  - Plan Window
- Tools
  - Difference Viewer
  - Data Generator
  - To-Do List
  - Recall Statement
- Files
  - Version Control
  - Directories
  - Extensions

Defau[redacted]

Session Mode
- ● Multi session
- ○ Dual session
- ○ Single session

Logoff with open transaction: Commit

- □ Check connection
- □ Check all sessions

Oracle Home (empty is autodetect): OraDB19Home1

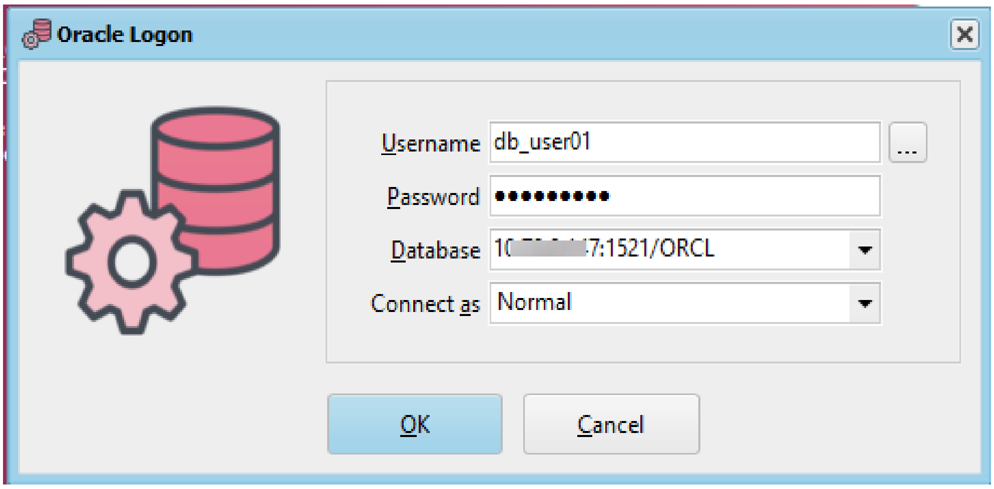
OCI library (empty is autodetect): D:\Oracle\instantclient_19_17\oci.dll

Oracle Environment Variables

Variable	Value

Multiple Connections
- ☑ Allow multiple connections
- □ Pin window connections by default
- □ Automatically close unused connections

Step 3 Go back to the PL/SQL Developer login page. Enter the username, password, and database address, for example, xx.xx.xx.xx:1521/ORCL.



Oracle Logon

Username: db_user01

Password: ●●●●●●●●●

Database: 10[redacted]7:1521/ORCL

Connect as: Normal

Step 4 Click **OK**. If the database is connected, it indicates that the PL/SQL Developer is installed successfully.

----End

2.1.3.2 Migrating Table Definitions and Syntax

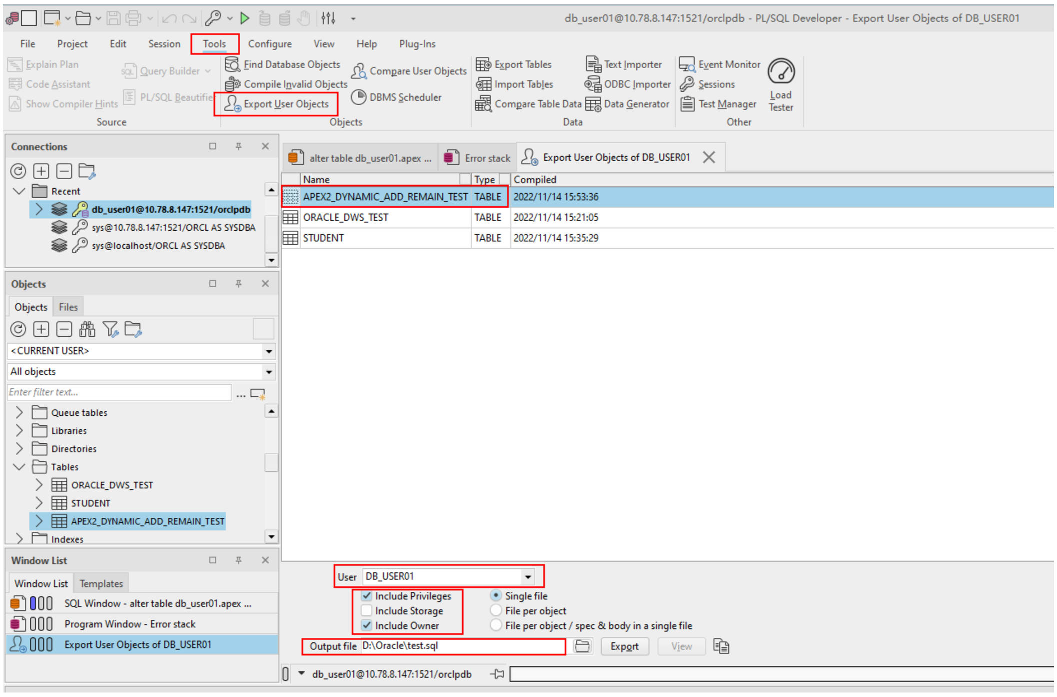
Step 1 Log in to the PL/SQL Developer use an account with the **sysdba** permission. In this example, the account **db_user01** is used.

NOTE

The following uses the PL/SQL Developer Trial Version as an example.

Step 2 On the menu bar, choose **Tools** > **Export User Objects**.

Step 3 Select the logged-in user **db_user01**, select the table object **APEX2_DYNAMIC_ADD_REMAIN_TEST** of the user, select the path to the output file (name the output SQL file as **test**), and click **Export**.



Name	Type	Compiled
APEX2_DYNAMIC_ADD_REMAIN_TEST	TABLE	2022/11/14 15:53:36
ORACLE_DWS_TEST	TABLE	2022/11/14 15:21:05
STUDENT	TABLE	2022/11/14 15:35:29

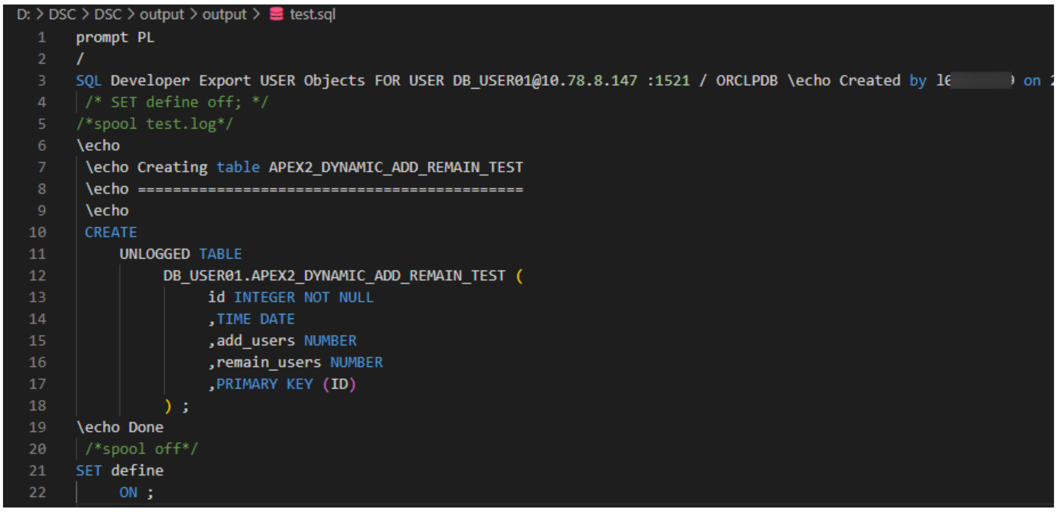
User DB_USER01

☑ Include Privileges
□ Include Storage
☑ Include Owner

● Single file
○ File per object
○ File per object / spec & body in a single file

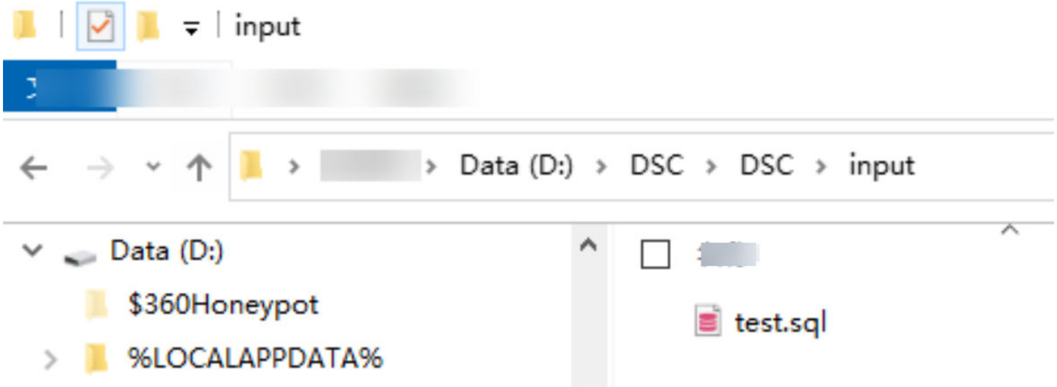
Output file D:\Oracle\test.sql

The exported DDL file is as follows:



```
prompt PL
/
SQL Developer Export USER Objects FOR USER DB_USER01@10.78.8.147 :1521 / ORCLPDB \echo Created by 1e[redacted]) on
 /* SET define off; */
/*spool test.log*/
\echo
 \echo Creating table APEX2_DYNAMIC_ADD_REMAIN_TEST
 \echo ==========================================
 \echo
 CREATE
     UNLOGGED TABLE
          DB_USER01.APEX2_DYNAMIC_ADD_REMAIN_TEST (
               id INTEGER NOT NULL
               ,TIME DATE
               ,add_users NUMBER
               ,remain_users NUMBER
               ,PRIMARY KEY (ID)
          ) ;
\echo Done
 /*spool off*/
SET define
     ON ;
```

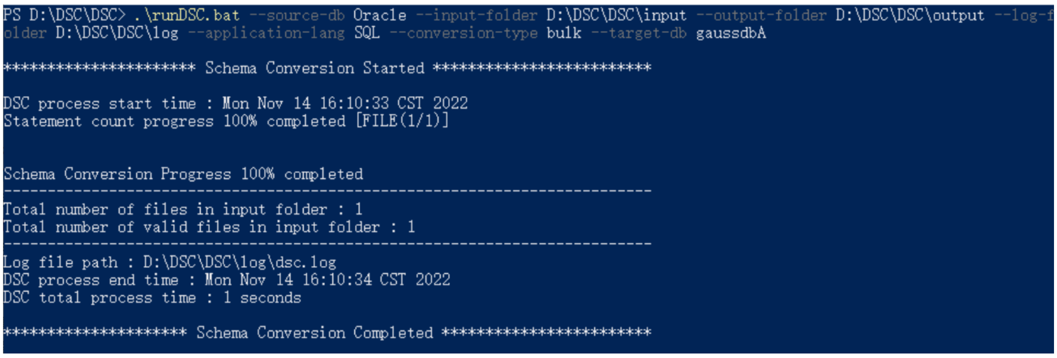
Step 4 Place the exported DDL file in the **input** directory of the decompressed DSC folder.



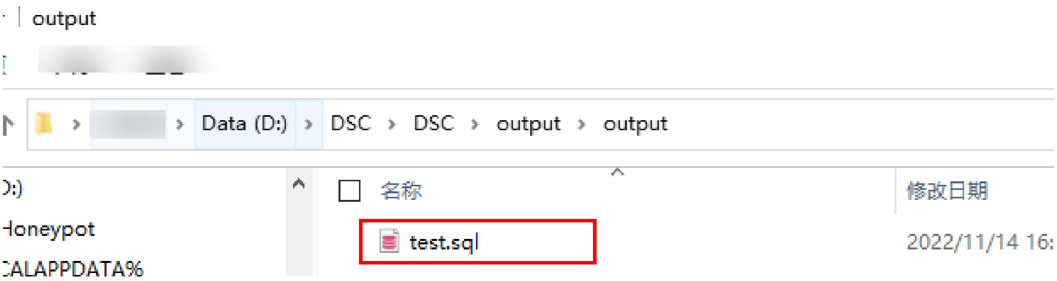
Step 5 In the directory of runDSC.bat, press Shift and right-click. Choose **Open PowerShell window here** and perform the conversion. Replace **D:\DSC\DSC\input**, **D:\DSC\DSC\output**, and **D:\DSC\DSC\log** with the actual DSC paths.

```
.\runDSC.bat --source-db Oracle --input-folder D:\DSC\DSC\input --output-folder D:\DSC\DSC\output --log-folder D:\DSC\DSC\log --application-lang SQL --conversion-type bulk --target-db gaussdbA
```

Step 6 After the conversion is complete, the converted DDL file is automatically generated in the **output** directory of DSC.



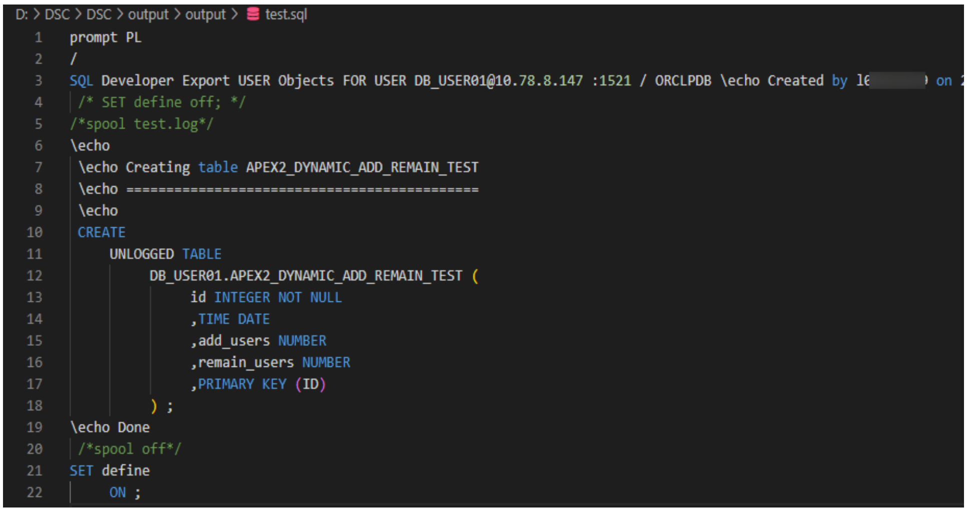
```
PS D:\DSC\DSC> .\runDSC.bat --source-db Oracle --input-folder D:\DSC\DSC\input --output-folder D:\DSC\DSC\output --log-f
older D:\DSC\DSC\log --application-lang SQL --conversion-type bulk --target-db gaussdbA

********************** Schema Conversion Started ************************

DSC process start time : Mon Nov 14 16:10:33 CST 2022
Statement count progress 100% completed [FILE(1/1)]

Schema Conversion Progress 100% completed
--------------------------------------------------------------------------
Total number of files in input folder : 1
Total number of valid files in input folder : 1
--------------------------------------------------------------------------
Log file path : D:\DSC\DSC\log\dsc.log
DSC process end time : Mon Nov 14 16:10:34 CST 2022
DSC total process time : 1 seconds

********************* Schema Conversion Completed ***********************
```



Step 7 The table definition structure of GaussDB(DWS) is different from that of Oracle. You need to manually modify the converted table definition.

Comment out **\echo** in the file (if you use gsql to import table definitions, you do not need to do this) and manually change the distribution column of the specified table.

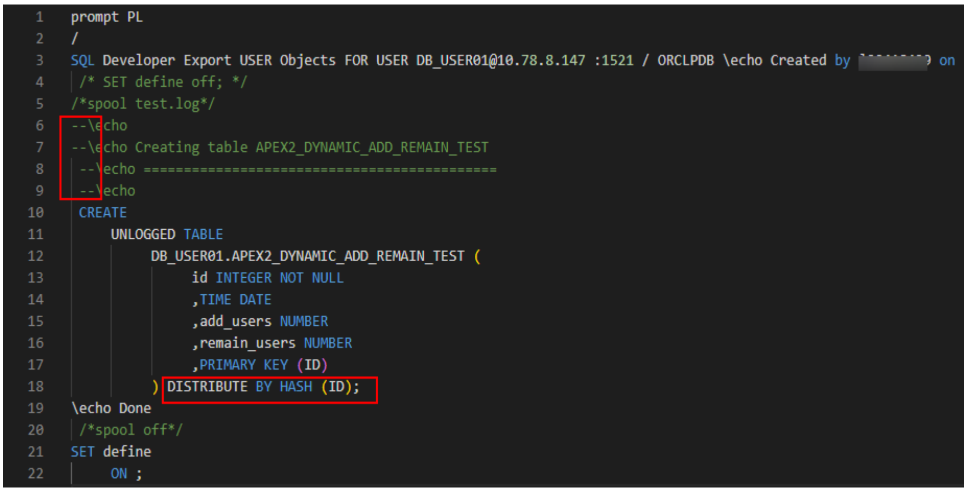
- Before the change:



D: > DSC > DSC > output > output > test.sql

```
prompt PL
/
SQL Developer Export USER Objects FOR USER DB_USER01@10.78.8.147 :1521 / ORCLPDB \echo Created by 1[redacted] on
 /* SET define off; */
/*spool test.log*/
\echo
 \echo Creating table APEX2_DYNAMIC_ADD_REMAIN_TEST
 \echo ============================================
 \echo
 CREATE
     UNLOGGED TABLE
          DB_USER01.APEX2_DYNAMIC_ADD_REMAIN_TEST (
               id INTEGER NOT NULL
               ,TIME DATE
               ,add_users NUMBER
               ,remain_users NUMBER
               ,PRIMARY KEY (ID)
          ) ;
\echo Done
 /*spool off*/
SET define
     ON ;
```

- After the change:



```
prompt PL
/
SQL Developer Export USER Objects FOR USER DB_USER01@10.78.8.147 :1521 / ORCLPDB \echo Created by [redacted] on
 /* SET define off; */
/*spool test.log*/
--\echo
--\echo Creating table APEX2_DYNAMIC_ADD_REMAIN_TEST
 --\echo ============================================
 --\echo
 CREATE
     UNLOGGED TABLE
          DB_USER01.APEX2_DYNAMIC_ADD_REMAIN_TEST (
               id INTEGER NOT NULL
               ,TIME DATE
               ,add_users NUMBER
               ,remain_users NUMBER
               ,PRIMARY KEY (ID)
          ) DISTRIBUTE BY HASH (ID);
\echo Done
 /*spool off*/
SET define
     ON ;
```

NOTE

The distribution column in a hash table must meet the following requirements, which are ranked by priority in descending order:

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 where a constant filter exists. 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. Select the join condition as the distribution column, so that join tasks can be pushed down to DNs to execute, reducing the amount of data transferred between the DNs.

Step 8 Create a GaussDB(dws) cluster. For details, see **Creating a Cluster**.

Step 9 Connect to the GaussDB(DWS) cluster as the system administrator **dbadmin**. For details, see **Using the Data Studio GUI Client to Connect to a Cluster**. By default, the first connection is to the default database **gaussdb**.

Step 10 Create a new target database **test**, and then switch to it.

```
CREATE DATABASE test WITH ENCODING 'UTF-8' DBCOMPATIBILITY 'ORA' TEMPLATE template0;
```

Step 11 Create a schema and switch to it. The schema name must be the same as the Oracle user name (**db_user01** in this example).

```
CREATE SCHEMA db_user01;
SET CURRENT_SCHEMA = db_user01;
```

Step 12 Copy the converted DDL statements in **Step 7** to Data Studio for execution.

Step 13 If the **APEX2_DYNAMIC_ADD_REMAIN_TEST** table can be found in the schema in the **test** database of the GaussDB(DWS) cluster, the table definition is migrated.

```
SELECT COUNT(*) FORM db_user01.APEX2_DYNAMIC_ADD_REMAIN_TEST;
```

----End

2.1.4 Migrating Full Table Data

2.1.4.1 Configuring a GaussDB(DWS) Data Source Connection

Step 1 Create a cluster and bind an EIP to the cluster. For details, see section **Creating a CDM Cluster**.

NOTICE

Ensure that the CDM cluster and the GaussDB(DWS) cluster are in the same region and VPC to ensure network connectivity.

Step 2 On the **Cluster Management** page, click **Job Management** in the **Operation** column of the cluster and choose **Links** > **Create Link**.

Step 3 Select **Data Warehouse Service** and click **Next**.

Step 4 Configure the GaussDB(DWS) connection, click **Test**. If the connection is successful, click **Save**.

Table 2-3 GaussDB(DWS) connection information

Parameter	Value
Name	dws
Database Server	Click **Select** and select the GaussDB(DWS) cluster to be connected from the cluster list. **NOTE** The system automatically displays the GaussDB(DWS) clusters in the same region and VPC. If no GaussDB(DWS) cluster is available, manually enter the IP address of the GaussDB(DWS) cluster that has been connected to the network.
Host Port	8000
Database Name	test
User Name	dbadmin
Password	Password of user **dbadmin**

Parameter	Value
Use Agent	No

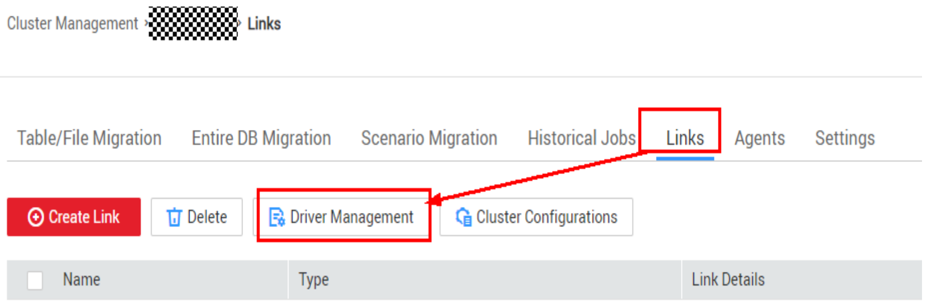
----End

2.1.4.2 Configuring an Oracle Data Source Connection

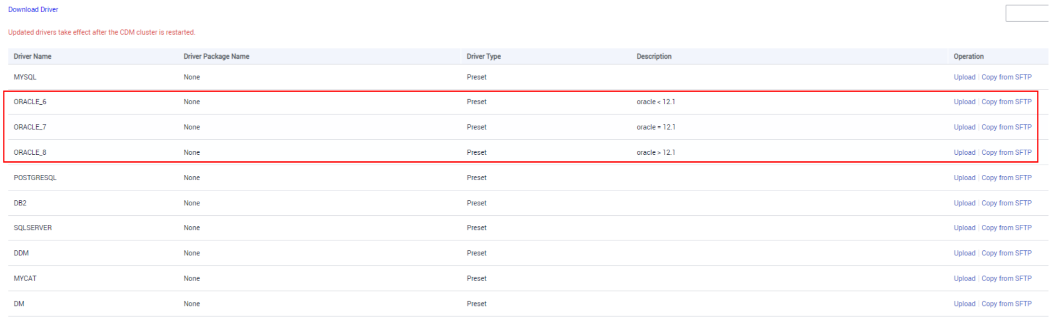
To migrate data from Oracle to GaussDB(DWS), you need to configure an Oracle data source connection first.

Procedure

Step 1 On the **Cluster Management** page, click **Job Management** in the **Operation** column of the cluster and choose **Links** > **Driver Management**.



Step 2 Click **Upload** on the right of ORACLE, select an Oracle driver package (if no driver package is available on the local PC, download it by referring to **Managing Drivers**), and click **Upload**.


Download Driver

Updated drivers take effect after the CDM cluster is restarted.

Driver Name	Driver Package Name	Driver Type	Description	Operation
MYSQL	None	Preset		Upload | Copy from SFTP
ORACLE_6	None	Preset	oracle < 12.1	Upload | Copy from SFTP
ORACLE_7	None	Preset	oracle = 12.1	Upload | Copy from SFTP
ORACLE_8	None	Preset	oracle > 12.1	Upload | Copy from SFTP
POSTGRESQL	None	Preset		Upload | Copy from SFTP
DB2	None	Preset		Upload | Copy from SFTP
SQLSERVER	None	Preset		Upload | Copy from SFTP
DDM	None	Preset		Upload | Copy from SFTP
MYCAT	None	Preset		Upload | Copy from SFTP
DM	None	Preset		Upload | Copy from SFTP

Step 3 On the **Cluster Management** page, click **Job Management** in the **Operation** column of the cluster and choose **Links** > **Create Link**.

Step 4 Select Oracle as the connector and click **Next**.

Step 5 Configure the Oracle connection, click **Test**. If the connection is successful, click **Save**.

Table 2-4 Oracle connection information

Parameter	Value
Name	oracle
Database Server	192.168.1.100 (This is an example. Enter the actual public IP address of the Oracle database.)
Host Port	1521
Connection Type	Service Name
Database Name	orcl
User Name	db_user01
Password	-
Use Local API	No
Use Agent	No
Oracle Version	Later than 12.1

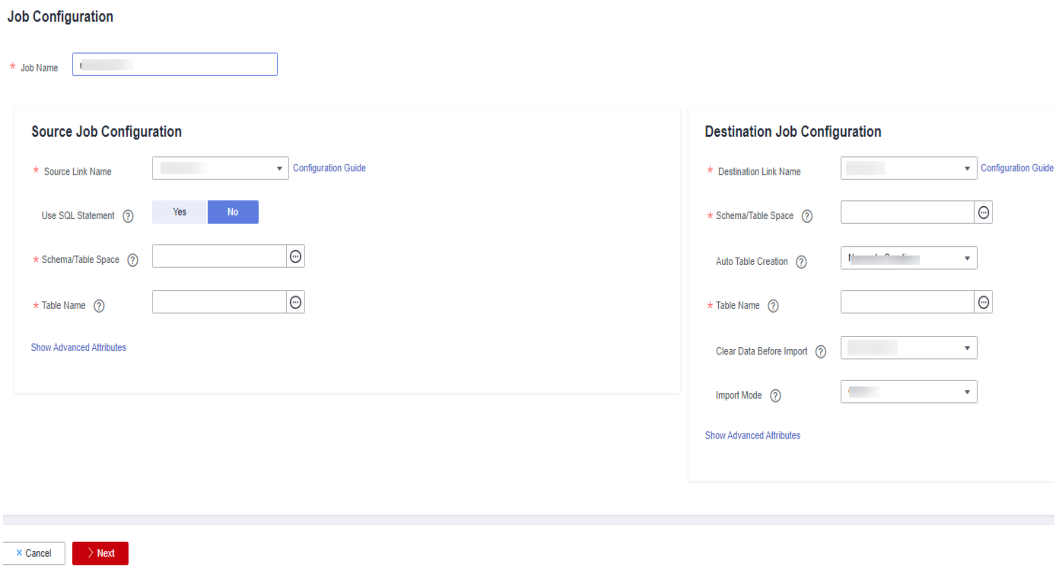
----End

2.1.4.3 Migrating Tables

Procedure

Step 1 On the **Cluster Management** page, click **Job Management** in the **Operation** column of the cluster and choose **Table/File Migration** > **Create Job**.

Step 2 Configure jobs at the source end and destination end.



Job Configuration

* Job Name

Source Job Configuration

* Source Link Name

Use SQL Statement: Yes [✓ No]

* Schema/Table Space

* Table Name

Destination Job Configuration

* Destination Link Name

* Schema/Table Space

Auto Table Creation

* Table Name

Clear Data Before Import

Import Mode

Step 3 Configure source job parameters based on the type of the source database.

Table 2-5 Source job parameters

Parameter	Example Value
Schema/Table Space	db_user01
Use SQL Statement	No
Table Name	APEX2_DYNAMIC_ADD_REMAIN_TEST
WHERE Clause	-
Null in Partition Column	Yes

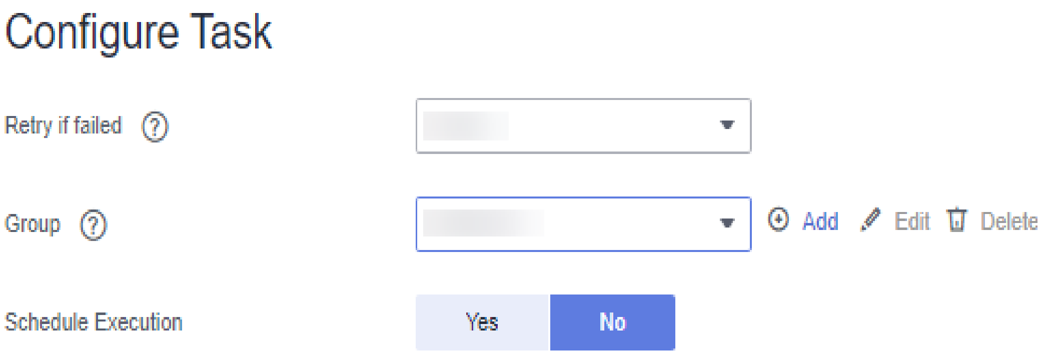
Step 4 Configure the destination job parameters based on the destination cloud service.

Table 2-6 Destination job parameters

1. Parameter	Example Value
Schema/Table Space	db_user01
Auto Table Creation	Non-auto creation
Table Name	apex2_dynamic_add_remain_test
Clear Data Before Import	Clear all data
Import Mode	COPY
Import to Staging Table	No
Prepare for Data Import	-
Complete Statement After Data Import	analyze db_user01. apex2_dynamic_add_remain_test;

Step 5 Mapping between source fields and destination fields.

Step 6 If the task fails to be configured, retry for three times, save the configuration, and run the task.



Configure Task

Retry if failed

Group

Schedule Execution: Yes [✓ No]

Step 7 The task is executed, and the data migration is finished.

----End

2.1.4.4 Verification

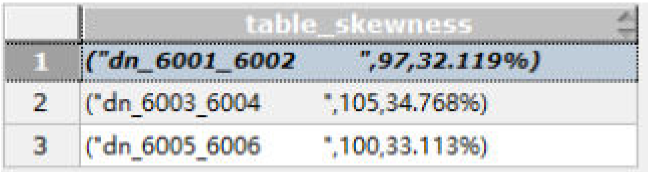
Step 1 In the **test** database of GaussDB(DWS), run the following SQL statement to query the number of rows in the table **apex2_dynamic_add_remain_test**. If the number of rows is the same as that in the source table, the data is consistent.

```
SELECT COUNT(*) FROM  db_user01.apex2_dynamic_add_remain_test;
```

Step 2 Run the following statement to check the data skewness:

If the data skewness is within 10%, the data distribution is normal. The data migration is complete.

```
SELECT TABLE_SKEWNESS('db_user01.apex2_dynamic_add_remain_test');
```



	table_skewness
1	("dn_6001_6002 ",97,32.119%)
2	("dn_6003_6004 ",105,34.768%)
3	("dn_6005_6006 ",100,33.113%)

----End

2.1.5 Migrating SQL Statements

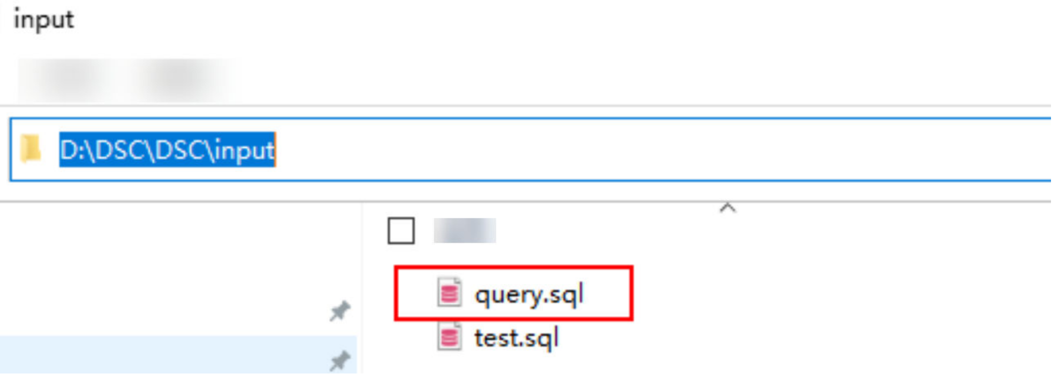
2.1.5.1 Migrating Syntax

Step 1 Save the following SQL statements in an Oracle database as an query.sql file.

```
-- Generally, the HAVING clause must appear after the GROUP BY clause, but Oracle allows HAVING to appear before or after the GROUP BY clause. Therefore, you need to move the HAVING clause after the GROUP BY clause in the target database.
SELECT
id,
count(*),
sum(remain_users)
FROM LYC.APEX2_DYNAMIC_ADD_REMAIN_TEST
HAVING id <= 5
GROUP BY id;
```

```
UNIQUE keywords are migrated as DISTINCT keywords.
SELECT UNIQUE add_users FROM LYC.APEX2_DYNAMIC_ADD_REMAIN_TEST;

-- In NVL2(expression,value1,value2), if the expression is not Null, NVL2 returns Value1. If the expression is
Null, NVL2 returns Value2.
SELECT NVL2(add_users, 1, 2) FROM LYC.APEX2_DYNAMIC_ADD_REMAIN_TEST SHERE rownum <= 2;
```

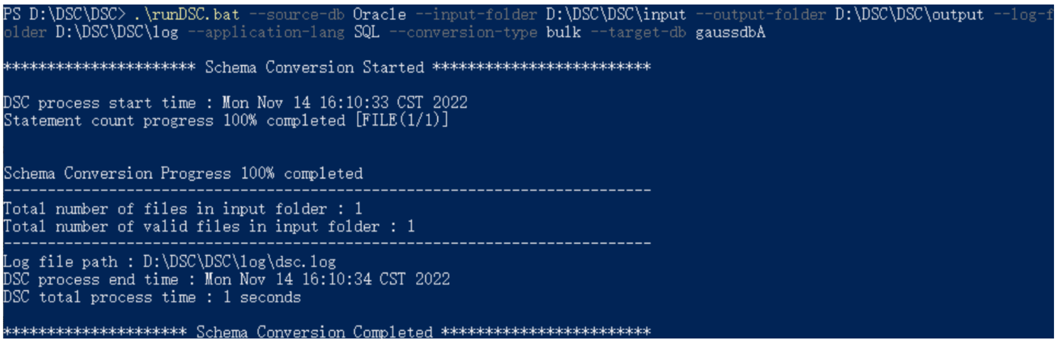
Step 2 Place the query.sql file obtained in **Step 1** in the **input** directory of the decompressed DSC folder.



Step 3 In the directory of runDSC.bat, press Shift and right-click. Choose **Open PowerShell window here** and perform the conversion.

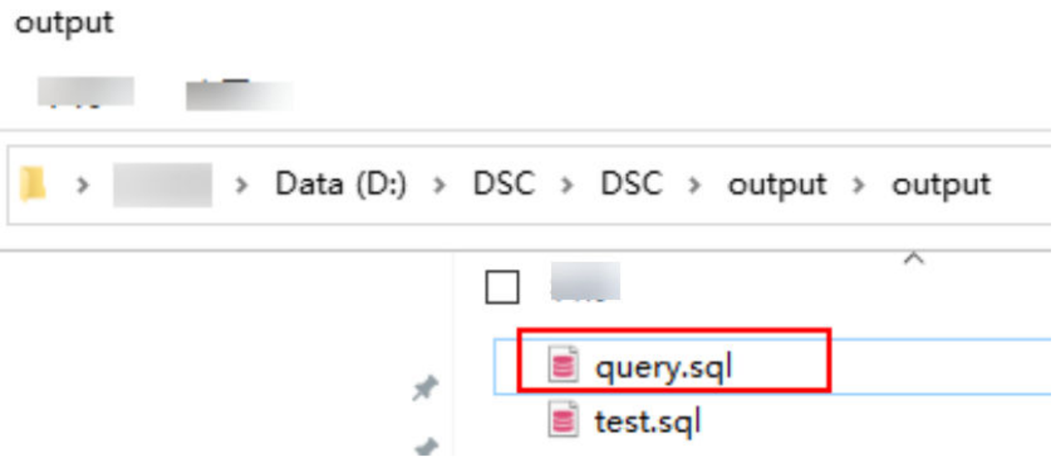
Replace **D:\DSC\DSC\input**, **D:\DSC\DSC\output**, and **D:\DSC\DSC\log** with the actual DSC paths.

```
.\runDSC.bat --source-db Oracle --input-folder D:\DSC\DSC\input --output-folder D:\DSC\DSC\output --
log-folder D:\DSC\DSC\log --application-lang SQL --conversion-type bulk --target-db gaussdbA
```



```
PS D:\DSC\DSC> .\runDSC.bat --source-db Oracle --input-folder D:\DSC\DSC\input --output-folder D:\DSC\DSC\output --log-f
older D:\DSC\DSC\log --application-lang SQL --conversion-type bulk --target-db gaussdbA

********************** Schema Conversion Started *************************

DSC process start time : Mon Nov 14 16:10:33 CST 2022
Statement count progress 100% completed [FILE(1/1)]


Schema Conversion Progress 100% completed
--------------------------------------------------------------------------
Total number of files in input folder : 1
Total number of valid files in input folder : 1
--------------------------------------------------------------------------
Log file path : D:\DSC\DSC\log\dsc.log
DSC process end time : Mon Nov 14 16:10:34 CST 2022
DSC total process time : 1 seconds

********************* Schema Conversion Completed ************************
```

Step 4 After the conversion is complete, a DML file is generated in the output directory.



----End

2.1.5.2 Verification

Step 1 Execute the SQL statements in the Oracle database before migration.

Step 2 Execute the migrated SQL statements on Data Studio.

Step 3 Compare the execution results. If they are the same, the SQL migration is complete.

----End

2.2 Synchronizing MySQL Table Data to GaussDB(DWS) in Real Time

This practice demonstrates how to use Data Replication Service (DRS) to synchronize MySQL data to GaussDB (DWS) in real time. For details about DRS, see **What Is DRS?**

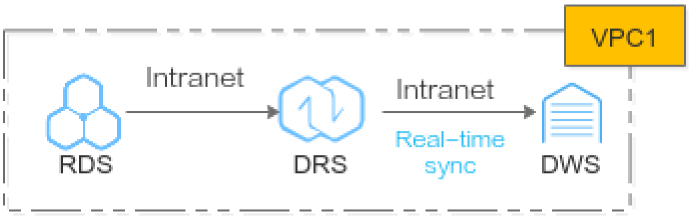
This practice takes about 60 minutes. The process is as follows:

1. **Preparations**
2. **Step 1: Prepare a MySQL Source Table**
3. **Step 2: Create a GaussDB(DWS) Cluster**
4. **Step 3: Create a DRS Synchronization Task**
5. **Step 4: Verify Data Synchronization**

Scenario Description

In big data analysis scenarios, MySQL serves as an OLTP database. After MySQL is connected to the GaussDB(DWS) data warehouse for OLAP analysis, data written by MySQL in real time needs to be synchronized to the GaussDB(DWS) data warehouse in real time. DRS is used to perform the synchronization.

Figure 2-3 DRS real-time synchronization



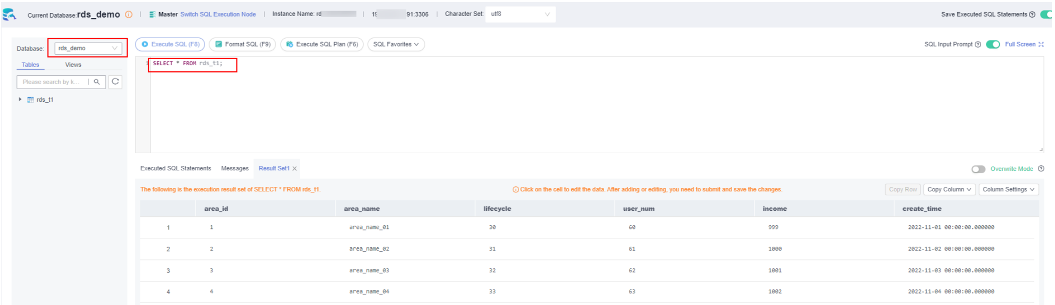
Preparations

- You have registered a Huawei account and enabled Huawei Cloud services.. Before using GaussDB(DWS), check the account status. The account cannot be in arrears or frozen.
- The MySQL source table to be migrated has been prepared. In this practice, a Huawei Cloud RDS MySQL database is used as the source data. If your MySQL database is offline, ensure that the network connection is normal.

Step 1: Prepare a MySQL Source Table

Step 1 You have purchased an RDS MySQL DB engine (this practice use MySQL 8.0.x as an example). For details, see **Buy a DB Instance**.

Step 2 The source database **rds_demo** with the **utf8mb4** character set has been created, and there is the table **rds_t1** with data in the database.



```
SELECT * FROM rds_t1;
```

The following is the execution result set of SELECT * FROM rds_t1.

Click on the cell to edit the data. After adding or editing, you need to submit and save the changes.

	area_id	area_name	lifecycle	user_num	income	create_time
1	1	area_name_01	30	60	999	2022-11-01 00:00:00.000000
2	2	area_name_02	31	61	1000	2022-11-02 00:00:00.000000
3	3	area_name_03	32	62	1001	2022-11-03 00:00:00.000000
4	4	area_name_04	33	63	1002	2022-11-04 00:00:00.000000

----End

Step 2: Create a GaussDB(DWS) Cluster

Step 1 **Creating a Cluster**. To ensure network connectivity, the GaussDB(DWS) cluster and RDS must be in the same region.

Step 2 On the **Clusters** page of the GaussDB(DWS) console, locate the row that contains the target cluster and click **Login** in the **Operation** column.

> NOTE
>
> This practice uses version 8.1.3.x as an example. 8.1.2 and earlier versions do not support this login mode. You can use Data Studio to connect to a cluster. For details, see **Using Data Studio to Connect to a Cluster**.

Step 3 After logging in to the GaussDB(DWS) database, create the database **rds_demo** for synchronization.

```
CREATE DATABASE rds_demo WITH ENCODING 'UTF-8' DBCOMPATIBILITY 'mysql' TEMPLATE template0;
```

Step 4 Switch to the **rds_demo** database and create a schema named **rds_demo**.

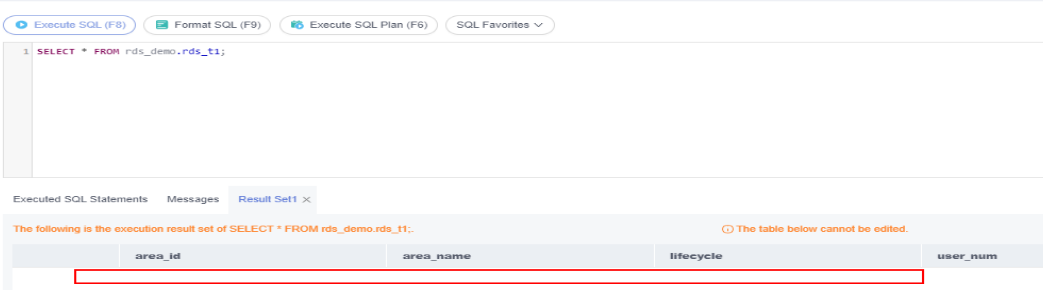
```
CREATE SCHEMA rds_demo;
```

Step 5 Create a table named **rds_t1** in the schema **rds_demo**.

```
CREATE TABLE rds_demo.rds_t1 (
  area_id varchar(256) NOT NULL,
  area_name varchar(256) DEFAULT NULL,
  lifecycle varchar(256) DEFAULT NULL,
  user_num int DEFAULT NULL,
  income  bigint DEFAULT NULL,
  create_time timestamp DEFAULT CURRENT_TIMESTAMP,
   PRIMARY KEY (area_id)
)distribute by hash(area_id);
COMMENT on column rds_demo.rds_t1.area_id is 'Region Code';
COMMENT on column rds_demo.rds_t1.area_name is 'Region Name';
COMMENT on column rds_demo.rds_t1.lifecycle is 'Life Cycle';
 COMMENT on column rds_demo.rds_t1.user_num is 'Subscribers in Each Life Cycle';
 COMMENT on column rds_demo.rds_t1.income is 'Region Income';
COMMENT on column rds_demo.rds_t1.create_time is 'Creation Time';
```

Step 6 Query table data. Currently, the table is empty.

```
SELECT * FROM rds_demo.rds_t1;
```



```
SELECT * FROM rds_demo.rds_t1;
```

The following is the execution result set of SELECT * FROM rds_demo.rds_t1;.

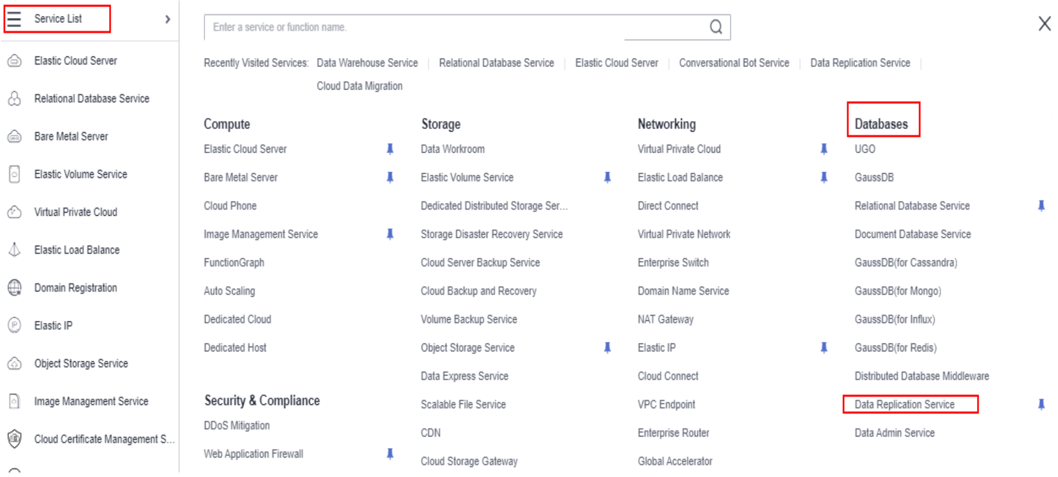
The table below cannot be edited.

	area_id	area_name	lifecycle	user_num

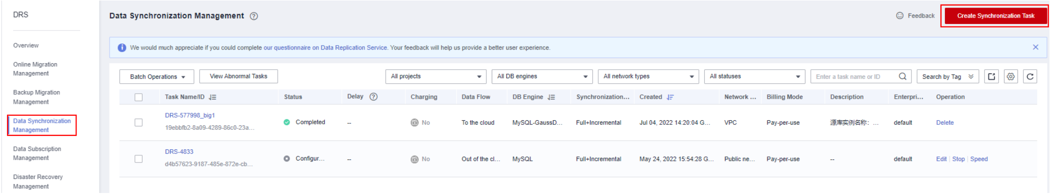
----End

Step 3: Create a DRS Synchronization Task

Step 1 Choose **Service List** > **Databases** > **Data Replication Service** to switch to the DRS console.



Step 2 Choose **Data Synchronization Management** on the left and click **Create Synchronization Task** in the upper right corner.



DRS
Overview
Online Migration Management
Backup Migration Management
Data Synchronization Management
Data Subscription Management
Disaster Recovery Management
Feedback
Create Synchronization Task
Batch Operations
View Abnormal Tasks
All projects
All DB engines
All network types
All statuses
Enter a task name or ID
Search by Tag

Data Synchronization Management

We would much appreciate if you could complete our questionnaire on Data Replication Service. Your feedback will help us provide a better user experience.

Task Name/ID	Status	Delay	Charging	Data Flow	DB Engine	Synchronization...	Created	Network ...	Billing Mode	Description	Enterpri...	Operation
DRS-577998_big1 19ebbfb2-8a09-4289-86c0-23a...	Completed	--	No	To the cloud	MySQL-GaussD...	Full+Incremental	Jul 04, 2022 14:20:04 G...	VPC	Pay-per-use	源库实例名称: ...	default	Delete
DRS-4833 d4b57623-9187-485e-872e-cb...	Configur...	--	No	Out of the cl...	MySQL	Full+Incremental	May 24, 2022 15:54:28 G...	Public ne...	Pay-per-use	--	default	Edit | Stop | Speed

Step 3 Configure basic parameters. For details, see **Table 2-7**.

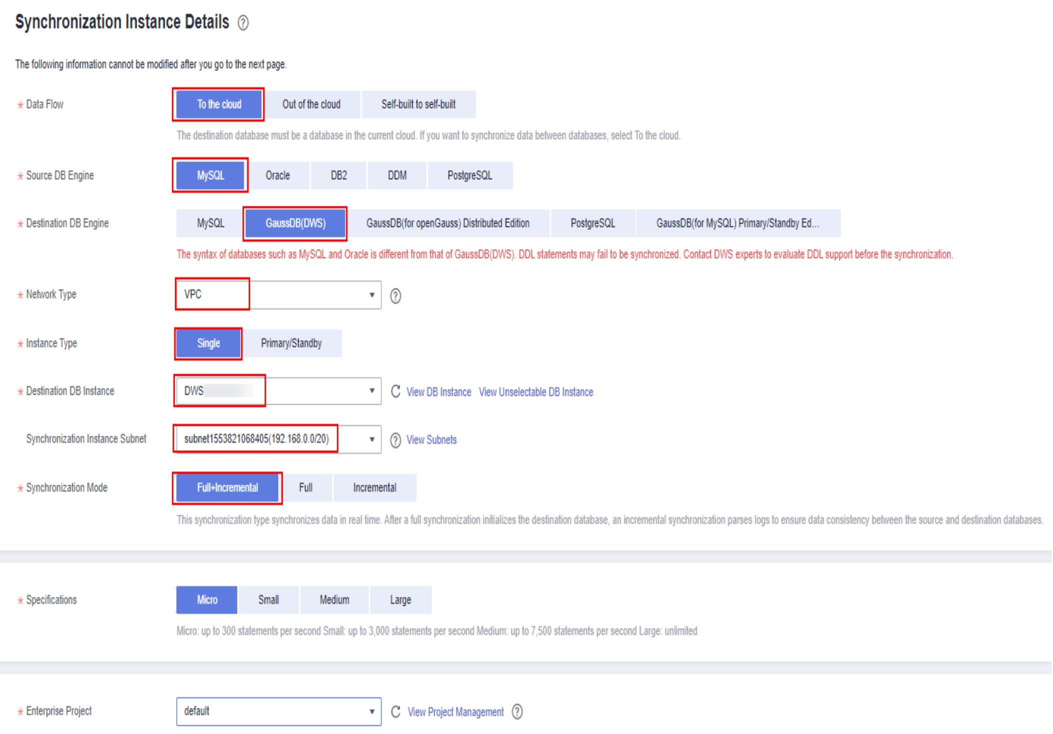
Table 2-7 Basic parameters

Parameter	Value
Billing Mode	Pay-per-use
Region	EU-Dublin. Ensure that RDS and GaussDB(DWS) are in the same region.
Project	Europe-Dublin
Task Name	DRS-DWS
Description	-

Step 4 Configure the following parameters. For details, see **Table 2-8**.

Table 2-8 Synchronized instance parameters

Parameter	Value
Data Flow	To the cloud
Source DB Engine	MySQL
Destination DB engine	GaussDB(DWS)
Network Type	In this practice, select **VPC**. If the MySQL database is offline, select **Public Network**.
Instance Type	Single
Destination DB Instance	Select the cluster created in **Step 2: Create a GaussDB(DWS) Cluster**.
Synchronization Instance Subnet	Select the subnet where the GaussDB(DWS) cluster resides. In this practice, RDS and GaussDB(DWS) are in the same VPC and subnet.
Synchronous Mode	Full+Incremental
Specifications	In this practice, select **Micro**. This option is selected based on the data volume and synchronization rate.



Synchronization Instance Details

The following information cannot be modified after you go to the next page.

* Data Flow: To the cloud | Out of the cloud | Self-built to self-built

The destination database must be a database in the current cloud. If you want to synchronize data between databases, select To the cloud.

* Source DB Engine: MySQL | Oracle | DB2 | DDM | PostgreSQL

* Destination DB Engine: MySQL | GaussDB(DWS) | GaussDB(for openGauss) Distributed Edition | PostgreSQL | GaussDB(for MySQL) Primary/Standby Ed...

The syntax of databases such as MySQL and Oracle is different from that of GaussDB(DWS). DDL statements may fail to be synchronized. Contact DWS experts to evaluate DDL support before the synchronization.

* Network Type: VPC

* Instance Type: Single | Primary/Standby

* Destination DB Instance: DWS [redacted]

Synchronization Instance Subnet: subnet1553821068405(192.168.0.0/20)

* Synchronization Mode: Full+Incremental | Full | Incremental

This synchronization type synchronizes data in real time. After a full synchronization initializes the destination database, an incremental synchronization parses logs to ensure data consistency between the source and destination databases.

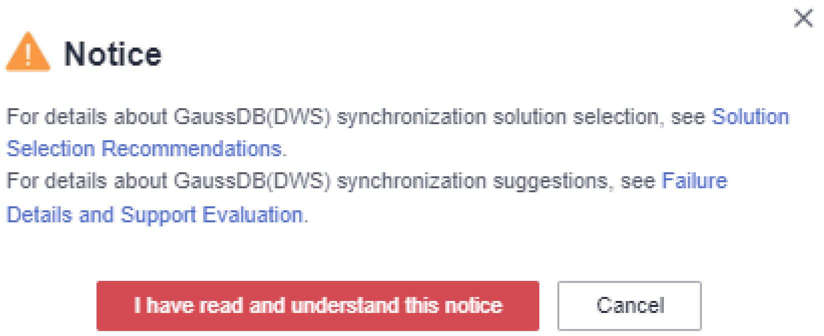
* Specifications: Micro | Small | Medium | Large

Micro: up to 300 statements per second Small: up to 3,000 statements per second Medium: up to 7,500 statements per second Large: unlimited

* Enterprise Project: default

Step 5 Click **Next** and click **I have read and understand this notice**.

Wait for about 5 to 10 minutes for the synchronization to complete.



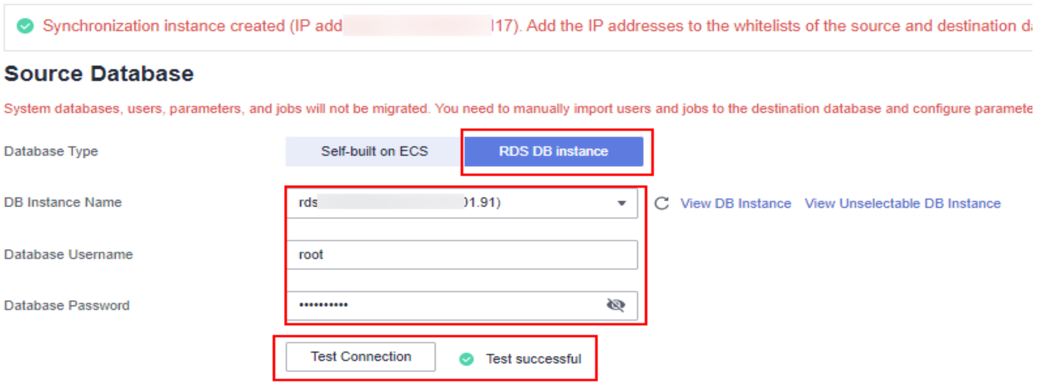
Notice

For details about GaussDB(DWS) synchronization solution selection, see Solution Selection Recommendations.
For details about GaussDB(DWS) synchronization suggestions, see Failure Details and Support Evaluation.

Step 6 After the synchronization succeeds, enter the source database information and click **Test Connection**.

Table 2-9 Source database information

Parameter	Value
Database Type	RDS DB Instance
DB Instance Name	Select the created RDS DB instance.
Database Username	root
Database Password	****



✓ Synchronization instance created (IP add[redacted]17). Add the IP addresses to the whitelists of the source and destination d

Source Database

System databases, users, parameters, and jobs will not be migrated. You need to manually import users and jobs to the destination database and configure paramete

Database Type: Self-built on ECS | RDS DB instance

DB Instance Name: rds[redacted]01.91) — View DB Instance — View Unselectable DB Instance

Database Username: root

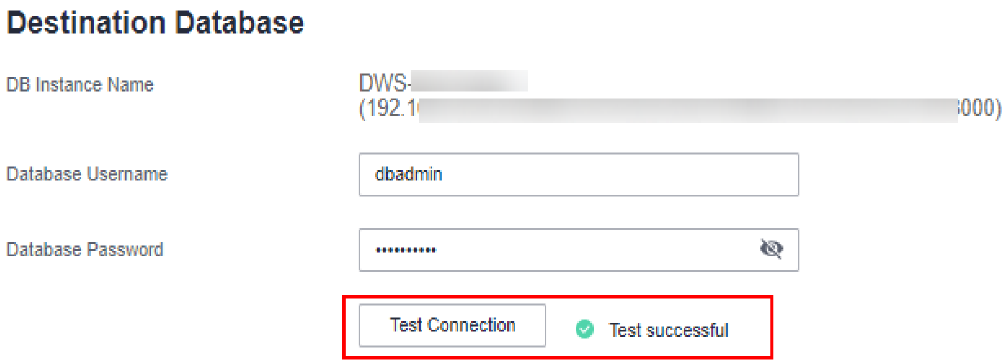
Database Password: ••••••••••

Test Connection ✓ Test successful

Step 7 Enter the destination database information and click **Test Connection**. The connection test is successful.

Table 2-10 Destination database information

Parameter	Value
Database Username	dbadmin
Database Password	****



Destination Database

DB Instance Name: DWS-[redacted]
(192.1[redacted]000)

Database Username: dbadmin

Database Password: ••••••••••

Test Connection ✓ Test successful

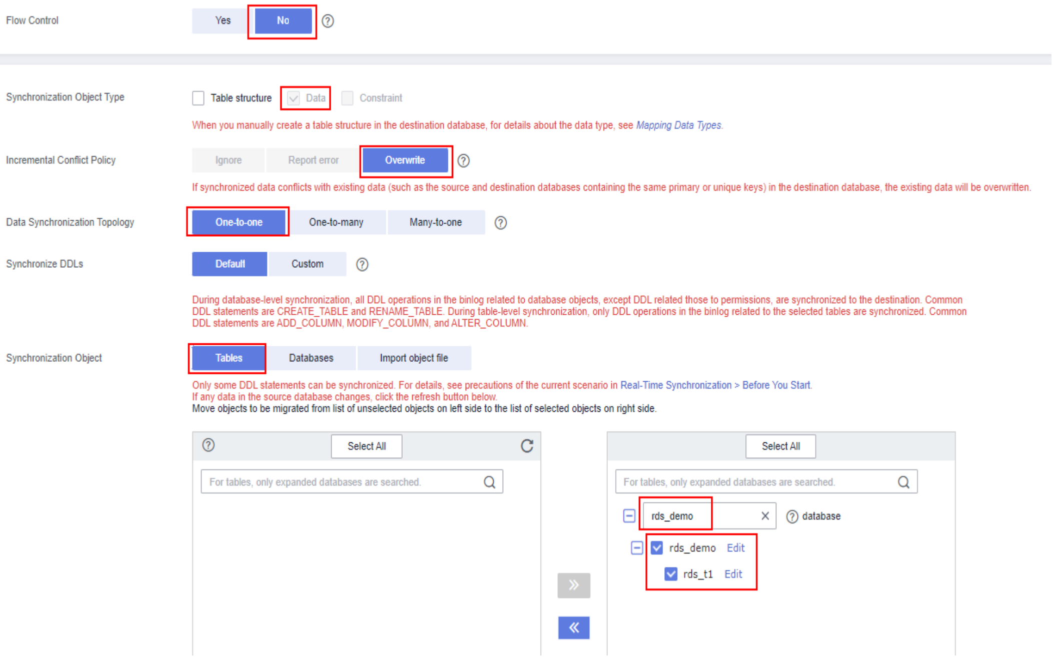
Step 8 Click **Next**, and then click **Agree**.

Step 9 Set the synchronization policy. For details, see **Table 2-11**.

Table 2-11 Synchronization policy

Parameter	Value
Flow Control	No

Parameter	Value
Synchronization Object Type	Data
Incremental Conflict Policy	Overwrite
Data Synchronization Topology	One-to-one
Synchronize DDLs	Default
Synchronization Object	Tables Select the table to be synchronized from the source database. In this practice, select **rds_t1** under **rds_demo**. Enter the name of the GaussDB(DWS) database that data is synchronized to: **rds_demo**



Flow Control: Yes [✓ No]

Synchronization Object Type: □ Table structure ☑ Data □ Constraint

When you manually create a table structure in the destination database, for details about the data type, see *Mapping Data Types*.

Incremental Conflict Policy: Ignore Report error [✓ Overwrite]

If synchronized data conflicts with existing data (such as the source and destination databases containing the same primary or unique keys) in the destination database, the existing data will be overwritten.

Data Synchronization Topology: [✓ One-to-one] One-to-many Many-to-one

Synchronize DDLs: [✓ Default] Custom

During database-level synchronization, all DDL operations in the binlog related to database objects, except DDL related those to permissions, are synchronized to the destination. Common DDL statements are CREATE_TABLE and RENAME_TABLE. During table-level synchronization, only DDL operations in the binlog related to the selected tables are synchronized. Common DDL statements are ADD_COLUMN, MODIFY_COLUMN, and ALTER_COLUMN.

Synchronization Object: [✓ Tables] Databases Import object file

Only some DDL statements can be synchronized. For details, see precautions of the current scenario in Real-Time Synchronization > Before You Start.
If any data in the source database changes, click the refresh button below.
Move objects to be migrated from list of unselected objects on left side to the list of selected objects on right side.

rds_demo database

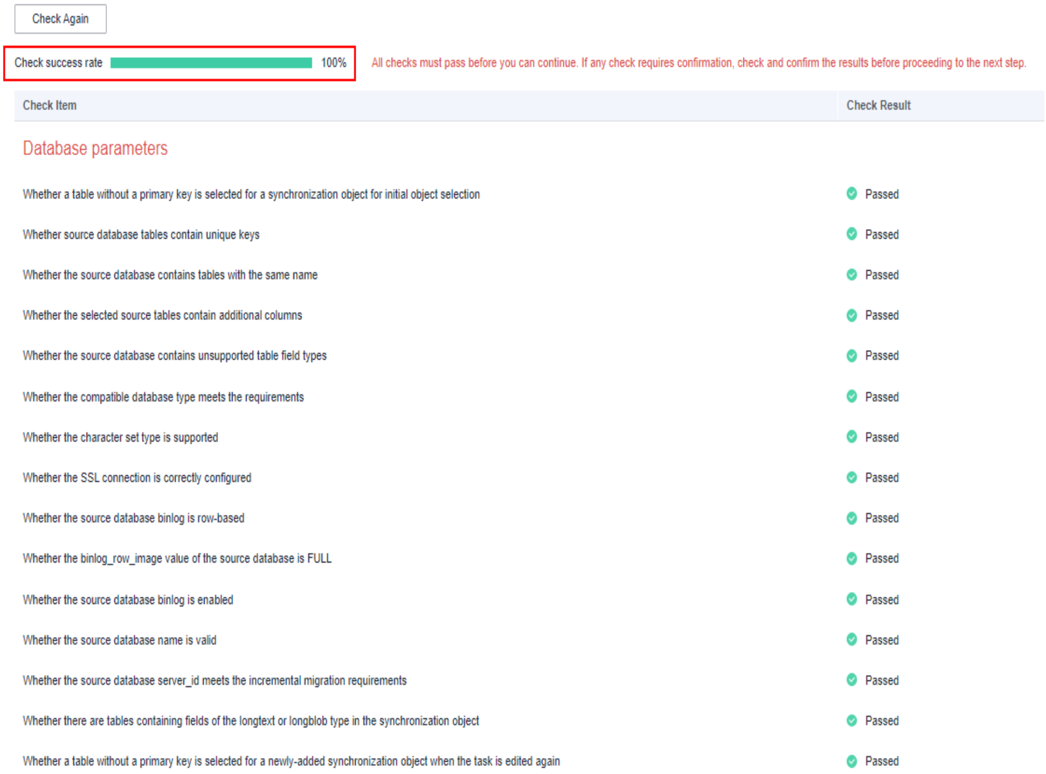
☑ rds_demo Edit

☑ rds_t1 Edit

Select All
For tables, only expanded databases are searched.
Select All
For tables, only expanded databases are searched.
»
«

Step 10 Click **Next**, confirm the information, and click **Next**.

Wait until the database parameter check is successful. If the check fails, click **Check Again**.

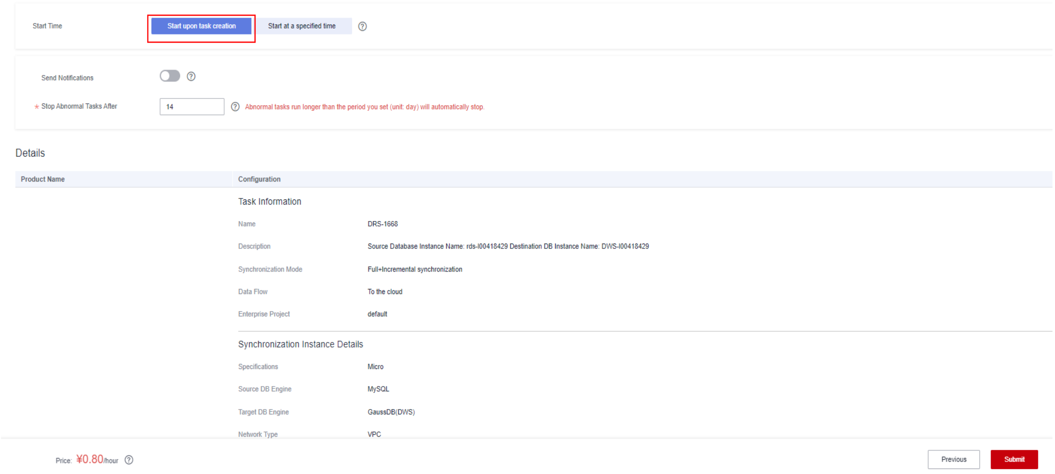


Check success rate 100%

All checks must pass before you can continue. If any check requires confirmation, check and confirm the results before proceeding to the next step.

Check Item	Check Result
Database parameters	
Whether a table without a primary key is selected for a synchronization object for initial object selection	✓ Passed
Whether source database tables contain unique keys	✓ Passed
Whether the source database contains tables with the same name	✓ Passed
Whether the selected source tables contain additional columns	✓ Passed
Whether the source database contains unsupported table field types	✓ Passed
Whether the compatible database type meets the requirements	✓ Passed
Whether the character set type is supported	✓ Passed
Whether the SSL connection is correctly configured	✓ Passed
Whether the source database binlog is row-based	✓ Passed
Whether the binlog_row_image value of the source database is FULL	✓ Passed
Whether the source database binlog is enabled	✓ Passed
Whether the source database name is valid	✓ Passed
Whether the source database server_id meets the incremental migration requirements	✓ Passed
Whether there are tables containing fields of the longtext or longblob type in the synchronization object	✓ Passed
Whether a table without a primary key is selected for a newly-added synchronization object when the task is edited again	✓ Passed

Step 11 Click **Next**, select **Start upon task creation**, verify other information, and click **Submit** in the lower right corner.



Start Time [✓ Start upon task creation] Start at a specified time

Send Notifications ○

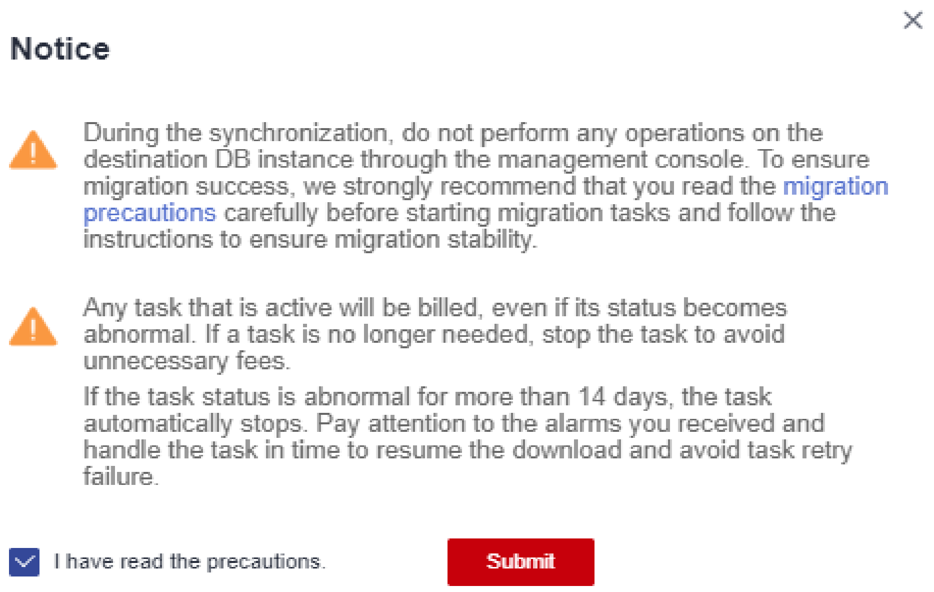
* Stop Abnormal Tasks After 14 Abnormal tasks run longer than the period you set (unit: day) will automatically stop.

Details

Product Name	Configuration	
	Task Information	
	Name	DRS-1668
	Description	Source Database Instance Name: rds-l00418429 Destination DB Instance Name: DWS-l00418429
	Synchronization Mode	Full+Incremental synchronization
	Data Flow	To the cloud
	Enterprise Project	default
	Synchronization Instance Details	
	Specifications	Micro
	Source DB Engine	MySQL
	Target DB Engine	GaussDB(DWS)
	Network Type	VPC

Price: ¥0.80/hour

Step 12 In the dialog box that is displayed, confirm the information, select **I have read and understand this notice**, and click **Start Task**.



Notice

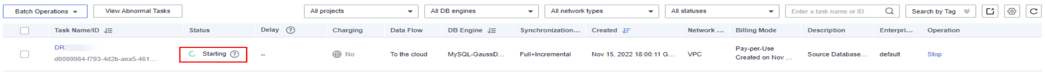
During the synchronization, do not perform any operations on the destination DB instance through the management console. To ensure migration success, we strongly recommend that you read the migration precautions carefully before starting migration tasks and follow the instructions to ensure migration stability.

Any task that is active will be billed, even if its status becomes abnormal. If a task is no longer needed, stop the task to avoid unnecessary fees.

If the task status is abnormal for more than 14 days, the task automatically stops. Pay attention to the alarms you received and handle the task in time to resume the download and avoid task retry failure.

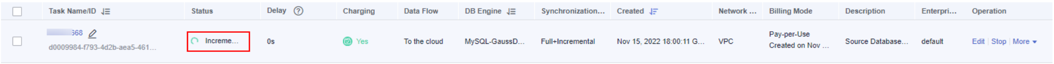
☑ I have read the precautions.

Go back to the **Data Synchronization Management** page and wait for about 5 to 10 minutes. The synchronization is started successfully.



□	Task Name/ID	Status	Delay	Charging	Data Flow	DB Engine	Synchronization...	Created	Network ...	Billing Mode	Description	Enterpri...	Operation
□	DR[redacted] d0009984-f793-4d2b-aea5-461...	Starting	--	No	To the cloud	MySQL-GaussD...	Full+Incremental	Nov 15, 2022 18:00:11 G...	VPC	Pay-per-Use Created on Nov ...	Source Database...	default	Stop

Wait for about 5 minutes and continue with **Step 4: Verify Data Synchronization**.



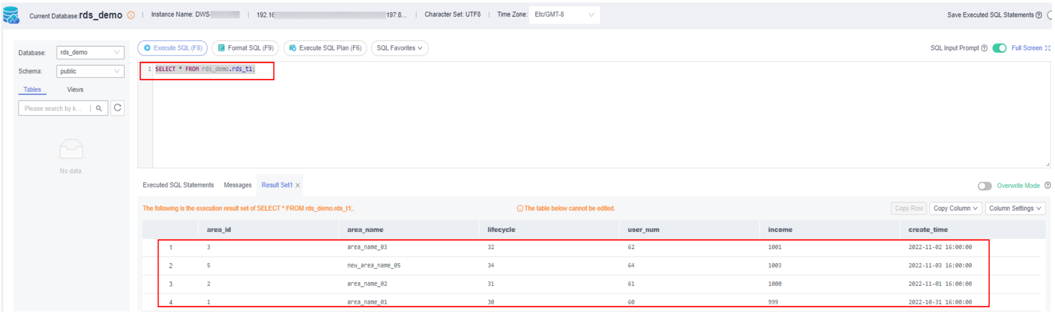
□	Task Name/ID	Status	Delay	Charging	Data Flow	DB Engine	Synchronization...	Created	Network ...	Billing Mode	Description	Enterpri...	Operation
□	[redacted]368 d0009984-f793-4d2b-aea5-461...	Increme...	0s	Yes	To the cloud	MySQL-GaussD...	Full+Incremental	Nov 15, 2022 18:00:11 G...	VPC	Pay-per-Use Created on Nov ...	Source Database...	default	Edit | Stop | More

----End

Step 4: Verify Data Synchronization

Step 1 Log in to GaussDB(DWS) console again, and run the following statement to query the table data again. If the result is shown as follows, the full data synchronization is successful.

```
SELECT * FROM rds_demo.rds_t1;
```



Current Database:rds_demo | Instance Name: DWS-[redacted] | 192.16[redacted]197:8... | Character Set: UTF8 | Time Zone: Etc/GMT-8

Database: rds_demo
Schema: public

```
SELECT * FROM rds_demo.rds_t1;
```

The following is the execution result set of SELECT * FROM rds_demo.rds_t1;.

The table below cannot be edited.

	area_id	area_name	lifecycle	user_num	income	create_time
1	3	area_name_03	32	62	1001	2022-11-02 16:00:00
2	5	new_area_name_05	34	64	1003	2022-11-03 16:00:00
3	2	area_name_02	31	61	1000	2022-11-01 16:00:00
4	1	area_name_01	30	60	999	2022-10-31 16:00:00

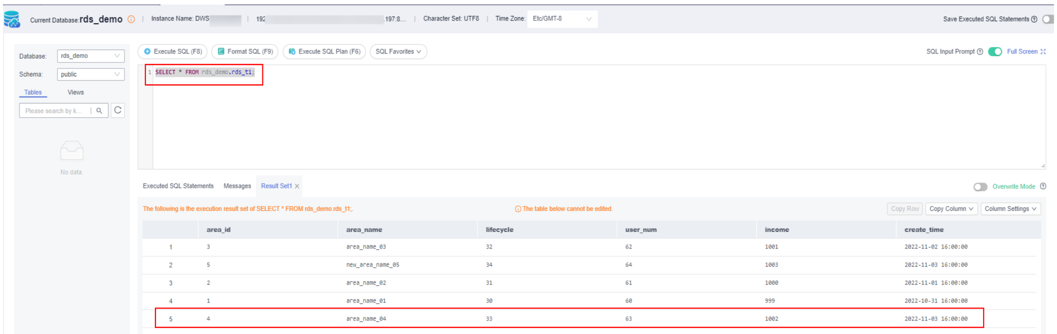
Step 2 Switch to the RDS console, log in to the RDS database, and insert new data into the table **rds_t1**.

```
INSERT INTO rds_t1 VALUES ('5','new_area_name_05',34,64,1003,'2022-11-04');
```

Step 3 Switch back to the GaussDB(DWS) database and run the following statement to query table data:

A row of data is added to the query result, indicating that the data in the MySQL database has been synchronized to GaussDB(DWS) in real time.

```
SELECT * FROM rds_demo.rds_t1;
```



Current Database: rds_demo | Instance Name: DWS[redacted] | 192[redacted]197:8... | Character Set: UTF8 | Time Zone: Etc/GMT-8

Database: rds_demo
Schema: public

```
1 SELECT * FROM rds_demo.rds_t1;
```

The following is the execution result set of SELECT * FROM rds_demo.rds_t1;.

The table below cannot be edited.

	area_id	area_name	lifecycle	user_num	income	create_time
1	3	area_name_03	32	62	1001	2022-11-02 16:00:00
2	5	new_area_name_05	34	64	1003	2022-11-03 16:00:00
3	2	area_name_02	31	61	1000	2022-11-01 16:00:00
4	1	area_name_01	30	60	999	2022-10-31 16:00:00
5	4	area_name_04	33	63	1002	2022-11-03 16:00:00

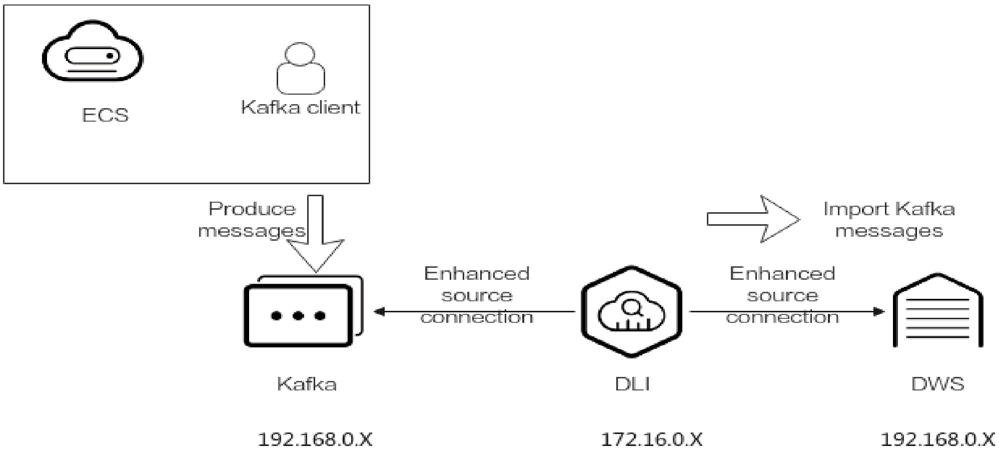
----End

2.3 Using DLI Flink Jobs to Write Kafka Data to GaussDB(DWS) in Real Time

This practice demonstrates how to use DLI Flink jobs to synchronize consumption data from Kafka to GaussDB(DWS) in real time. The demonstration process includes writing and updating existing data in real time.

- For details, see **What Is Data Lake Insight?**
- For details about Kafka, see **What Is DMS for Kafka?**

Figure 2-4 Importing Kafka data to GaussDB(DWS) in real time



This practice takes about 90 minutes. The cloud services used in this practice include **Virtual Private Cloud (VPC) and subnets**, **Elastic Load Balance (ELB)**, **Elastic Cloud Server (ECS)**, **Object Storage Service (OBS)**, **Distributed Message Service (DMS) for Kafka**, **Data Lake Insight (DLI)**, and **Data Warehouse Service (DWS)**. The basic process is as follows:

1. **Preparations**
2. **Step 1: Creating a Kafka Instance**
3. **Step 2: Creating a GaussDB(DWS) Cluster and Target Table**
4. **Step 3: Creating a DLI Queue**
5. **Step 4: Creating an Enhanced Datasource Connection for Kafka and GaussDB(DWS)**
6. **Step 5: Preparing the dws-connector-flink Tool for Interconnecting GaussDB(DWS) with Flink**
7. **Step 6: Creating and Editing a DLI Flink Job**
8. **Step 7: Creating and Modifying Messages on the Kafka Client**

Scenario Description

Assume that the sample data of the data source Kafka is a user information table, as shown in **Table 2-12**, which contains the **id**, **name**, and **age** fields. The **id** field is unique and fixed, which is shared by multiple service systems. Generally, the **id** field does not need to be modified. Only the **name** and **age** fields need to be modified.

Use Kafka to generate the following three groups of data and use DLI Flink jobs to synchronize the data to GaussDB(DWS): Change the users whose IDs are **2** and **3** to **jim** and **tom**, and use DLI Flink jobs to update data and synchronize the data to GaussDB(DWS).

Table 2-12 Sample data

id	name	age
1	lily	16
2	lucy > jim	17
3	lilei > tom	15

Constraints

- Ensure that VPC, ECS, OBS, Kafka, DLI, and GaussDB(DWS) are in the same region, for example, Europe-Dublin.
- Ensure that Kafka, DLI, and GaussDB(DWS) can communicate with each other. In this practice, Kafka and GaussDB(DWS) are created in the same region and VPC, and the security groups of Kafka and GaussDB(DWS) allow the network segment of the DLI queues.
- To ensure that the link between DLI and DWS is stable, bind the ELB service to the created data warehouse cluster.

Preparations

- You have registered a Huawei account and enabled Huawei Cloud services.. Before using GaussDB(DWS), check the account status. The account cannot be in arrears or frozen.

- You have created a VPC and subnet. For details, see **Creating a VPC**.

Step 1: Creating a Kafka Instance

Step 1 Log in to the Huawei Cloud management console and choose **Middleware** > **Distributed Message Service (for Kafka)** from the service list. The Kafka management console is displayed.

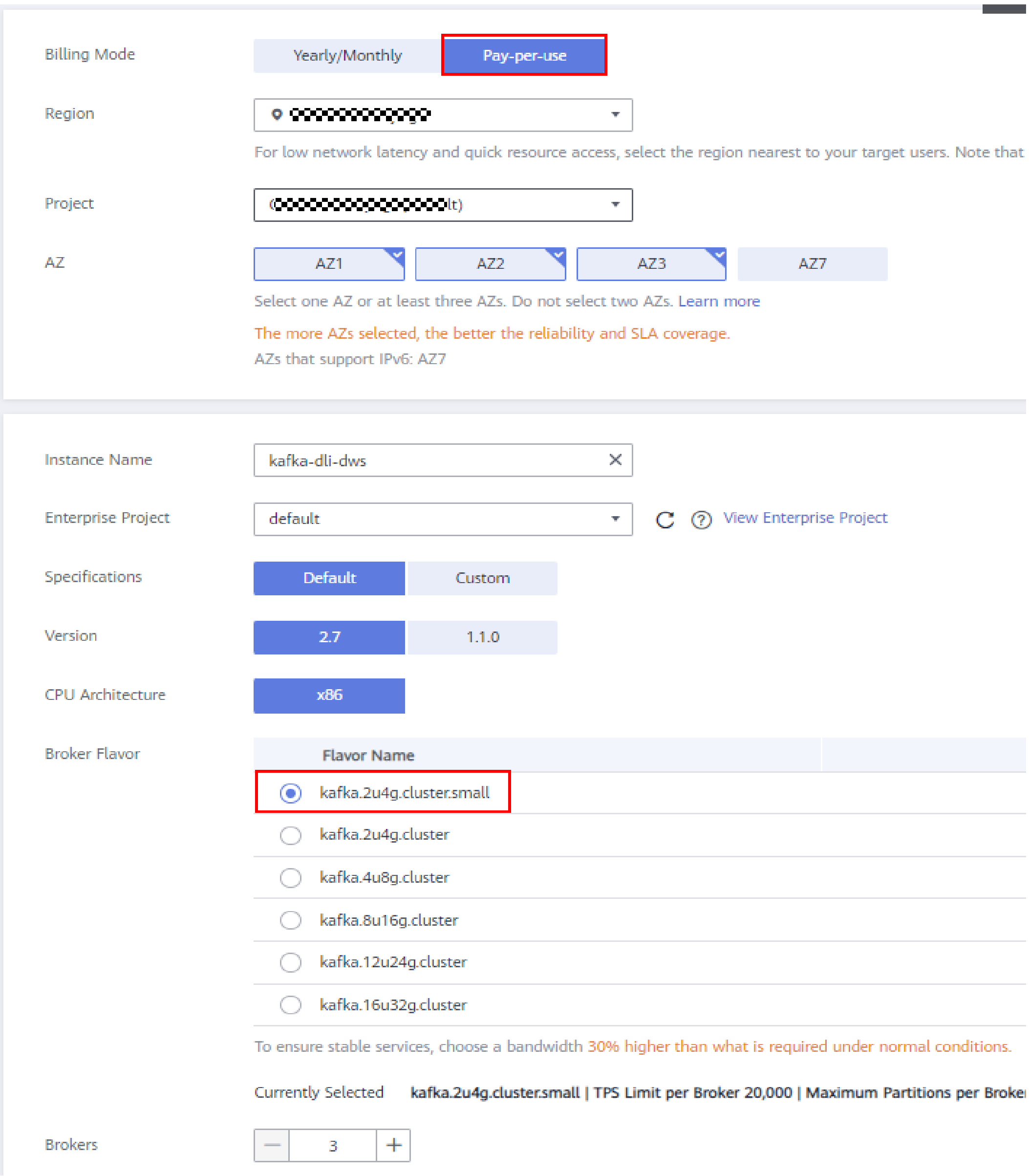
Step 2 Click **DMS for Kafka** on the left and click **Buy Instance** in the upper right corner.

Step 3 Set the following parameters. Retain the default values for other parameters that are not described in the table.

Table 2-13 Kafka instance parameters

Parameter	Value
Billing Mode	Pay-per-use
Region	Europe-Dublin
Project	Default
AZ	AZ 1 (If not available, select another AZ.)
Instance Name	kafka-dli-dws
Enterprise Project	default
Specifications	Default
Version	2.7
CPU Architecture	x86
Broker Flavor	kafka.2u4g.cluster.small (For reference only. Select the smallest flavor.)
Brokers	3
VPC	Select a created VPC. If no VPC is available, create one.
Security Group	Select a created security group. If no security group is available, create one.
Other parameters	Retain the default value.

Figure 2-5 Creating a Kafka instance



Billing Mode: Yearly/Monthly | Pay-per-use

Region: [redacted]

For low network latency and quick resource access, select the region nearest to your target users. Note that

Project: [redacted]

AZ: AZ1 | AZ2 | AZ3 | AZ7

Select one AZ or at least three AZs. Do not select two AZs. Learn more

The more AZs selected, the better the reliability and SLA coverage.

AZs that support IPv6: AZ7

Instance Name: kafka-dli-dws

Enterprise Project: default | View Enterprise Project

Specifications: Default | Custom

Version: 2.7 | 1.1.0

CPU Architecture: x86

Broker Flavor:

	Flavor Name
●	kafka.2u4g.cluster.small
○	kafka.2u4g.cluster
○	kafka.4u8g.cluster
○	kafka.8u16g.cluster
○	kafka.12u24g.cluster
○	kafka.16u32g.cluster

To ensure stable services, choose a bandwidth 30% higher than what is required under normal conditions.

Currently Selected **kafka.2u4g.cluster.small | TPS Limit per Broker 20,000 | Maximum Partitions per Broke**

Brokers: 3

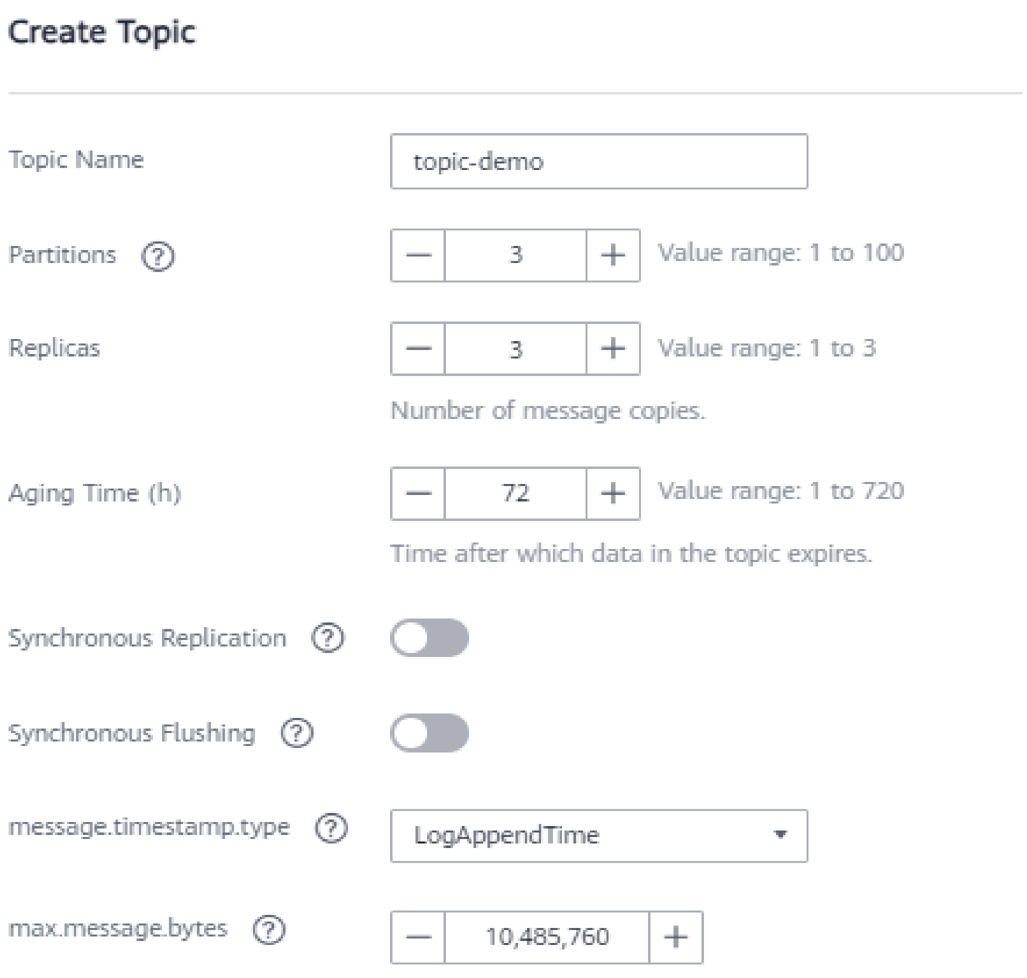
Step 4 Click **Buy** and complete the payment. Wait until the creation is successful.

Step 5 In the Kafka instance list, click the name of the created Kafka instance. The **Basic Information** page is displayed.

Step 6 Choose **Topics** on the left and click **Create Topic**.

Set **Topic Name** to **topic-demo** and retain the default values for other parameters.

Figure 2-6 Creating a topic



Create Topic

Topic Name: topic-demo

Partitions: 3 — Value range: 1 to 100

Replicas: 3 — Value range: 1 to 3

Number of message copies.

Aging Time (h): 72 — Value range: 1 to 720

Time after which data in the topic expires.

Synchronous Replication: off

Synchronous Flushing: off

message.timestamp.type: LogAppendTime

max.message.bytes: 10,485,760

Step 7 Click **OK**. In the topic list, you can see that topic-demo is successfully created.

Step 8 Choose **Consumer Groups** on the left and click **Create Consumer Group**.

Step 9 Enter **kafka01** for **Consumer Group Name** and click **OK**.

----End

Step 2: Creating a GaussDB(DWS) Cluster and Target Table

Step 1 **Create a dedicated load balancer**, set **Network Type** to **IPv4 private network**. Set Region and VPC to the same values as those of the Kafka instance. In this example, set Region to Europe-Dublin.

Step 2 **Creating a Cluster**. To ensure network connectivity, the region and VPC of the GaussDB(DWS) cluster must be the same as those of the Kafka instance. In this practice, the region and VPC are Europe-Dublin. The VPC must be the same as that created for Kafka.

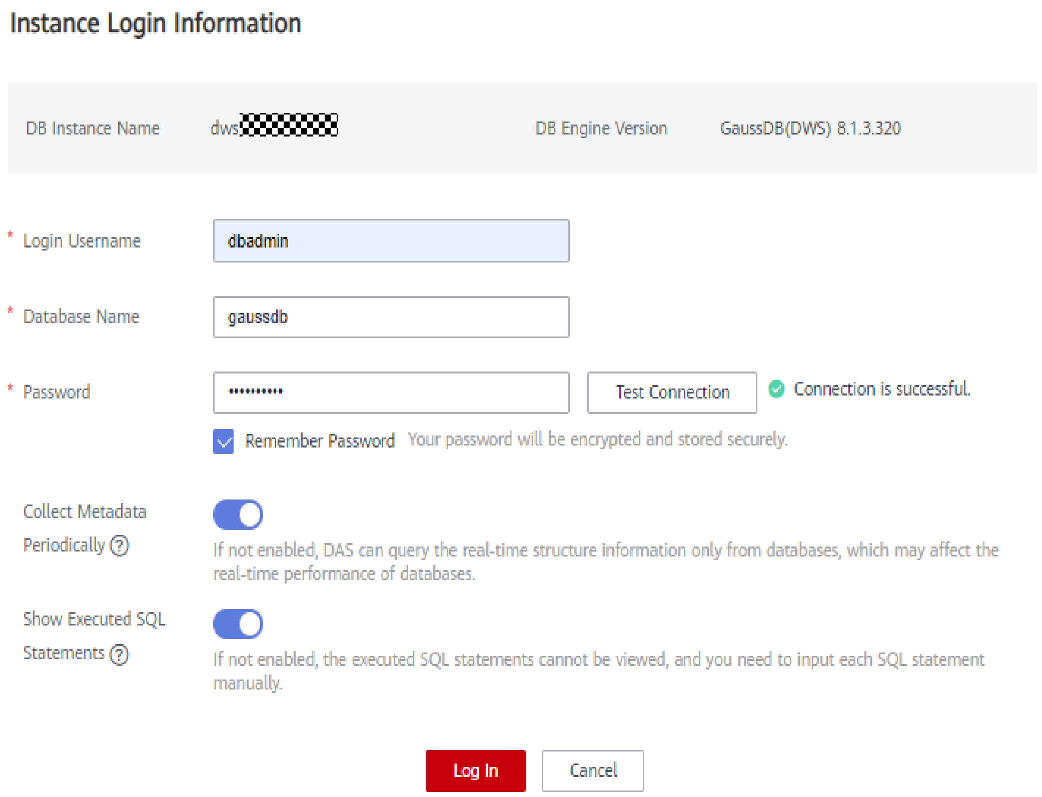
Step 3 On the **Clusters** page of the GaussDB(DWS) console, locate the row that contains the target cluster and click **Login** in the **Operation** column.

NOTE

This practice uses version 8.1.3.x as an example. 8.1.2 and earlier versions do not support this login mode. You can use Data Studio to connect to a cluster. For details, see **Using Data Studio to Connect to a Cluster**.

Step 4 The login username is **dbadmin**, the database name is **gaussdb**, and the password is the password of user **dbadmin** set during data warehouse cluster creation. Select **Remember Password**, enable **Collect Metadata Periodically** and **Show Executed SQL Statements**, and click **Log In**.

Figure 2-7 Logging In to GaussDB(DWS)



Instance Login Information

DB Instance Name dws[redacted]
DB Engine Version GaussDB(DWS) 8.1.3.320

* Login Username: dbadmin

* Database Name: gaussdb

* Password: •••••••••• Test Connection ✓ Connection is successful.

☑ Remember Password Your password will be encrypted and stored securely.

Collect Metadata Periodically ? ●

If not enabled, DAS can query the real-time structure information only from databases, which may affect the real-time performance of databases.

Show Executed SQL Statements ? ●

If not enabled, the executed SQL statements cannot be viewed, and you need to input each SQL statement manually.

Log In Cancel

Step 5 Click the database name **gaussdb** and click **SQL Window** in the upper right corner to access the SQL editor.

Step 6 Copy the following SQL statement. In the SQL window, click Execute SQL to create the target table **user_dws**.

```
CREATE TABLE user_dws (
id int,
name varchar(50),
age int,
PRIMARY KEY (id)
);
```

----End

Step 3: Creating a DLI Queue

Step 1 Log in to the Huawei Cloud management console and choose **Analytics** > **Data Lake Insight** from the service list. The DLI management console is displayed.

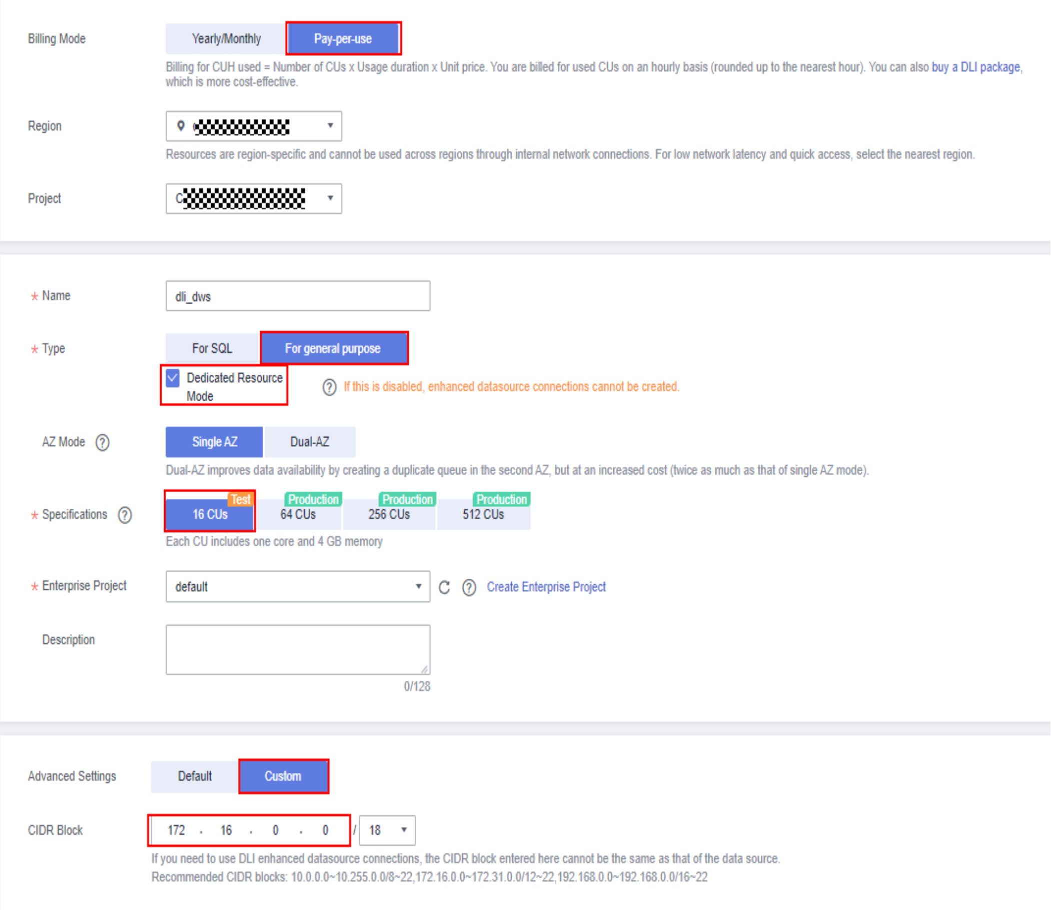
Step 2 In the navigation pane on the left, choose Resource Management > Queue Manager.

Step 3 Click **Buy Queue** in the upper right corner, set the following parameters, and retain the default values for other parameters that are not described in the table.

Table 2-14 DLI queue parameters

Parameter	Value
Billing Mode	Pay-per-use
Region	Europe-Dublin
Project	Default
Name	dli_dws
Type	For a general queue, select **Dedicated Resource Mode**.
AZ Mode	Single-AZ deployment
Specifications	16 CUs
Enterprise Project	default
Advanced Settings	Custom
CIDR Block	172.16.0.0/18. It must be in a different network segment from Kafka and GaussDB(DWS). For example, if Kafka and GaussDB(DWS) are in the 192.168.x.x network segment, select 172.16.x.x for DLI.

Figure 2-8 Creating a DLI queue



Billing Mode: Yearly/Monthly | **Pay-per-use**

Billing for CUH used = Number of CUs x Usage duration x Unit price. You are billed for used CUs on an hourly basis (rounded up to the nearest hour). You can also buy a DLI package, which is more cost-effective.

Region: [redacted]

Resources are region-specific and cannot be used across regions through internal network connections. For low network latency and quick access, select the nearest region.

Project: C[redacted]

* Name: dli_dws

* Type: For SQL | **For general purpose**

☑ Dedicated Resource Mode

If this is disabled, enhanced datasource connections cannot be created.

AZ Mode: **Single AZ** | Dual-AZ

Dual-AZ improves data availability by creating a duplicate queue in the second AZ, but at an increased cost (twice as much as that of single AZ mode).

* Specifications: **16 CUs** (Test) | 64 CUs (Production) | 256 CUs (Production) | 512 CUs (Production)

Each CU includes one core and 4 GB memory

* Enterprise Project: default

Create Enterprise Project

Description:

0/128

Advanced Settings: Default | **Custom**

CIDR Block: 172 . 16 . 0 . 0 / 18

If you need to use DLI enhanced datasource connections, the CIDR block entered here cannot be the same as that of the data source.

Recommended CIDR blocks: 10.0.0.0~10.255.0.0/8~22,172.16.0.0~172.31.0.0/12~22,192.168.0.0~192.168.0.0/16~22

Step 4 Click **Buy**.

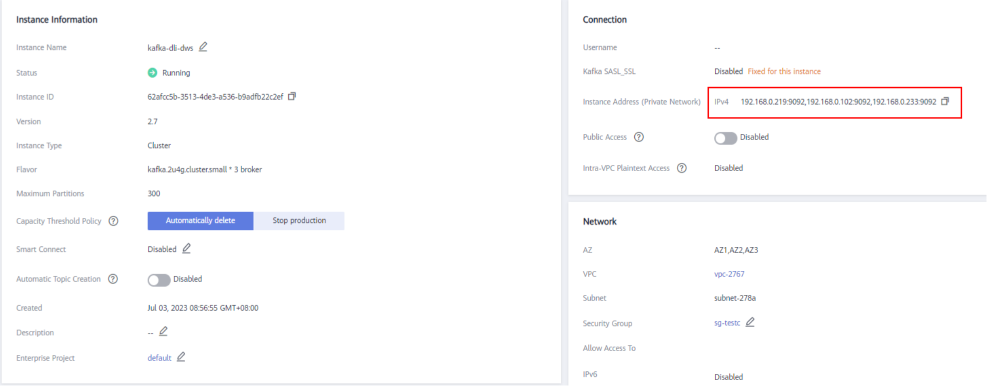
----End

Step 4: Creating an Enhanced Datasource Connection for Kafka and GaussDB(DWS)

Step 1 In the security group of Kafka, allow the network segment where the DLI queue is located.

1. Return to the Kafka console and click the Kafka instance name to go to the **Basic Information** page. View the value of **Instance Address (Private Network)** in connection information and record the address for future use.

Figure 2-9 Kafka private network address



Instance Information

Instance Name	kafka-dli-dws
Status	Running
Instance ID	62afcc5b-3513-4de3-a536-b9adfb22c2ef
Version	2.7
Instance Type	Cluster
Flavor	kafka.2u4g.cluster.small * 3 broker
Maximum Partitions	300
Capacity Threshold Policy	Automatically delete / Stop production
Smart Connect	Disabled
Automatic Topic Creation	Disabled
Created	Jul 03, 2023 08:56:55 GMT+08:00
Description	--
Enterprise Project	default

Connection

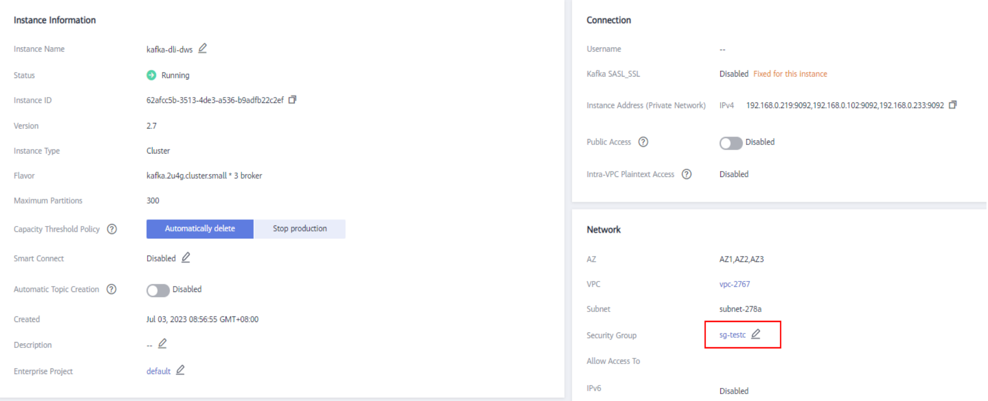
Username	--
Kafka SASL_SSL	Disabled Fixed for this instance
Instance Address (Private Network)	IPv4 192.168.0.219:9092,192.168.0.102:9092,192.168.0.233:9092
Public Access	Disabled
Intra-VPC Plaintext Access	Disabled

Network

AZ	AZ1,AZ2,AZ3
VPC	vpc-2767
Subnet	subnet-278a
Security Group	sg-testc
Allow Access To	
IPv6	Disabled

2. Click the security group name.

Figure 2-10 Kafka security group



Instance Information

Instance Name	kafka-dli-dws
Status	Running
Instance ID	62afcc5b-3513-4de3-a536-b9adfb22c2ef
Version	2.7
Instance Type	Cluster
Flavor	kafka.2u4g.cluster.small * 3 broker
Maximum Partitions	300
Capacity Threshold Policy	Automatically delete / Stop production
Smart Connect	Disabled
Automatic Topic Creation	Disabled
Created	Jul 03, 2023 08:56:55 GMT+08:00
Description	--
Enterprise Project	default

Connection

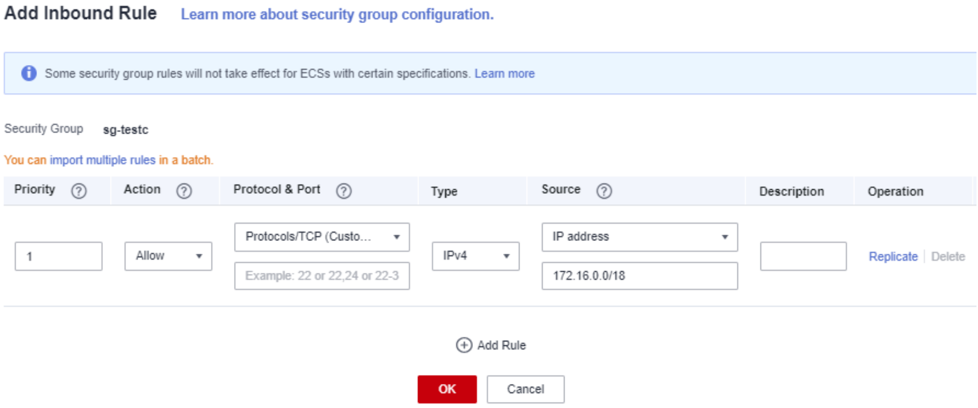
Username	--
Kafka SASL_SSL	Disabled Fixed for this instance
Instance Address (Private Network)	IPv4 192.168.0.219:9092,192.168.0.102:9092,192.168.0.233:9092
Public Access	Disabled
Intra-VPC Plaintext Access	Disabled

Network

AZ	AZ1,AZ2,AZ3
VPC	vpc-2767
Subnet	subnet-278a
Security Group	sg-testc
Allow Access To	
IPv6	Disabled

3. Choose **Inbound Rules** > **Add Rule**, as shown in the following figure. Add the network segment of the DLI queue. In this example, the network segment is **172.16.0.0/18**. Ensure that the network segment is the same as that entered during **Step 3: Creating a DLI Queue**.

Figure 2-11 Adding rules to the Kafka security group



Add Inbound Rule Learn more about security group configuration.

Some security group rules will not take effect for ECSs with certain specifications. Learn more

Security Group sg-testc

You can import multiple rules in a batch.

Priority	Action	Protocol & Port	Type	Source	Description	Operation
1	Allow	Protocols/TCP (Custo... Example: 22 or 22,24 or 22-3	IPv4	IP address 172.16.0.0/18		Replicate | Delete

4. Click **OK**.

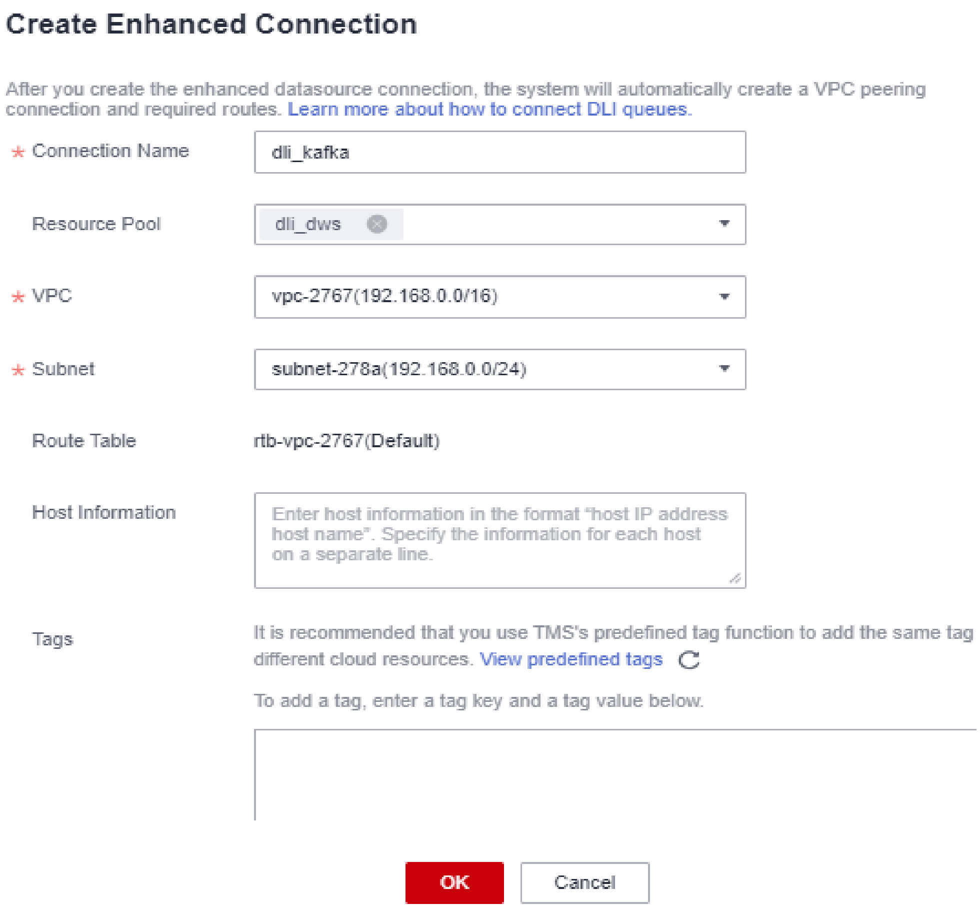
Step 2 Return to the DLI management console, click **Datasource Connections** on the left, select **Enhanced**, and click **Create**.

Step 3 Set the following parameters. Retain the default values for other parameters that are not described in the table.

Table 2-15 Connection from DLI to Kafka

Parameter	Value
Connection Name	dli_kafka
Resource Pool	Select the created DLI queue **dli_dws**.
VPC	Select the VPC of Kafka.
Subnet	Select the subnet where Kafka is located.
Other parameters	Retain the default value.

Figure 2-12 Creating an enhanced connection



Create Enhanced Connection

After you create the enhanced datasource connection, the system will automatically create a VPC peering connection and required routes. Learn more about how to connect DLI queues.

* Connection Name: dli_kafka

Resource Pool: dli_dws

* VPC: vpc-2767(192.168.0.0/16)

* Subnet: subnet-278a(192.168.0.0/24)

Route Table: rtb-vpc-2767(Default)

Host Information: Enter host information in the format "host IP address host name". Specify the information for each host on a separate line.

Tags: It is recommended that you use TMS's predefined tag function to add the same tag different cloud resources. View predefined tags

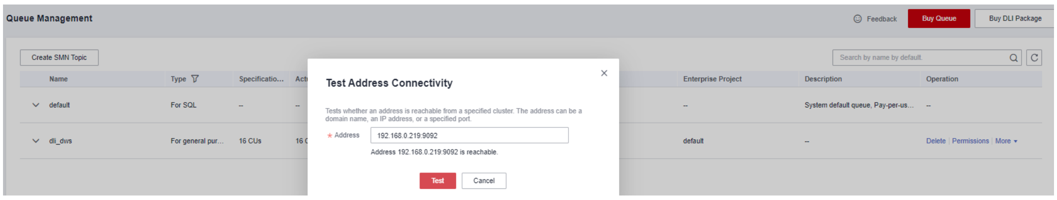
To add a tag, enter a tag key and a tag value below.

Step 4 Click **OK**. Wait until the Kafka connection is successfully created.

Step 5 Choose **Resources** > **Queue Management** on the left, and choose **More** > **Test Address Connectivity** on the right of **dli_dws**.

Step 6 In the address box, enter the private IP address and port number of the Kafka instance obtained in **Step 1.1**. (There are three Kafka addresses. Enter only one of them.)

Figure 2-13 Testing Kafka connectivity



Name	Type	Specificatio...	Act...	Enterprise Project	Description	Operation
default	For SQL	--	--	--	System default queue, Pay-per-us...	--
dli_dws	For general pur...	16 CUs	16 C	default	--	Delete | Permissions | More

Test Address Connectivity

Tests whether an address is reachable from a specified cluster. The address can be a domain name, an IP address, or a specified port.

* Address: 192.168.0.219:9092

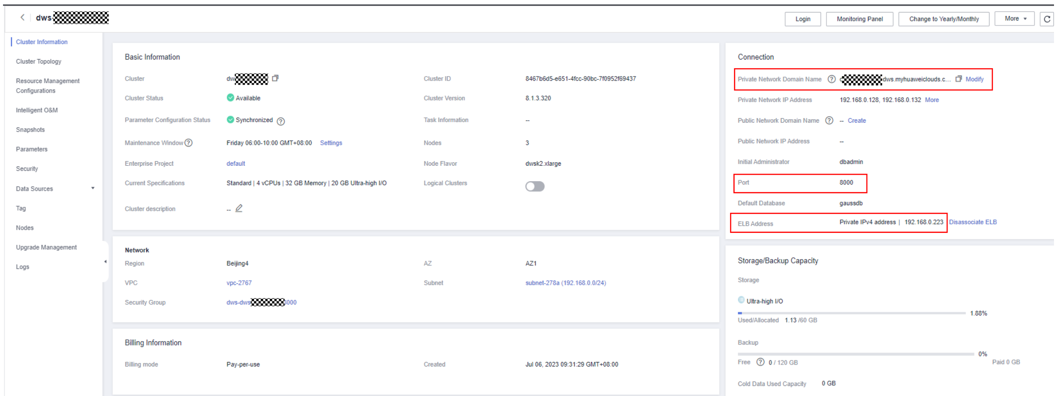
Address 192.168.0.219:9092 is reachable.

Step 7 Click **Test** to verify that DLI is successfully connected to Kafka.

Step 8 Log in to the GaussDB(DWS) management console, choose **Clusters** on the left, and click the cluster name to go to the details page.

Step 9 Record the private network domain name, port number, and Elastic Load Balance address of the data warehouse cluster for future use.

Figure 2-14 Private Domain Name and ELB Address



Basic Information

Cluster	dw[redacted]	Cluster ID	8467b6d5-e651-4fcc-90bc-7f0952f69437
Cluster Status	Available	Cluster Version	8.1.3.320
Parameter Configuration Status	Synchronized	Task Information	--
Maintenance Window	Friday 06:00-10:00 GMT+08:00 Settings	Nodes	3
Enterprise Project	default	Node Flavor	dwsk2.xlarge
Current Specifications	Standard | 4 vCPUs | 32 GB Memory | 20 GB Ultra-high I/O	Logical Clusters	
Cluster description	--		

Network

Region	Beijing4	AZ	AZ1
VPC	vpc-2767	Subnet	subnet-278a (192.168.0.0/24)
Security Group	dws-dws[redacted]000		

Billing Information

Billing mode	Pay-per-use	Created	Jul 06, 2023 09:31:29 GMT+08:00

Connection

Private Network Domain Name	[redacted]dws.myhuaweiclouds.c... Modify
Private Network IP Address	192.168.0.128, 192.168.0.132 More
Public Network Domain Name	-- Create
Public Network IP Address	--
Initial Administrator	dbadmin
Port	8000
Default Database	gaussdb
ELB Address	Private IPv4 address | 192.168.0.223 Disassociate ELB

Storage/Backup Capacity

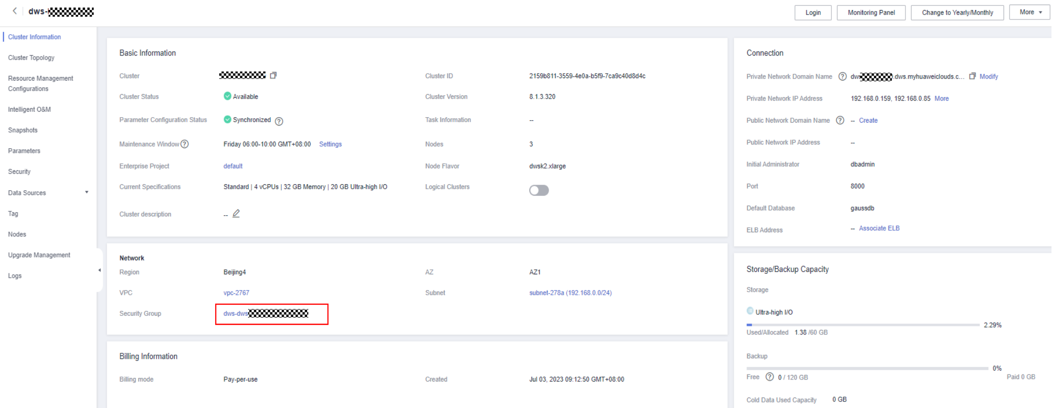
Storage: Ultra-high I/O 1.88% Used/Allocated 1.13 /60 GB

Backup: 0% Free 0 / 120 GB Paid 0 GB

Cold Data Used Capacity 0 GB

Step 10 Click the security group name.

Figure 2-15 GaussDB(DWS) security group



Basic Information

Cluster	[redacted]	Cluster ID	2159b811-3559-4e0a-b5f9-7ca9c40d8d4c
Cluster Status	Available	Cluster Version	8.1.3.320
Parameter Configuration Status	Synchronized	Task Information	--
Maintenance Window	Friday 06:00-10:00 GMT+08:00 Settings	Nodes	3
Enterprise Project	default	Node Flavor	dwsk2.xlarge
Current Specifications	Standard | 4 vCPUs | 32 GB Memory | 20 GB Ultra-high I/O	Logical Clusters	
Cluster description	--		

Network

Region	Beijing4	AZ	AZ1
VPC	vpc-2767	Subnet	subnet-278a (192.168.0.0/24)
Security Group	dws-dws[redacted]		

Billing Information

Billing mode	Pay-per-use	Created	Jul 03, 2023 09:12:50 GMT+08:00

Connection

Private Network Domain Name	dws[redacted].dws.myhuaweiclouds.c... Modify
Private Network IP Address	192.168.0.159, 192.168.0.85 More
Public Network Domain Name	-- Create
Public Network IP Address	--
Initial Administrator	dbadmin
Port	8000
Default Database	gaussdb
ELB Address	-- Associate ELB

Storage/Backup Capacity

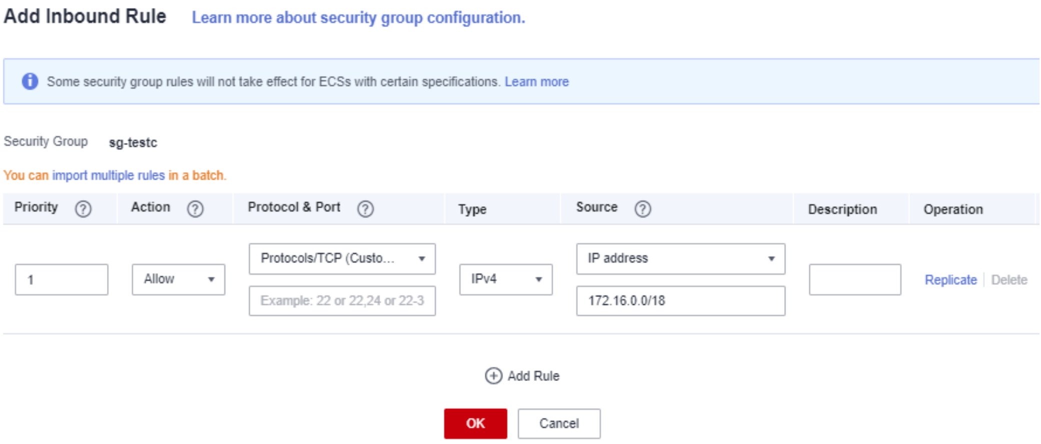
Storage: Ultra-high I/O 2.29% Used/Allocated 1.38 /60 GB

Backup: 0% Free 0 / 120 GB Paid 0 GB

Cold Data Used Capacity 0 GB

Step 11 Choose **Inbound Rules** > **Add Rule**, as shown in the following figure. Add the network segment of the DLI queue. In this example, the network segment is **172.16.0.0/18**. Ensure that the network segment is the same as that entered during **Step 3: Creating a DLI Queue**.

Figure 2-16 Adding a rule to the GaussDB(DWS) security group



Add Inbound Rule Learn more about security group configuration.

Some security group rules will not take effect for ECSs with certain specifications. Learn more

Security Group sg-testc

You can import multiple rules in a batch.

Priority	Action	Protocol & Port	Type	Source	Description	Operation
1	Allow	Protocols/TCP (Custo... Example: 22 or 22,24 or 22-3	IPv4	IP address 172.16.0.0/18		Replicate | Delete

Add Rule

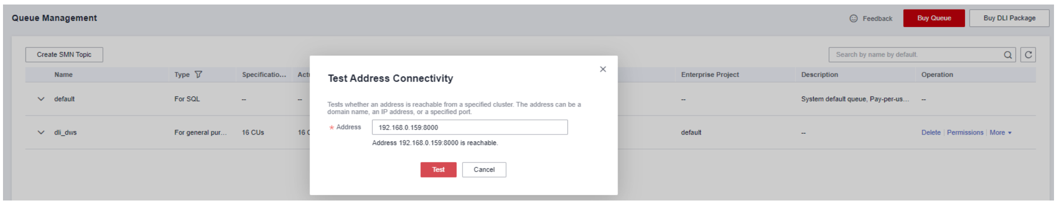
OK Cancel

Step 12 Click **OK**.

Step 13 Switch to the DLI console, choose **Resources** > **Queue Management** on the left, and click **More** > **Test Address Connectivity** on the right of **dli_dws**.

Step 14 In the address box, enter the Elastic Load Balance IP address and port number of the GaussDB (DWS) cluster obtained in **Step 9**.

Figure 2-17 Testing GaussDB(DWS) connectivity



Queue Management

Feedback Buy Queue Buy DLI Package

Create SMN Topic

Search by name by default.

Name	Type	Specificatio...	Act...	Enterprise Project	Description	Operation
default	For SQL	--	--	--	System default queue, Pay-per-us...	--
dli_dws	For general pur...	16 CUs	16 C...	default	--	Delete | Permissions | More

Test Address Connectivity

Tests whether an address is reachable from a specified cluster. The address can be a domain name, an IP address, or a specified port.

* Address 192.168.0.159:8000

Address 192.168.0.159:8000 is reachable.

Test Cancel

Step 15 Click **Test** to verify that DLI is successfully connected to GaussDB(DWS).

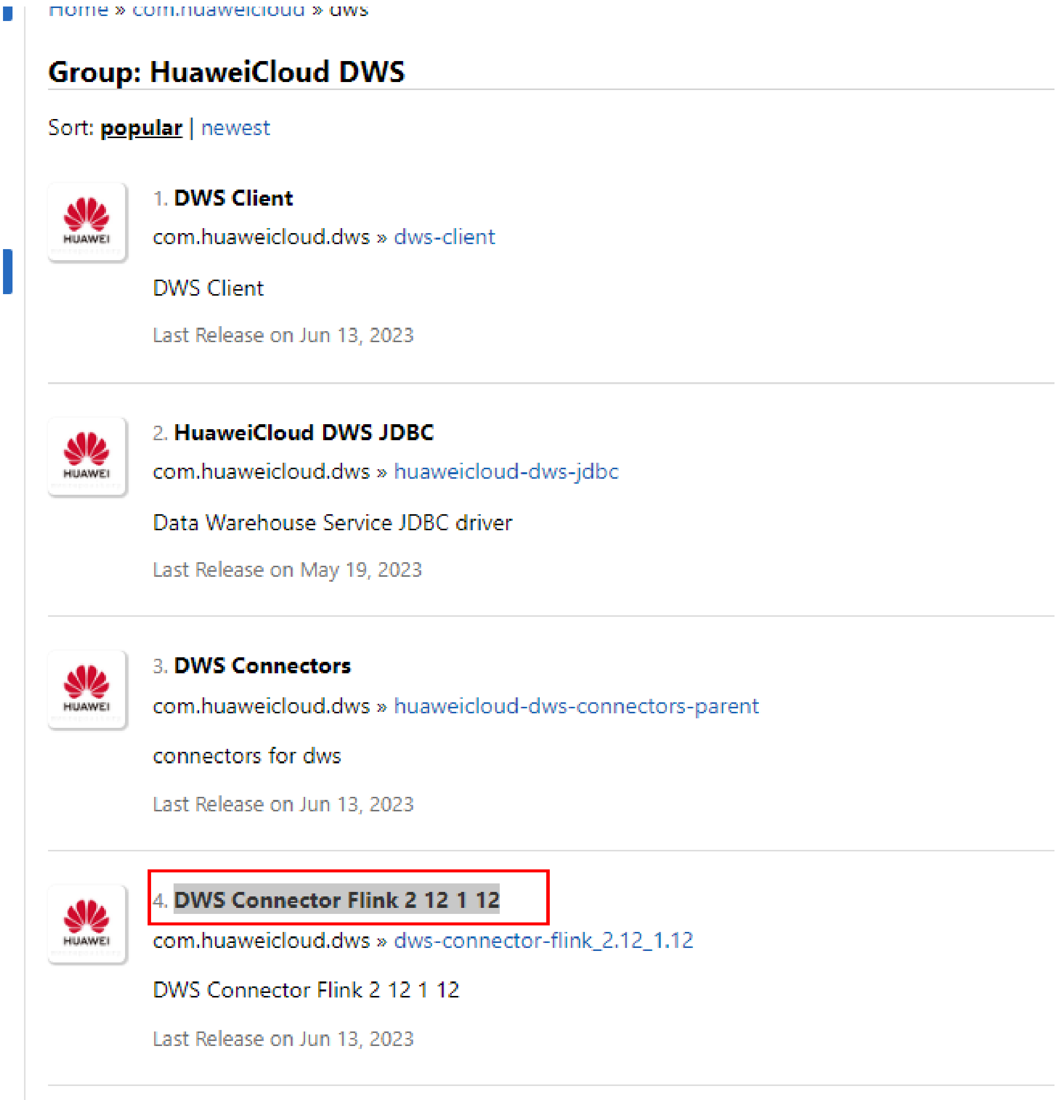
----End

Step 5: Preparing the dws-connector-flink Tool for Interconnecting GaussDB(DWS) with Flink

dws-connector-flink is a tool for interconnecting with Flink based on DWS JDBC APIs. During DLI job configuration, this tool and its dependencies are stored in the Flink class loading directory to improve the capability of importing Flink jobs to GaussDB(DWS).

Step 1 Go to **https://mvnrepository.com/artifact/com.huaweicloud.dws** using a browser.

Step 2 In the software list, select the latest version of GaussDB(DWS) Connectors Flink. In this practice, select **DWS Connector Flink 2 12 1 12**.



Home » com.huaweicloud » dws

Group: HuaweiCloud DWS

Sort: popular | newest

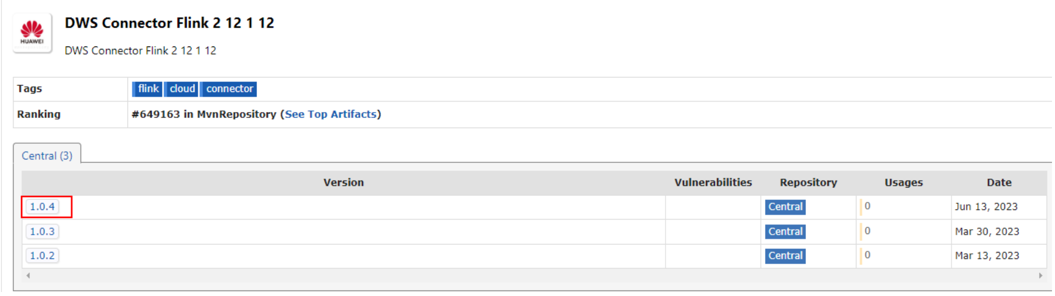
1. DWS Client
com.huaweicloud.dws » dws-client
DWS Client
Last Release on Jun 13, 2023

2. HuaweiCloud DWS JDBC
com.huaweicloud.dws » huaweicloud-dws-jdbc
Data Warehouse Service JDBC driver
Last Release on May 19, 2023

3. DWS Connectors
com.huaweicloud.dws » huaweicloud-dws-connectors-parent
connectors for dws
Last Release on Jun 13, 2023

4. DWS Connector Flink 2 12 1 12
com.huaweicloud.dws » dws-connector-flink_2.12_1.12
DWS Connector Flink 2 12 1 12
Last Release on Jun 13, 2023

Step 3 Click the 1.0.4 branch.(Click the newest branch in actual scenarios).



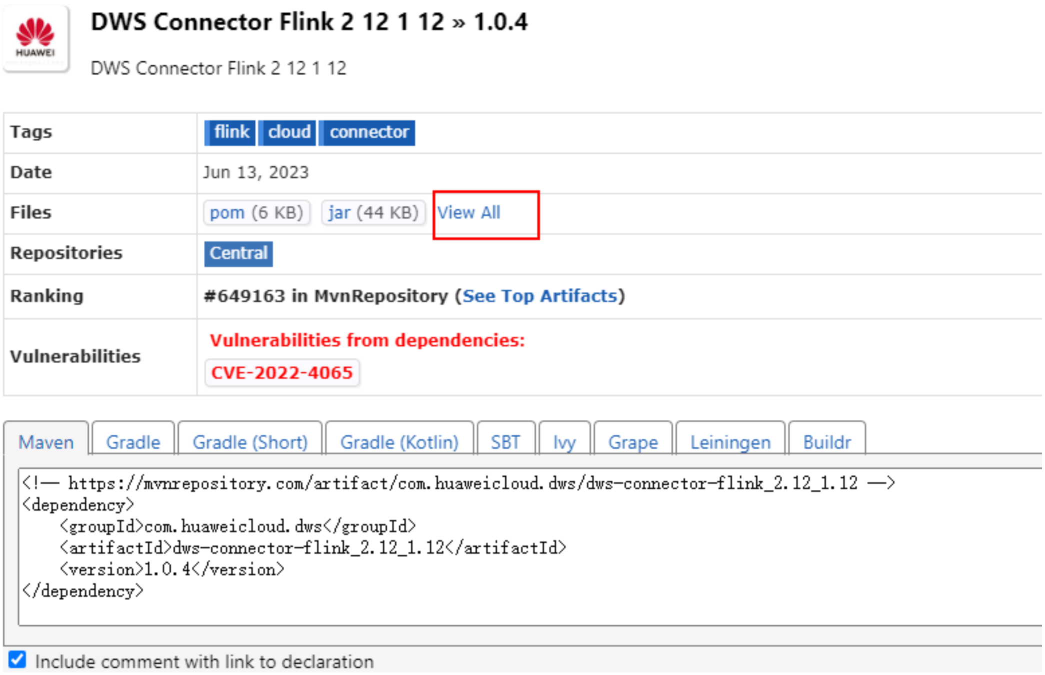
DWS Connector Flink 2 12 1 12
DWS Connector Flink 2 12 1 12

Tags	flink cloud connector
Ranking	#649163 in MvnRepository (See Top Artifacts)

Central (3)

Version	Vulnerabilities	Repository	Usages	Date
1.0.4		Central	0	Jun 13, 2023
1.0.3		Central	0	Mar 30, 2023
1.0.2		Central	0	Mar 13, 2023

Step 4 Click **View ALL**.



DWS Connector Flink 2 12 1 12 » 1.0.4

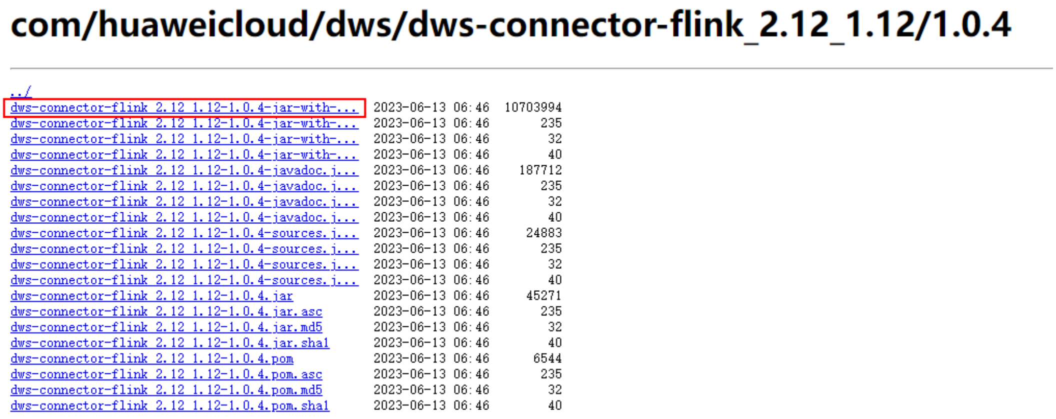
DWS Connector Flink 2 12 1 12

Tags	flink cloud connector
Date	Jun 13, 2023
Files	pom (6 KB) jar (44 KB) View All
Repositories	Central
Ranking	**#649163 in MvnRepository (See Top Artifacts)**
Vulnerabilities	**Vulnerabilities from dependencies:** **CVE-2022-4065**

```
<!-- https://mvnrepository.com/artifact/com.huaweicloud.dws/dws-connector-flink_2.12_1.12 -->
<dependency>
    <groupId>com.huaweicloud.dws</groupId>
    <artifactId>dws-connector-flink_2.12_1.12</artifactId>
    <version>1.0.4</version>
</dependency>
```

☑ Include comment with link to declaration

Step 5 Click **dws-connector-flink_2.12_1.12-1.0.4-jar-with-dependencies.jar** to download it to the local host.

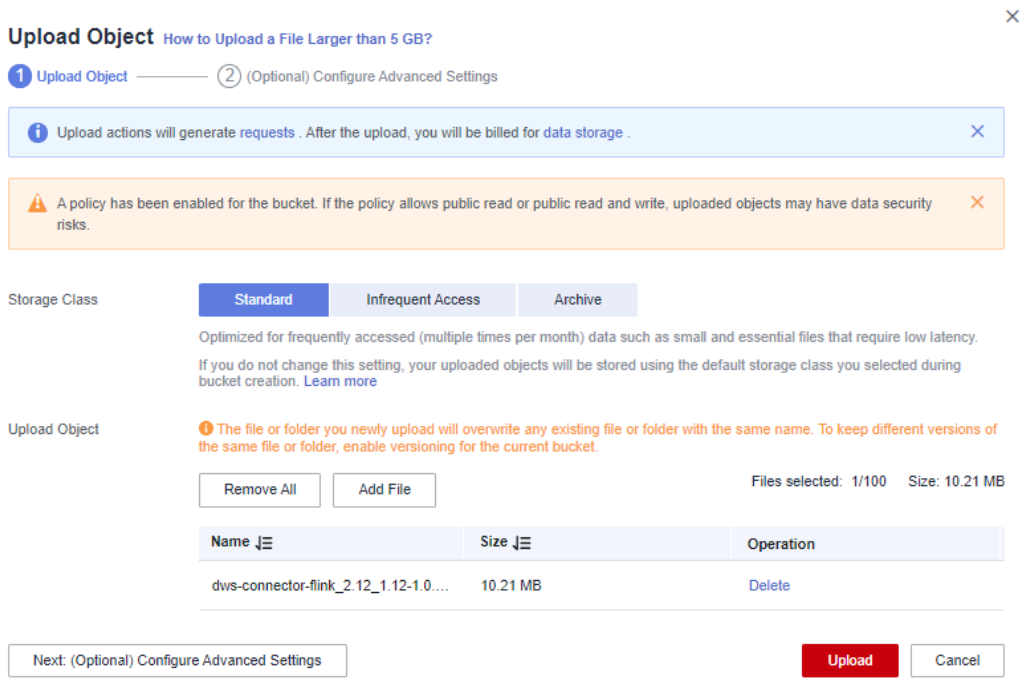


com/huaweicloud/dws/dws-connector-flink_2.12_1.12/1.0.4

```
../
dws-connector-flink_2.12_1.12-1.0.4-jar-with-...  2023-06-13 06:46  10703994
dws-connector-flink_2.12_1.12-1.0.4-jar-with-...  2023-06-13 06:46       235
dws-connector-flink_2.12_1.12-1.0.4-jar-with-...  2023-06-13 06:46        32
dws-connector-flink_2.12_1.12-1.0.4-jar-with-...  2023-06-13 06:46        40
dws-connector-flink_2.12_1.12-1.0.4-javadoc.j...  2023-06-13 06:46    187712
dws-connector-flink_2.12_1.12-1.0.4-javadoc.j...  2023-06-13 06:46       235
dws-connector-flink_2.12_1.12-1.0.4-javadoc.j...  2023-06-13 06:46        32
dws-connector-flink_2.12_1.12-1.0.4-javadoc.j...  2023-06-13 06:46        40
dws-connector-flink_2.12_1.12-1.0.4-sources.j...  2023-06-13 06:46     24883
dws-connector-flink_2.12_1.12-1.0.4-sources.j...  2023-06-13 06:46       235
dws-connector-flink_2.12_1.12-1.0.4-sources.j...  2023-06-13 06:46        32
dws-connector-flink_2.12_1.12-1.0.4-sources.j...  2023-06-13 06:46        40
dws-connector-flink_2.12_1.12-1.0.4.jar           2023-06-13 06:46     45271
dws-connector-flink_2.12_1.12-1.0.4.jar.asc       2023-06-13 06:46       235
dws-connector-flink_2.12_1.12-1.0.4.jar.md5       2023-06-13 06:46        32
dws-connector-flink_2.12_1.12-1.0.4.jar.sha1      2023-06-13 06:46        40
dws-connector-flink_2.12_1.12-1.0.4.pom           2023-06-13 06:46      6544
dws-connector-flink_2.12_1.12-1.0.4.pom.asc       2023-06-13 06:46       235
dws-connector-flink_2.12_1.12-1.0.4.pom.md5       2023-06-13 06:46        32
dws-connector-flink_2.12_1.12-1.0.4.pom.sha1      2023-06-13 06:46        40
```

Step 6 Create an OBS bucket. In this practice, set the bucket name to **obs-flink-dws** and upload the file to the OBS bucket. Ensure that the bucket is in the same region as DLI, which in this practice is Europe-Dublin.

Figure 2-18 Uploading the JAR package to the OBS bucket



Upload Object How to Upload a File Larger than 5 GB?

1 Upload Object —— 2 (Optional) Configure Advanced Settings

Upload actions will generate requests . After the upload, you will be billed for data storage .

A policy has been enabled for the bucket. If the policy allows public read or public read and write, uploaded objects may have data security risks.

Storage Class: Standard | Infrequent Access | Archive

Optimized for frequently accessed (multiple times per month) data such as small and essential files that require low latency.

If you do not change this setting, your uploaded objects will be stored using the default storage class you selected during bucket creation. Learn more

Upload Object: The file or folder you newly upload will overwrite any existing file or folder with the same name. To keep different versions of the same file or folder, enable versioning for the current bucket.

Files selected: 1/100 Size: 10.21 MB

Name	Size	Operation
dws-connector-flink_2.12_1.12-1.0....	10.21 MB	Delete

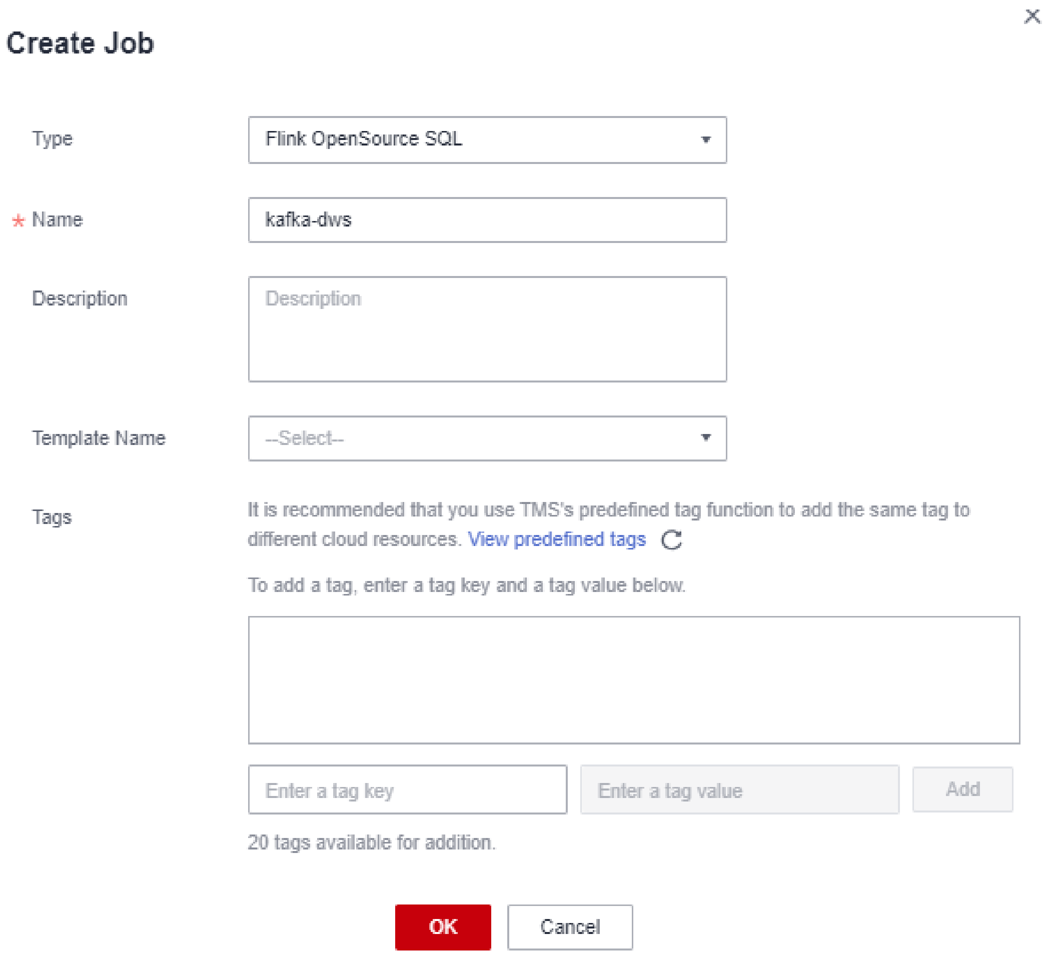
----End

Step 6: Creating and Editing a DLI Flink Job

Step 1 Return to the DLI management console, choose **Job Management** > **Flink Jobs** on the left, and click **Create Job** in the upper right corner.

Step 2 Set **Type** to **Flink OpenSource SQL** and **Name** to **kafka-dws**.

Figure 2-19 Creating a job



Create Job

Type: Flink OpenSource SQL

* Name: kafka-dws

Description: Description

Template Name: --Select--

Tags: It is recommended that you use TMS's predefined tag function to add the same tag to different cloud resources. View predefined tags

To add a tag, enter a tag key and a tag value below.

Enter a tag key | Enter a tag value | Add

20 tags available for addition.

OK | Cancel

Step 3 Click **OK**. The page for editing the job is displayed.

Step 4 Set the following parameters on the right of the page. Retain the default values for other parameters that are not described in the table.

Table 2-16 Flink job parameters

Parameter	Value
Queue	dli_dws
Flink Version	1.12

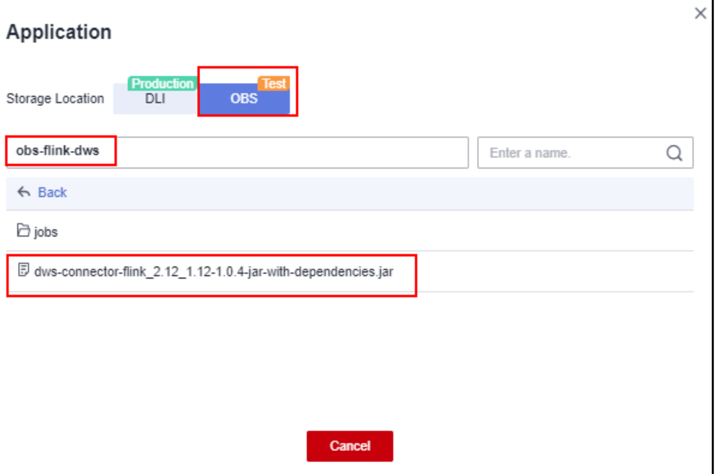
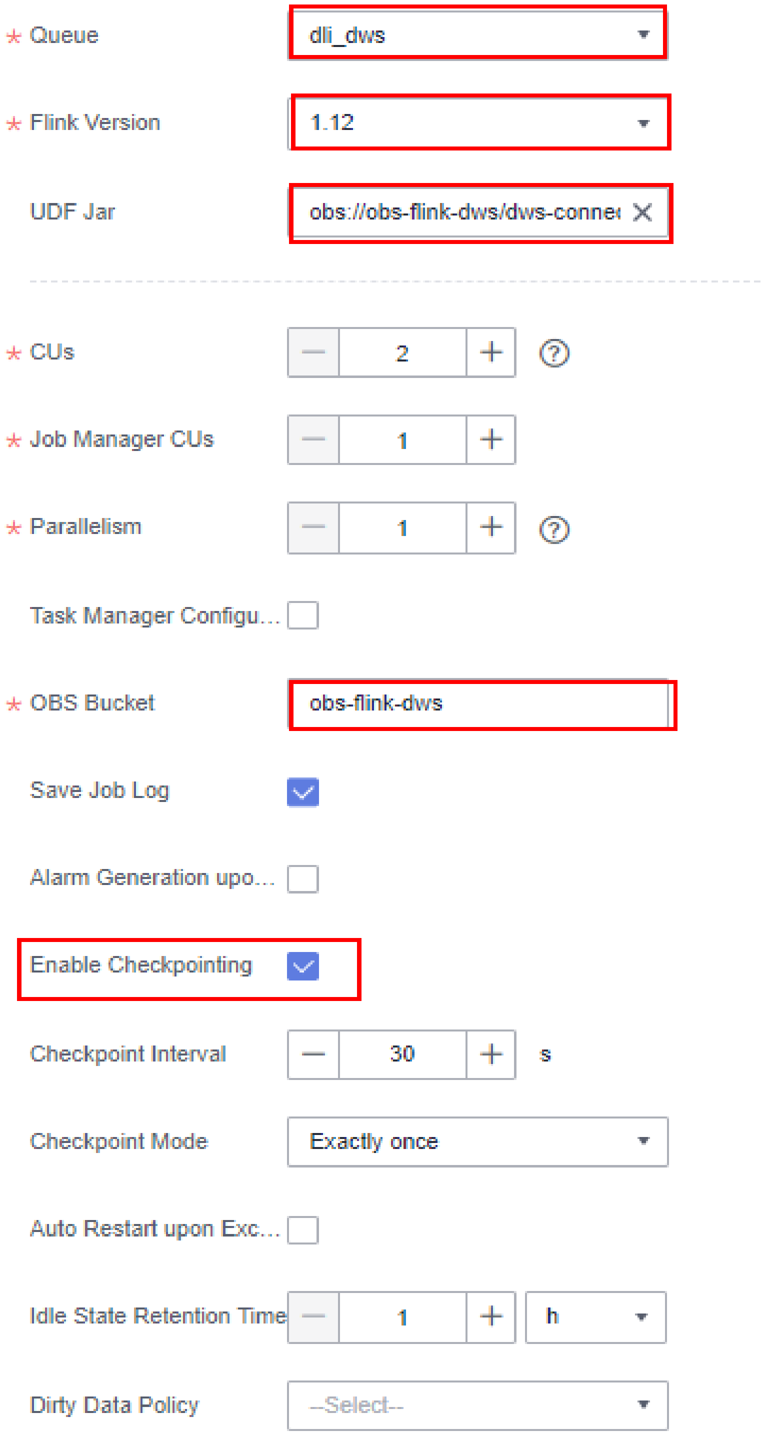
Parameter	Value
UDF Jar	Select the JAR file in the OBS bucket created in **Step 5: Preparing the dws-connector-flink Tool for Interconnecting GaussDB(DWS) with Flink**.  Application Storage Location: OBS obs-flink-dws jobs dws-connector-flink_2.12_1.12-1.0.4-jar-with-dependencies.jar Production DLI Test Enter a name. Back Cancel
OBS Bucket	Select the bucket created in **Step 5: Preparing the dws-connector-flink Tool for Interconnecting GaussDB(DWS) with Flink**.
Enable Checkpointing	Check the box.
Other parameters	Retain the default value.

Figure 2-20 Editing a job



* Queue: dli_dws

* Flink Version: 1.12

UDF Jar: obs://obs-flink-dws/dws-conne ✕

* CUs: 2

* Job Manager CUs: 1

* Parallelism: 1

Task Manager Configu... □

* OBS Bucket: obs-flink-dws

Save Job Log ☑

Alarm Generation upo... □

Enable Checkpointing ☑

Checkpoint Interval: 30 s

Checkpoint Mode: Exactly once

Auto Restart upon Exc... □

Idle State Retention Time: 1 h

Dirty Data Policy: --Select--

Step 5 Copy the following SQL code to the SQL code window on the left.

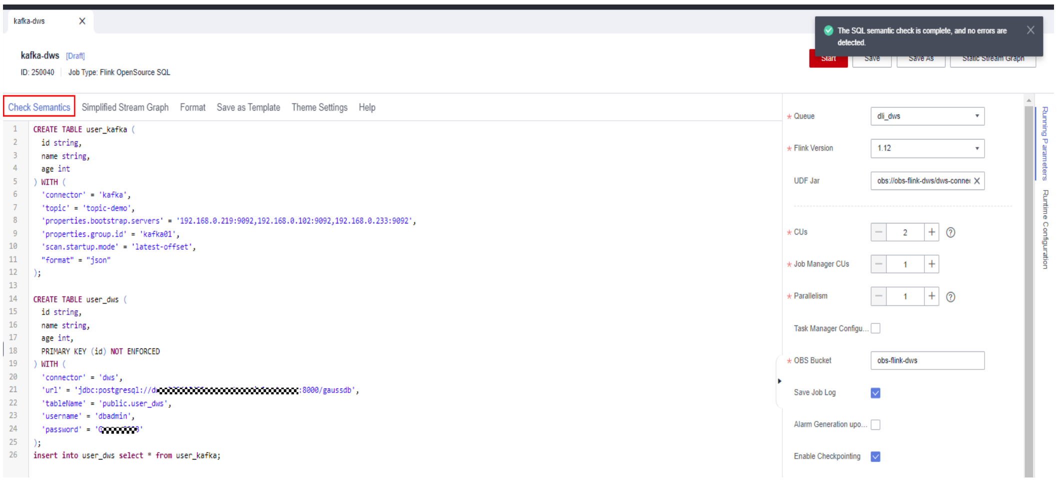
Obtain the private IP address and port number of the Kafka instance from **Step 1.1**, and obtain the private domain name from **Step 9**.

```
CREATE TABLE user_kafka (
  id string,
  name string,
  age int
) WITH (
  'connector' = 'kafka',
  'topic' = 'topic-demo',
'properties.bootstrap.servers' ='Private IP address and port number of the Kafka instance',
  'properties.group.id' = 'kafka01',
  'scan.startup.mode' = 'latest-offset',
  "format" = "json"
);

CREATE TABLE user_dws (
  id string,
  name string,
  age int,
  PRIMARY KEY (id) NOT ENFORCED
) WITH (
  'connector' = 'dws',
'url'='jdbc:postgresql://GaussDB(DWS) private network domain name:8000/gaussdb',
  'tableName' = 'public.user_dws',
  'username' = 'dbadmin',
'password' ='Password of database user dbdamin'
);

insert into user_dws select * from user_kafka;
```

Step 6 Click **Check Semantics** and wait until the verification is successful.

If the verification fails, check whether the SQL input has syntax errors.

Figure 2-21 SQL statement of a job



kafka-dws [Draft]
ID: 250040 Job Type: Flink OpenSource SQL

The SQL semantic check is complete, and no errors are detected.

```
CREATE TABLE user_kafka (
  id string,
  name string,
  age int
) WITH (
  'connector' = 'kafka',
  'topic' = 'topic-demo',
  'properties.bootstrap.servers' = '192.168.0.219:9092,192.168.0.102:9092,192.168.0.233:9092',
  'properties.group.id' = 'kafka01',
  'scan.startup.mode' = 'latest-offset',
  "format" = "json"
);

CREATE TABLE user_dws (
  id string,
  name string,
  age int,
  PRIMARY KEY (id) NOT ENFORCED
) WITH (
  'connector' = 'dws',
  'url' = 'jdbc:postgresql://d[redacted]:8000/gaussdb',
  'tableName' = 'public.user_dws',
  'username' = 'dbadmin',
  'password' = '[redacted]'
);
insert into user_dws select * from user_kafka;
```

* Queue: dli_dws
* Flink Version: 1.12
UDF Jar: obs://obs-flink-dws/dws-conne
* CUs: 2
* Job Manager CUs: 1
* Parallelism: 1
Task Manager Configu... □
* OBS Bucket: obs-flink-dws
Save Job Log ☑
Alarm Generation upo... □
Enable Checkpointing ☑

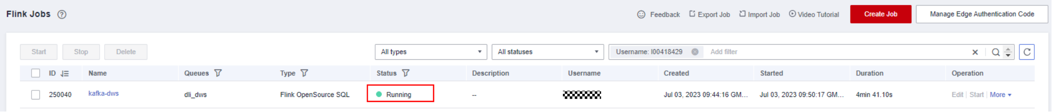
Step 7 Click **Save**.

Step 8 Return to the DLI console home page and choose **Job Management** > **Flink Jobs** on the left.

Step 9 Click **Start** on the right of the job name **kafka-dws** and click **Start Now**.

Wait for about 1 minute and refresh the page. If the status is **Running**, the job is successfully executed.

Figure 2-22 Job execution status



ID	Name	Queues	Type	Status	Description	Username	Created	Started	Duration	Operation
250040	kafka-dws	dli_dws	Flink OpenSource SQL	Running	--	[redacted]	Jul 03, 2023 09:44:16 GM...	Jul 03, 2023 09:50:17 GM...	4min 41.10s	Edit | Start | More

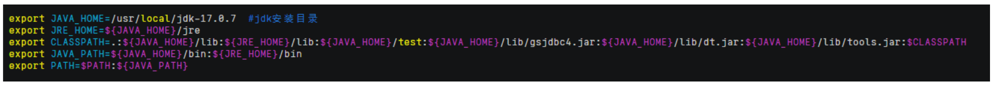
----End

Step 7: Creating and Modifying Messages on the Kafka Client

Step 1 Create an ECS by referring to the ECS document. Ensure that the region and VPC of the ECS are the same as those of Kafka.

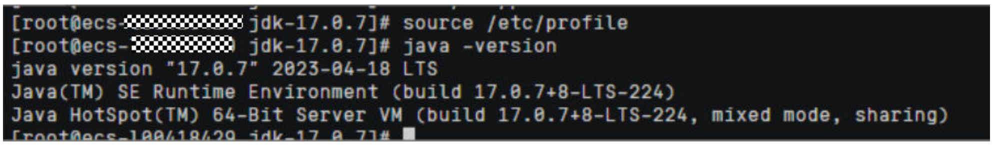
Step 2 Install JDK.

1. Log in to the ECS, go to the **/usr/local** directory, and download the JDK package.
   ```
   cd /usr/local
   wget https://download.oracle.com/java/17/latest/jdk-17_linux-x64_bin.tar.gz
   ```
2. Decompress the downloaded JDK package.
   ```
   tar -zxvf jdk-17_linux-x64_bin.tar.gz
   ```
3. Run the following command to open the **/etc/profile** file:
   ```
   vim /etc/profile
   ```
4. Press **i** to enter editing mode and add the following content to the end of the **/etc/profile** file:
   ```
   export JAVA_HOME=/usr/local/jdk-17.0.7 #JDK installation directory
   export JRE_HOME=${JAVA_HOME}/jre
   export CLASSPATH=.:${JAVA_HOME}/lib:${JRE_HOME}/lib:${JAVA_HOME}/test:${JAVA_HOME}/lib/
   gsjdbc4.jar:${JAVA_HOME}/lib/dt.jar:${JAVA_HOME}/lib/tools.jar:$CLASSPATH
   export JAVA_PATH=${JAVA_HOME}/bin:${JRE_HOME}/bin
   export PATH=$PATH:${JAVA_PATH}
   ```



```
export JAVA_HOME=/usr/local/jdk-17.0.7  #jdk安装目录
export JRE_HOME=${JAVA_HOME}/jre
export CLASSPATH=.:${JAVA_HOME}/lib:${JRE_HOME}/lib:${JAVA_HOME}/test:${JAVA_HOME}/lib/gsjdbc4.jar:${JAVA_HOME}/lib/dt.jar:${JAVA_HOME}/lib/tools.jar:$CLASSPATH
export JAVA_PATH=${JAVA_HOME}/bin:${JRE_HOME}/bin
export PATH=$PATH:${JAVA_PATH}
```

5. Press **Esc** and enter **:wq!** to save the settings and exit.
6. Run the following command for the environment variables to take effect:
   ```
   source /etc/profile
   ```
7. Run the following command. If the following information is displayed, the JDK is successfully installed:
   ```
   java -version
   ```



```
[root@ecs-[redacted] jdk-17.0.7]# source /etc/profile
[root@ecs-[redacted] jdk-17.0.7]# java -version
java version "17.0.7" 2023-04-18 LTS
Java(TM) SE Runtime Environment (build 17.0.7+8-LTS-224)
Java HotSpot(TM) 64-Bit Server VM (build 17.0.7+8-LTS-224, mixed mode, sharing)
[root@ecs-100418429 jdk-17.0.7]#
```

Step 3 Install the Kafka client.

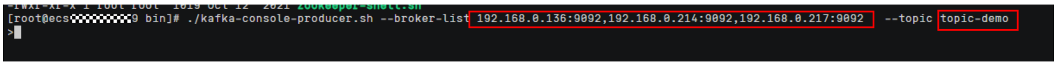
1. Go to the **/opt** directory and run the following command to obtain the Kafka client software package.
   ```
   cd /opt
   wget https://archive.apache.org/dist/kafka/2.7.2/kafka_2.12-2.7.2.tgz
   ```
2. Decompress the downloaded software package.
   ```
   tar -zxf kafka_2.12-2.7.2.tgz
   ```
3. Go to the Kafka client directory.
   ```
   cd /opt/kafka_2.12-2.7.2/bin
   ```

Step 4 Run the following command to connect to Kafka: {*Connection address*} indicates the internal network connection address of Kafka. For details about how to obtain the address, see **Step 1.1**. *topic* indicates the name of the Kafka topic created in **Step 6**.

```
./kafka-console-producer.sh --broker-list {connection address} --topic {Topic name}
```

The following is an example:

./kafka-console-producer.sh --broker-list 192.168.0.136:9092,192.168.0.214:9092,192.168.0.217:9092 --topic topic-demo

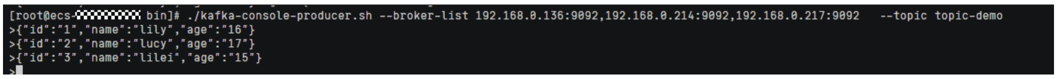


```
-rwxr-xr-x 1 root root  1019 Oct 12  2021 zookeeper-shell.sh
[root@ecs[redacted]9 bin]# ./kafka-console-producer.sh --broker-list 192.168.0.136:9092,192.168.0.214:9092,192.168.0.217:9092  --topic topic-demo
>
```

If **>** is displayed and no other error message is displayed, the connection is successful.

Step 5 In the window of the connected Kafka client, copy the following content (one line at a time) based on the data planned in the **Scenario Description** and press **Enter** to produce messages:

```
{"id":"1","name":"lily","age":"16"}
{"id":"2","name":"lucy","age":"17"}
{"id":"3","name":"lilei","age":"15"}
```

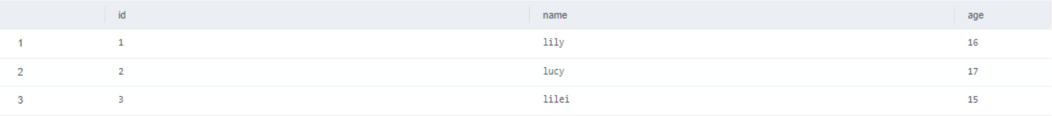


```
[root@ecs-[redacted] bin]# ./kafka-console-producer.sh --broker-list 192.168.0.136:9092,192.168.0.214:9092,192.168.0.217:9092   --topic topic-demo
>{"id":"1","name":"lily","age":"16"}
>{"id":"2","name":"lucy","age":"17"}
>{"id":"3","name":"lilei","age":"15"}
>
```

Step 6 Return to the GaussDB(DWS) console, choose **Clusters** on the left, and click **Log In** on the right of the GaussDB(DWS) cluster. The SQL page is displayed.

Step 7 Run the following SQL statement. You can find that the data is successfully saved to the database in real time.

```
SELECT * FROM user_dws ORDER BY id;
```



	id	name	age
1	1	lily	16
2	2	lucy	17
3	3	lilei	15

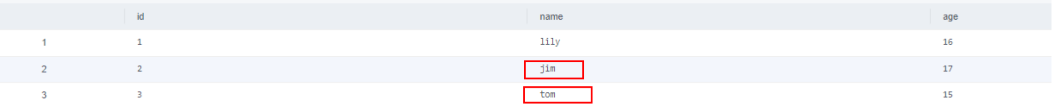
Step 8 Go back to the client window for connecting to Kafka on the ECS, copy the following content (one line at a time), and press **Enter** to produce messages.

```
{"id":"2","name":"jim","age":"17"}
{"id":"3","name":"tom","age":"15"}
```

Step 9 Go back to the opened SQL window of GaussDB(DWS) and run the following SQL statement. It is found that the names whose IDs are **2** and **3** have been changed to **jim** and **tom**.

The scenario description is as expected. End of this practice.

```
SELECT * FROM user_dws ORDER BY id;
```



	id	name	age
1	1	lily	16
2	2	jim	17
3	3	tom	15

----End

2.4 Practice of Data Interconnection Between Two DWS Clusters Based on GDS

This practice demonstrates how to migrate 15 million rows of data between two data warehouse clusters within minutes based on the high concurrency of GDS import and export.

NOTE

- This function is supported only by clusters of version 8.1.2 or later.
- GDS is a high-concurrency import and export tool developed by GaussDB(DWS). For more information, visit **GDS Usage Description**.
- This section describes only the operation practice. For details about GDS interconnection and syntax description, see **GDS-based cross-cluster interconnection**.

This practice takes about 90 minutes. The cloud service resources used in this practice are Data Warehouse Service (DWS), Elastic Cloud Server (ECS), and Virtual Private Cloud (VPC). The basic process is as follows:

1. **Preparations**
2. **Step 1: Creating Two DWS Clusters**
3. **Step 2: Preparing Source Data**
4. **Step 3: Installing and Starting the GDS Server**
5. **Step 4: Implementing Data Interconnection Across DWS Clusters**

Supported Regions

Table 2-17 Regions and OBS bucket names

Region	OBS Bucket
EU-Dublin	dws-demo-eu-west-101

Constraints

In this practice, two sets of DWS and ECS services are deployed in the same region and VPC to ensure network connectivity.

Preparations

- You have registered a Huawei account and enabled Huawei Cloud services.. Before using GaussDB(DWS), check the account status. The account cannot be in arrears or frozen.
- You have obtained the AK and SK of the account.
- You have created a VPC and subnet. For details, see **Creating a VPC**.

Step 1: Creating Two DWS Clusters

Create two GaussDB(DWS) clusters in the Europe-Dublin region. For details, see **Creating a Cluster**. The two clusters are named dws-demo01 and dws-demo02.

Step 2: Preparing Source Data

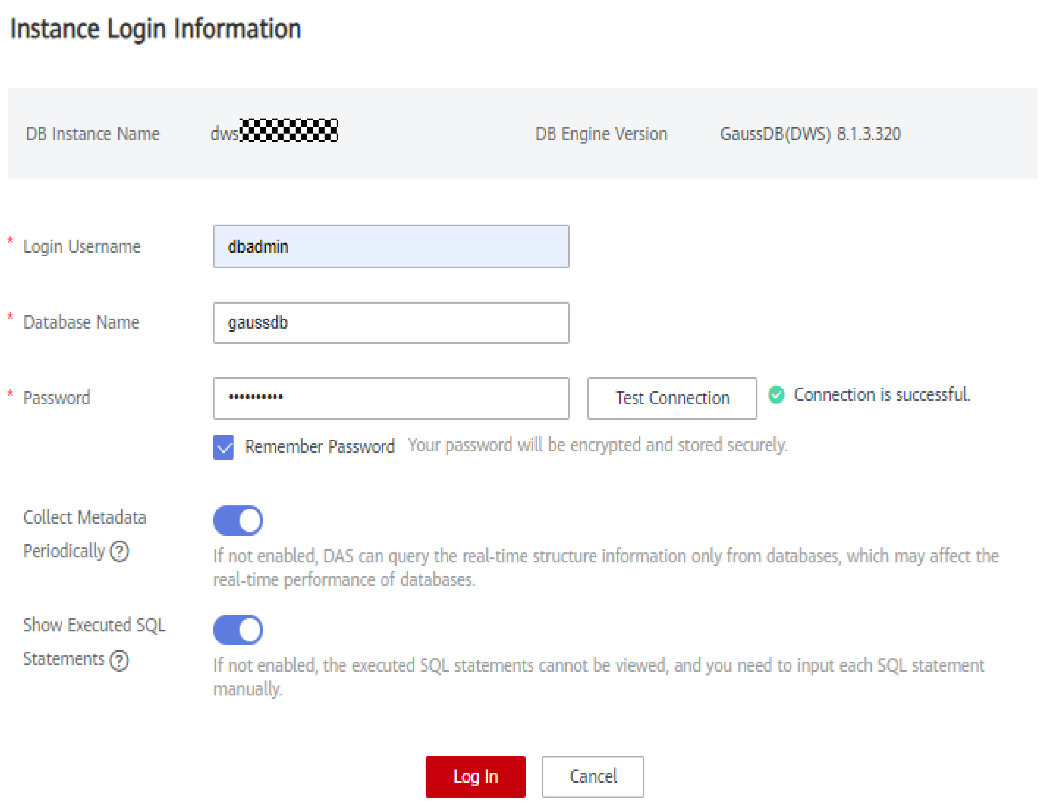
Step 1 On the Cluster Management page of the GaussDB (DWS) console, click Login in the Operation column of the source cluster dws-demo01.

NOTE

This practice uses version 8.1.3.x as an example. 8.1.2 and earlier versions do not support this login mode. You can use Data Studio to connect to a cluster. For details, see **Using Data Studio to Connect to a Cluster**.

Step 2 The login username is **dbadmin**, the database name is **gaussdb**, and the password is the password of user **dbadmin** set during data warehouse cluster creation. Select **Remember Password**, enable **Collect Metadata Periodically** and **Show Executed SQL Statements**, and click **Log In**.

Figure 2-23 Logging In to GaussDB(DWS)



Instance Login Information

DB Instance Name dws[redacted]

DB Engine Version GaussDB(DWS) 8.1.3.320

* Login Username: dbadmin

* Database Name: gaussdb

* Password: ••••••••••

Test Connection ✓ Connection is successful.

☑ Remember Password Your password will be encrypted and stored securely.

Collect Metadata Periodically ⓘ ● On

If not enabled, DAS can query the real-time structure information only from databases, which may affect the real-time performance of databases.

Show Executed SQL Statements ⓘ ● On

If not enabled, the executed SQL statements cannot be viewed, and you need to input each SQL statement manually.

Step 3 Click the database name **gaussdb** and click **SQL Window** in the upper right corner to access the SQL editor.

Step 4 Copy the following SQL statement to the SQL window and click Execute SQL to create the test TPC-H table ORDERS.

```
CREATE TABLE ORDERS
 (
 O_ORDERKEY BIGINT NOT NULL ,
 O_CUSTKEY BIGINT NOT NULL ,
 O_ORDERSTATUS CHAR(1) NOT NULL ,
 O_TOTALPRICE DECIMAL(15,2) NOT NULL ,
 O_ORDERDATE DATE NOT NULL ,
 O_ORDERPRIORITY CHAR(15) NOT NULL ,
 O_CLERK CHAR(15) NOT NULL ,
 O_SHIPPRIORITY BIGINT NOT NULL ,
 O_COMMENT VARCHAR(79) NOT NULL)
 with (orientation = column)
 distribute by hash(O_ORDERKEY)
 PARTITION BY RANGE(O_ORDERDATE)
 (
 PARTITION O_ORDERDATE_1 VALUES LESS THAN('1993-01-01 00:00:00'),
 PARTITION O_ORDERDATE_2 VALUES LESS THAN('1994-01-01 00:00:00'),
 PARTITION O_ORDERDATE_3 VALUES LESS THAN('1995-01-01 00:00:00'),
 PARTITION O_ORDERDATE_4 VALUES LESS THAN('1996-01-01 00:00:00'),
 PARTITION O_ORDERDATE_5 VALUES LESS THAN('1997-01-01 00:00:00'),
 PARTITION O_ORDERDATE_6 VALUES LESS THAN('1998-01-01 00:00:00'),
 PARTITION O_ORDERDATE_7 VALUES LESS THAN('1999-01-01 00:00:00')
 );
```

Step 5 Run the following SQL statement to create an OBS foreign table:

Replace AK and SK with the actual AK and SK of the account. <obs_bucket_name> is obtained from **Supported Regions**.

NOTE

// Hard-coded or plaintext AK and SK are risky. For security purposes, encrypt your AK and SK and store them in the configuration file or environment variables.

```
CREATE FOREIGN TABLE ORDERS01
 (
LIKE orders
 )
 SERVER gsmpp_server
 OPTIONS (
 ENCODING 'utf8',
 LOCATION obs://<obs_bucket_name>/tpch/orders.tbl',
 FORMAT 'text',
 DELIMITER '|',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
 CHUNKSIZE '64',
 IGNORE_EXTRA_DATA 'on'
 );
```

Step 6 Run the following SQL statement to import data from the OBS foreign table to the source data warehouse cluster: The import takes about 2 minutes. Please wait.

NOTE

If an import error occurs, the AK and SK values of the foreign table are incorrect. In this case, run the DROP FOREIGN TABLE order01; command to delete the foreign table, create a foreign table again, and run the following statement to import data again:

```
INSERT INTO orders SELECT * FROM orders01;
```

Step 7 Repeat the preceding steps to log in to the target cluster dws-demo02 and run the following SQL statement to create the target table orders:

```
CREATE TABLE ORDERS
 (
 O_ORDERKEY BIGINT NOT NULL ,
 O_CUSTKEY BIGINT NOT NULL ,
 O_ORDERSTATUS CHAR(1) NOT NULL ,
 O_TOTALPRICE DECIMAL(15,2) NOT NULL ,
 O_ORDERDATE DATE NOT NULL ,
 O_ORDERPRIORITY CHAR(15) NOT NULL ,
 O_CLERK CHAR(15) NOT NULL ,
 O_SHIPPRIORITY BIGINT NOT NULL ,
 O_COMMENT VARCHAR(79) NOT NULL)
 with (orientation = column)
 distribute by hash(O_ORDERKEY)
 PARTITION BY RANGE(O_ORDERDATE)
 (
 PARTITION O_ORDERDATE_1 VALUES LESS THAN('1993-01-01 00:00:00'),
 PARTITION O_ORDERDATE_2 VALUES LESS THAN('1994-01-01 00:00:00'),
 PARTITION O_ORDERDATE_3 VALUES LESS THAN('1995-01-01 00:00:00'),
 PARTITION O_ORDERDATE_4 VALUES LESS THAN('1996-01-01 00:00:00'),
 PARTITION O_ORDERDATE_5 VALUES LESS THAN('1997-01-01 00:00:00'),
 PARTITION O_ORDERDATE_6 VALUES LESS THAN('1998-01-01 00:00:00'),
 PARTITION O_ORDERDATE_7 VALUES LESS THAN('1999-01-01 00:00:00')
 );
```

----End

Step 3: Installing and Starting the GDS Server

Step 1 Create an ECS by referring to **Purchasing an ECS**. Note that the ECS and GaussDB(DWS) instances must be created in the same region and VPC. In this example, the CentOS 7.6 version is selected as the ECS image.

Step 2 Downloading the GDS Package

1. Log in to the GaussDB(DWS) console.
2. In the navigation tree on the left, click **Connections**.
3. Select the GDS client of the corresponding version from the drop-down list of **CLI Client**.

   Select a version based on the cluster version and the OS where the client is installed.

   NOTE

   The CPU architecture of the client must be the same as that of the cluster. If the cluster uses the x86 specifications, select the x86 client.
4. Click **Download**.

Step 3 Use the SFTP tool to upload the downloaded client (for example, **dws_client_8.2.x_redhat_x64.zip**) to the /opt directory of the ECS.

Step 4 Log in to the ECS as the root user and run the following commands to go to the /opt directory and decompress the client package:

```
cd /opt
unzip dws_client_8.2.x_redhat_x64.zip
```

Step 5 Create a GDS user and the user group to which the user belongs. This user is used to start GDS and read source data.

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

Step 6 Change the owner of the GDS package directory and source data file directory to the GDS user.

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

Step 7 Switch to user gds.

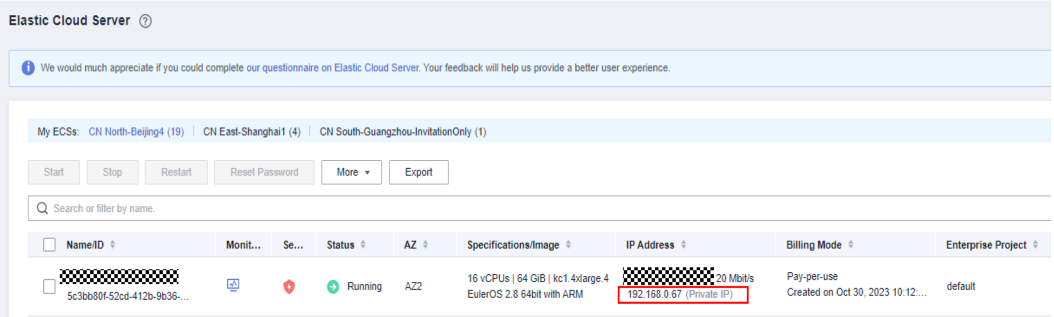
```
su - gds_user
```

Step 8 Run the following commands to go to the gds directory and execute environment variables:

```
cd /opt/gds/bin
source gds_env
```

Step 9 Run the following command to start GDS. You can view the internal IP address of the ECS on the ECS console.

```
/opt/gds/bin/gds -d /opt -p  ECS Intranet IP:5000 -H 0.0.0.0/0 -l /opt/gds/bin/gds_log.txt -D -t 2
```



Elastic Cloud Server

We would much appreciate if you could complete our questionnaire on Elastic Cloud Server. Your feedback will help us provide a better user experience.

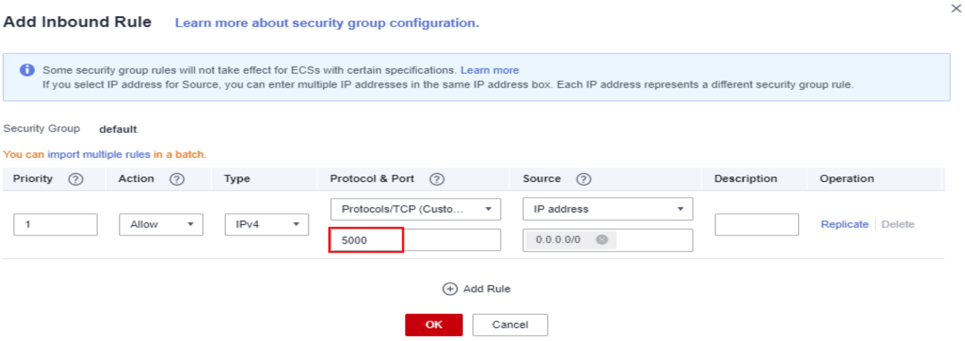
My ECSs: CN North-Beijing4 (19) | CN East-Shanghai1 (4) | CN South-Guangzhou-InvitationOnly (1)

Name/ID	Monit...	Se...	Status	AZ	Specifications/Image	IP Address	Billing Mode	Enterprise Project
[redacted] 5c3bb80f-52cd-412b-9b36-...			Running	AZ2	16 vCPUs | 64 GiB | kc1.4xlarge.4 EulerOS 2.8 64bit with ARM	[redacted] 20 Mbit/s 192.168.0.67 (Private IP)	Pay-per-use Created on Oct 30, 2023 10:12:...	default

Step 10 Enable the network port between the ECS and DWS.

The GDS server (ECS in this experiment) needs to communicate with DWS. The default security group of the ECS does not allow inbound traffic from GDS port 5000 and DWS port 8000. Perform the following steps:

1. Return to the ECS console and click the ECS name to go to the ECS details page.
2. Switch to the Security Groups tab and click Configure Rule.
3. Select Inbound Rules, click Add Rule, set Priority to 1, set Protocol Port to 5000, and click OK.



Add Inbound Rule Learn more about security group configuration.

Some security group rules will not take effect for ECSs with certain specifications. Learn more
If you select IP address for Source, you can enter multiple IP addresses in the same IP address box. Each IP address represents a different security group rule.

Security Group default

You can import multiple rules in a batch.

Priority	Action	Type	Protocol & Port	Source	Description	Operation
1	Allow	IPv4	Protocols/TCP (Custo... 5000	IP address 0.0.0.0/0		Replicate | Delete

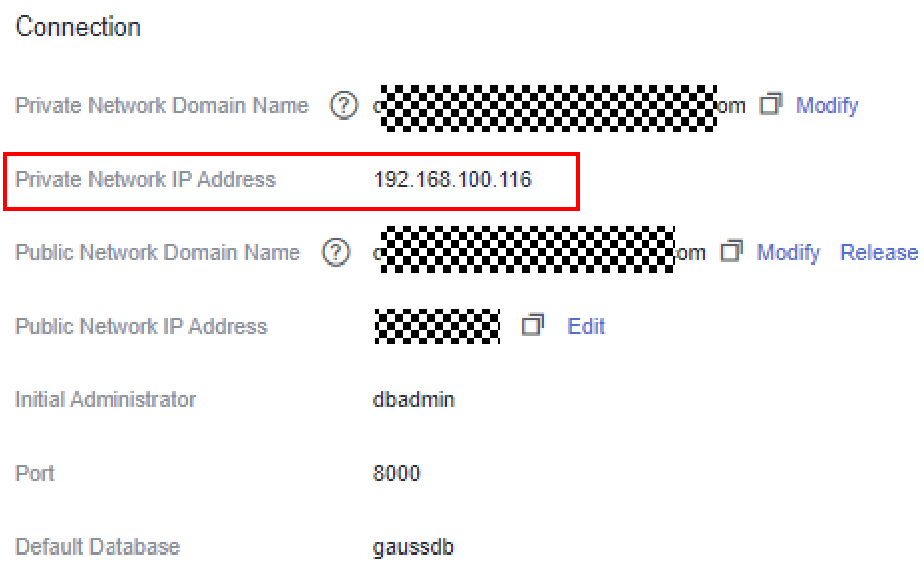
4. Repeat the preceding steps to add an inbound rule of 8000.

----End

Step 4: Implementing Data Interconnection Across DWS Clusters

Step 1 Create a server.

1. Obtain the private IP address of the source data warehouse cluster: Switch to the DWS console, choose Cluster Management on the left, and click the source cluster name dws-demo01.
2. Go to the cluster details page and record the internal IP address of DWS.



Connection

Private Network Domain Name ?	[redacted]om Modify
Private Network IP Address	192.168.100.116
Public Network Domain Name ?	[redacted]om Modify Release
Public Network IP Address	[redacted] Edit
Initial Administrator	dbadmin
Port	8000
Default Database	gaussdb

3. Switch back to the DWS console and click Log In in the Operation column of the target dws-demo02. The SQL window is displayed,

   Run the following command to create a server:

   The private IP address of the source data warehouse cluster is obtained in the previous step. The private IP address of the ECS server is obtained from the ECS console. The login password of user dbadmin is set when the data warehouse cluster is created.

```
CREATE SERVER server_remote FOREIGN DATA WRAPPER GC_FDW OPTIONS
 (
address'Private network IP address of the source DWS cluster :8000',
 dbname 'gaussdb',
 username 'dbadmin',
password'Password of user dbadmin',
syncsrv'gsfs://Internal IP address of the ECS server:5000'
 )
 ;
```

Step 2 Create a foreign table for interconnection.

In the SQL window of the destination cluster dws-demo02, run the following command to create a foreign table for interconnection:

```
CREATE FOREIGN TABLE ft_orders
 (
 O_ORDERKEY BIGINT ,
 O_CUSTKEY BIGINT ,
 O_ORDERSTATUS CHAR(1) ,
 O_TOTALPRICE DECIMAL(15,2) ,
 O_ORDERDATE DATE ,
 O_ORDERPRIORITY CHAR(15) ,
 O_CLERK CHAR(15) ,
 O_SHIPPRIORITY BIGINT ,
 O_COMMENT VARCHAR(79)

 )
 SERVER server_remote
 OPTIONS
 (
 schema_name 'public',
 table_name 'orders',
 encoding 'SQL_ASCII'
 );
```

Step 3 Import all table data.

In the SQL window, run the following SQL statement to import full data from the ft_orders foreign table: Wait for about 1 minute.

```
INSERT INTO orders SELECT * FROM ft_orders;
```

Run the following SQL statement. It is found that 15 million lines of data are successfully imported.

```
SELECT count(*) FROM orders;
```

Step 4 Import data based on filter criteria.

Run the following SQL statements to import data based on the filter criteria:

```
INSERT INTO orders SELECT * FROM ft_orders WHERE o_orderkey < '10000000';
```

----End

3 Table Optimization Practices

3.1 Table Structure Design

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

This section describes how to optimize table performance in GaussDB(DWS) by properly designing the table structure (for example, by configuring the table storage mode, compression level, distribution mode, distribution column, partitioned tables, and local clustering).

Selecting a Storage Mode

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

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

Storage Model	Application Scenario
Row storage	Point query (simple index-based query that returns only a few records). Query involving many **INSERT**, **UPDATE**, and **DELETE** operations.
Column storage	Statistics analysis query, in which operations, such as group and join, are performed many times.

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**.

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.

Selecting a Distribution Mode

GaussDB(DWS) supports the following distribution modes: replication, hash, and Round-robin.

NOTE

Round-robin is supported in cluster 8.1.2 and later.

Policy	Description	Application 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.

Policy	Description	Application Scenario	Advantages/ disadvantages
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 key 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 key 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. If a record is inserted, the system performs hash computing based on values in the distribute column and then stores data on the related 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 where a constant filter exists.** 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 improper distribution key may cause data skew or poor I/O performance on certain DNs. Therefore, you need to check the table to ensure that data is evenly distributed on each DN. You can run the following SQL 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.)

Using Partitioned Tables

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

1. High query performance: The system queries only the concerned partitions rather than the whole table, improving the query efficiency.
2. High availability: If a partition is faulty, data in the other partitions is still available.
3. Easy maintenance: You only need to fix the faulty partition.

The partitioned tables supported by GaussDB(DWS) include range partitioned tables and list partitioned tables. (List partitioned tables are supported only in cluster 8.1.3).

Using Partial Clustering

Partial Cluster Key is the column-based technology. It 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. Use the following principles to specify columns:

1. The selected columns must be restricted by simple expressions in base tables. Such constraints are usually represented by Col, Op, and Const. Col specifies the column name, Op specifies operators, (including =, >, >=, <=, and <) Const specifies constants.
2. Select columns that are frequently selected (to filter much more undesired data) in simple expressions.
3. List the less frequently selected columns on the top.
4. List the columns of the enumerated type at the top.

Selecting a Data type

You can use data types with the following features to improve efficiency:

1. **Data types that boost execution efficiency**

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

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

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

3. **Same data type for a join**

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

Index Use

- The purpose of creating indexes is to accelerate queries. Therefore, ensure that indexes can be used in some queries. If an index is not used by any query statement, the index is meaningless. Delete the index.
- Do not create unnecessary secondary indexes. Useful secondary indexes can accelerate query. However, the space occupied by indexes increases with the number of indexes. Each time an index is added, an additional key-value pair needs to be added when a piece of data is inserted. Therefore, the more indexes, the slower the write speed, and the larger the space usage. In addition, too many indexes affect the optimizer running time, and inappropriate indexes mislead the optimizer. Therefore, the more indexes, the better.
- Create proper indexes based on service characteristics. In principle, indexes need to be created for columns required in a query to improve performance. Indexes can be created in the following scenarios:
  - For columns with high differentiation, indexes can significantly reduce the number of rows after filtering. For example, you are advised to create an index in the ID card number column, but not in the gender column.
  - If there are multiple query conditions, you can select a combination index. Note that the column of the equivalent condition must be placed before the combination index. For example, if the common query is SELECT * FROM t where c1 = 10 and c2 = 100 and c3 > 10, you can create the combination index Index cidx (c1, c2, c3). In this way, you can use the query conditions to construct an index prefix for scanning.
- When an index column is used as a query condition, do not perform calculation, function, or type conversion on the index column. Otherwise, the optimizer cannot use the index.
- Ensure that the index column contains the query column. Do not always run the SELECT * statement to query all columns.
- The query condition is used. =. When NOT IN is used, indexes cannot be used.
- When LIKE is used, if the condition starts with the wildcard %, the index cannot be used.
- If multiple indexes are available for a query condition but you know which index is the optimal one, you are advised to use the optimizer hint to force the optimizer to use the index. This prevents the optimizer from selecting an incorrect index due to inaccurate statistics or other problems.

- When the IN expression is used as the query condition, the number of matched conditions should not be too large. Otherwise, the execution efficiency is low.

3.2 Table Optimization Overview

In this practice, you will learn how to optimize the design of your tables. You will start by creating tables without specifying their storage mode, distribution key, distribution mode, or compression mode. Load test data into these tables and test system performance. Then, follow excellent practices to create the tables again using new storage modes, distribution keys, distribution modes, and compression modes. Load the test data and test performance again. Compare the two test results to find out how table design affects the storage space, and the loading and query performance of the tables.

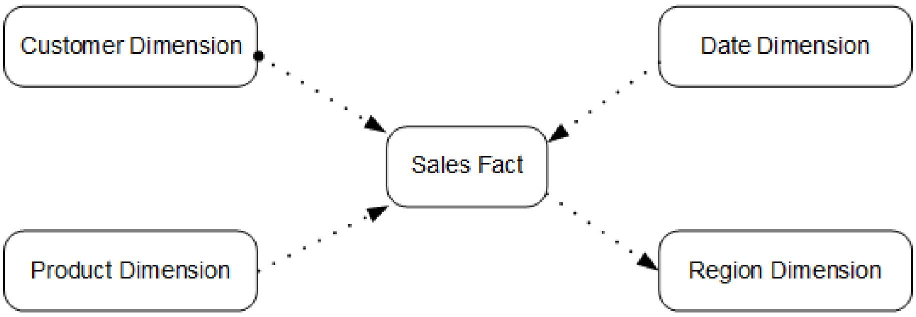
Estimated time: 60 minutes

3.3 Selecting a Table Model

The most common types of data warehouse schemas are star and snowflake schemas. Consider service and performance requirements when you choose a schema for your tables.

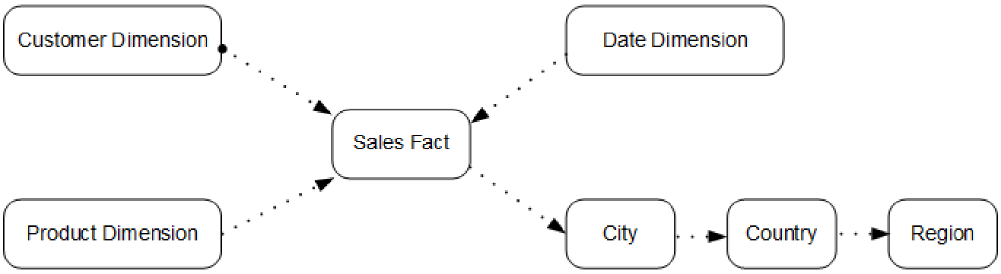
- In the star schema, a central fact table contains the core data for the database and several dimension tables provide descriptive attribute information for the fact table. The primary key of a dimension table associates a foreign key in a fact table, as shown in **Figure 3-1**.
  - All facts must have the same granularity.
  - Different dimensions are not associated.

Figure 3-1 Star schema



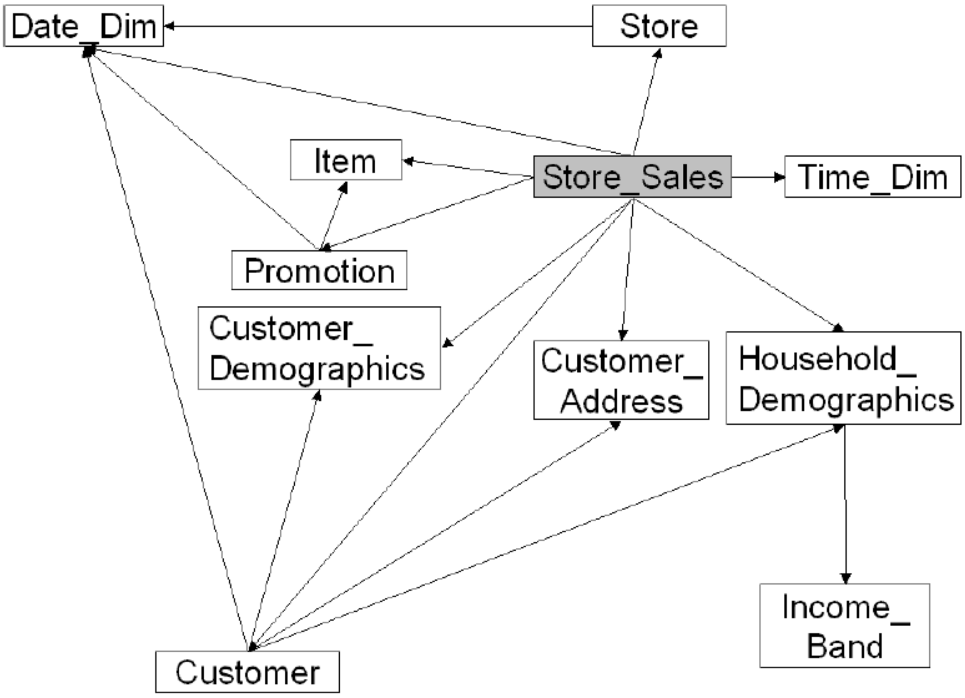
- The snowflake schema is developed based on the star schema. In this schema, each dimension can be associated with multiple dimensions and split into tables of different granularities based on the dimension level, as shown in **Figure 3-2**.
  - Dimension tables can be associated as needed, and the data stored in them is reduced.
  - This schema has more dimension tables to maintain than the star schema does.

Figure 3-2 Snowflake schema



This practice verifies performance using the Store Sales (SS) model of TPC-DS. The model uses the snowflake schema. **Figure 3-3** illustrates its structure.

Figure 3-3 TPC-DS Store Sales ER-Diagram



For details about the **store_sales** fact table and dimension tables in the model, see the official document of TPC-DS at **http://www.tpc.org/tpc_documents_current_versions/current_specifications5.asp**.

3.4 Step 1: Creating an Initial Table and Loading Sample Data

Supported Regions

Table 3-1 Regions and OBS bucket names

Region	OBS Bucket
EU-Dublin	dws-demo-eu-west-101

Create a group of tables without specifying their storage modes, distribution keys, distribution modes, or compression modes. Load sample data into these tables.

Step 1 (Optional) Create a cluster.

If a cluster is available, skip this step. For details about how to create a cluster, see **Creating a GaussDB(DWS) 2.0 Cluster**.

Connect to the cluster and test the connection. For details, see **Methods of Connecting to a Cluster**.

This practice uses an 8-node cluster as an example. You can also use a four-node cluster to perform the test.

Step 2 Create an SS test table **store_sales**.

NOTE

Before you create this table, delete existing SS tables first (if any) using the **DROP TABLE** command. For example, to delete the **store_sales** table, run the following command:

```
DROP TABLE store_sales;
```

Do not configure the storage mode, distribution key, distribution mode, or compression mode when you create this table.

Run the **CREATE TABLE** command to create the 11 tables in **Figure 3-3**. This section only provides the syntax for creating the **store_sales** table. To create all tables, copy the syntax in **Creating an Initial Table**.

```
CREATE TABLE store_sales
(
    ss_sold_date_sk           integer                    ,
    ss_sold_time_sk           integer                    ,
    ss_item_sk                integer            not null,
    ss_customer_sk            integer                    ,
    ss_cdemo_sk               integer                    ,
    ss_hdemo_sk               integer                    ,
    ss_addr_sk                integer                    ,
    ss_store_sk               integer                    ,
    ss_promo_sk               integer                    ,
    ss_ticket_number          bigint             not null,
    ss_quantity               integer                    ,
    ss_wholesale_cost         decimal(7,2)               ,
    ss_list_price             decimal(7,2)               ,
    ss_sales_price            decimal(7,2)                  ,
    ss_ext_discount_amt       decimal(7,2)                  ,
    ss_ext_sales_price        decimal(7,2)                  ,
    ss_ext_wholesale_cost     decimal(7,2)                  ,
    ss_ext_list_price         decimal(7,2)                  ,
    ss_ext_tax                decimal(7,2)                  ,
    ss_coupon_amt             decimal(7,2)                  ,
    ss_net_paid               decimal(7,2)                  ,
    ss_net_paid_inc_tax       decimal(7,2)                  ,
    ss_net_profit             decimal(7,2)
) ;
```

Step 3 Load sample data into these tables.

An OBS bucket provides sample data used for this practice. The bucket can be read by all authenticated cloud users. Perform the following operations to load the sample data:

1. Create a foreign table for each table.

   GaussDB(DWS) uses the foreign data wrappers (FDWs) provided by PostgreSQL to import data in parallel. To use FDWs, create FDW tables first (also called foreign tables). This section only provides the syntax for creating the **obs_from_store_sales_001** foreign table corresponding to the **store_sales** table. To create all foreign tables, copy the syntax in **Creating a Foreign Table**.

   NOTE

   – Note that *<obs_bucket_name>* in the following statement indicates the OBS bucket name. Only some regions are supported. For details about the supported regions and OBS bucket names, see **Table 3-1**. GaussDB(DWS) clusters do not support cross-region access to OBS bucket data.

   – The columns of the foreign table must be the same as that of the corresponding ordinary table. In this example, **store_sales** and **obs_from_store_sales_001** should have the same columns.

   – The foreign table syntax obtains the sample data used for this practice from the OBS bucket. To load other sample data, modify **SERVER gsmpp_server OPTIONS** as needed. For details, see **About Parallel Data Import from OBS**.

   – // Hard-coded or plaintext AK and SK are risky. For security purposes, encrypt your AK and SK and store them in the configuration file or environment variables.

```
CREATE FOREIGN TABLE obs_from_store_sales_001
(
  ss_sold_date_sk           integer                       ,
  ss_sold_time_sk           integer                       ,
  ss_item_sk                integer               not null,
  ss_customer_sk            integer                       ,
  ss_cdemo_sk               integer                       ,
  ss_hdemo_sk               integer                       ,
  ss_addr_sk                integer                       ,
  ss_store_sk               integer                       ,
  ss_promo_sk               integer                       ,
  ss_ticket_number          bigint                not null,
  ss_quantity               integer                       ,
  ss_wholesale_cost         decimal(7,2)                  ,
  ss_list_price             decimal(7,2)                  ,
  ss_sales_price            decimal(7,2)                  ,
  ss_ext_discount_amt       decimal(7,2)                  ,
  ss_ext_sales_price        decimal(7,2)                  ,
  ss_ext_wholesale_cost     decimal(7,2)                  ,
  ss_ext_list_price         decimal(7,2)                  ,
  ss_ext_tax                decimal(7,2)                  ,
  ss_coupon_amt             decimal(7,2)                  ,
  ss_net_paid               decimal(7,2)                  ,
    ss_net_paid_inc_tax       decimal(7,2)                  ,
    ss_net_profit             decimal(7,2)
)
-- Configure OBS server information and data format details.
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/store_sales',
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
-- If create foreign table failed,record error message
WITH err_obs_from_store_sales_001;
```

2. Set **ACCESS_KEY** and **SECRET_ACCESS_KEY** parameters as needed in the foreign table creation statement, and run this statement in a client tool to create a foreign table.

   For the values of **ACCESS_KEY** and **SECRET_ACCESS_KEY**, see **Creating Access Keys (AK and SK)**.

3. Import data.

   Create the **insert.sql** script containing the following statements and execute it:

```
\timing on
\parallel on 4
INSERT INTO store_sales SELECT * FROM obs_from_store_sales_001;
INSERT INTO date_dim SELECT * FROM obs_from_date_dim_001;
INSERT INTO store SELECT * FROM obs_from_store_001;
INSERT INTO item SELECT * FROM obs_from_item_001;
INSERT INTO time_dim SELECT * FROM obs_from_time_dim_001;
INSERT INTO promotion SELECT * FROM obs_from_promotion_001;
INSERT INTO customer_demographics SELECT * from obs_from_customer_demographics_001 ;
INSERT INTO customer_address SELECT * FROM obs_from_customer_address_001 ;
INSERT INTO household_demographics SELECT * FROM obs_from_household_demographics_001;
INSERT INTO customer SELECT * FROM obs_from_customer_001;
INSERT INTO income_band SELECT * FROM obs_from_income_band_001;
\parallel off
```

   Information similar to the following is displayed:

```
SET
Timing is on.
SET
Time: 2.831 ms
Parallel is on with scale 4.
Parallel is off.
INSERT 0 402
Time: 1820.909 ms
INSERT 0 73049
Time: 2715.275 ms
INSERT 0 86400
Time: 2377.056 ms
INSERT 0 1000
Time: 4037.155 ms
INSERT 0 204000
Time: 7124.190 ms
INSERT 0 7200
Time: 2227.776 ms
INSERT 0 1920800
Time: 8672.647 ms
INSERT 0 20
Time: 2273.501 ms
INSERT 0 1000000
Time: 11430.991 ms
```

```
INSERT 0 1981703
Time: 20270.750 ms
INSERT 0 287997024
Time: 341395.680 ms
total time: 341584  ms
```

4. Calculate the total time spent in creating the 11 tables. The result will be recorded as the loading time in the benchmark table in **Step 1** in the next section.
5. Run the following command to verify that each table is loaded correctly and records lines into the table:

```
SELECT COUNT(*) FROM store_sales;
SELECT COUNT(*) FROM date_dim;
SELECT COUNT(*) FROM store;
SELECT COUNT(*) FROM item;
SELECT COUNT(*) FROM time_dim;
SELECT COUNT(*) FROM promotion;
SELECT COUNT(*) FROM customer_demographics;
SELECT COUNT(*) FROM customer_address;
SELECT COUNT(*) FROM household_demographics;
SELECT COUNT(*) FROM customer;
SELECT COUNT(*) FROM income_band;
```

The number of rows in each SS table is as follows:

Table name	Number of Rows
Store_Sales	287997024
Date_Dim	73049
Store	402
Item	204000
Time_Dim	86400
Promotion	1000
Customer_Demographics	1920800
Customer_Address	1000000
Household_Demographics	7200
Customer	1981703
Income_Band	20

Step 4 Run the **ANALYZE** command to update statistics.

```
ANALYZE;
```

If **ANALYZE** is returned, the execution is successful.

```
ANALYZE
```

The **ANALYZE** statement collects statistics about table content in databases, which will be stored in the **PG_STATISTIC** system catalog. Then, the query optimizer uses the statistics to work out the most efficient execution plan.

After executing batch insertions and deletions, you are advised to run the **ANALYZE** statement on the table or the entire library to update statistics.

----End

3.5 Step 2: Testing System Performance of the Initial Table and Establishing a Baseline

Before and after tuning table structures, test and record the following information to compare differences in system performance:

- Load time
- Storage space occupied by tables
- Query performance

The examples in this practice are based on a dws.d2.xlarge cluster consisting of eight nodes. Because system performance is affected by many factors, clusters of the same flavor may have different results.

Model	dws.d2.xlarge VM
CPU	4*CPU E5-2680 v2 @ 2.80GHZ
Memory	32 GB
Network	1 GB
Disk	1.63 TB
Number of Nodes	8

Record the results using the following benchmark table.

Benchmark	Before	After
Loading time (11 tables)	341584 ms	-
Occupied storage space		
Store_Sales	-	-
Date_Dim	-	-
Store	-	-
Item	-	-
Time_Dim	-	-
Promotion	-	-
Customer_Demographics	-	-

Benchmark	Before	After
Customer_Address	-	-
Household_Demographics	-	-
Customer	-	-
Income_Band	-	-
Total storage space	-	-
Query execution time		
Query 1	-	-
Query 2	-	-
Query 3	-	-
Total execution time	-	-

Perform the following steps to test the system performance before tuning to establish a benchmark:

Step 1 Enter the cumulative load time for all the 11 tables in the benchmarks table in the **Before** column.

Step 2 Record the storage space usage of each table.

Determine how much disk space is used for each table using the **pg_size_pretty** function and record the results in base tables.

```
SELECT T_NAME, PG_SIZE_PRETTY(PG_RELATION_SIZE(t_name)) FROM (VALUES('store_sales'),('date_dim'),
('store'),('item'),('time_dim'),('promotion'),('customer_demographics'),('customer_address'),
('household_demographics'),('customer'),('income_band')) AS names1(t_name);
```

The following information is displayed:

```
         t_name          | pg_size_pretty
------------------------+----------------
 store_sales            | 42 GB
 date_dim               | 11 MB
 store                  | 232 kB
 item                   | 110 MB
 time_dim               | 11 MB
 promotion              | 256 kB
 customer_demographics  | 171 MB
 customer_address       | 170 MB
 household_demographics | 504 kB
 customer               | 441 MB
 income_band            | 88 kB
(11 rows)
```

Step 3 Test query performance.

Run the following queries and record the time spent on each query. The execution durations of the same query can be different, depending on the OS cache during execution. You are advised to perform several rounds of tests and select a group with average values.

```
\timing on
SELECT * FROM (SELECT  COUNT(*)
FROM store_sales
    ,household_demographics
    ,time_dim, store
WHERE ss_sold_time_sk = time_dim.t_time_sk
    AND ss_hdemo_sk = household_demographics.hd_demo_sk
    AND ss_store_sk = s_store_sk
    AND time_dim.t_hour = 8
    AND time_dim.t_minute >= 30
    AND household_demographics.hd_dep_count = 5
    AND store.s_store_name = 'ese'
ORDER BY COUNT(*)
 ) LIMIT 100;

SELECT * FROM (SELECT  i_brand_id brand_id, i_brand brand, i_manufact_id, i_manufact,
SUM(ss_ext_sales_price) ext_price
 FROM date_dim, store_sales, item,customer,customer_address,store
 WHERE d_date_sk = ss_sold_date_sk
   AND ss_item_sk = i_item_sk
   AND i_manager_id=8
   AND d_moy=11
   AND d_year=1999
   AND ss_customer_sk = c_customer_sk
   AND c_current_addr_sk = ca_address_sk
   AND substr(ca_zip,1,5) <> substr(s_zip,1,5)
   AND ss_store_sk = s_store_sk
 GROUP BY i_brand
      ,i_brand_id
      ,i_manufact_id
      ,i_manufact
 ORDER BY ext_price desc
         ,i_brand
         ,i_brand_id
         ,i_manufact_id
         ,i_manufact
 ) LIMIT 100;

SELECT * FROM (SELECT  s_store_name, s_store_id,
        SUM(CASE WHEN (d_day_name='Sunday') THEN ss_sales_price ELSE null END) sun_sales,
        SUM(CASE WHEN (d_day_name='Monday') THEN ss_sales_price ELSE null END) mon_sales,
        SUM(CASE WHEN (d_day_name='Tuesday') THEN ss_sales_price ELSE  null END) tue_sales,
        SUM(CASE WHEN (d_day_name='Wednesday') THEN ss_sales_price ELSE null END) wed_sales,
        SUM(CASE WHEN (d_day_name='Thursday') THEN ss_sales_price ELSE null END) thu_sales,
        SUM(CASE WHEN (d_day_name='Friday') THEN ss_sales_price ELSE null END) fri_sales,
        SUM(CASE WHEN (d_day_name='Saturday') THEN ss_sales_price ELSE null END) sat_sales
 FROM date_dim, store_sales, store
 WHERE d_date_sk = ss_sold_date_sk AND
       s_store_sk = ss_store_sk AND
       s_gmt_offset = -5 AND
       d_year = 2000
 GROUP BY s_store_name, s_store_id
 ORDER BY s_store_name, s_store_id,sun_sales,mon_sales,tue_sales,wed_sales,thu_sales,fri_sales,sat_sales
  ) LIMIT 100;
```

----End

After the preceding statistics are collected, the benchmark table is as follows:

Benchmark	Before	After
Loading time (11 tables)	341584 ms	-
Occupied storage space		
Store_Sales	42 GB	-

Benchmark	Before	After
Date_Dim	11 MB	-
Store	232 KB	-
Item	110 MB	-
Time_Dim	11 MB	-
Promotion	256 KB	-
Customer_Demographics	171 MB	-
Customer_Address	170 MB	-
Household_Demographics	504 KB	-
Customer	441 MB	-
Income_Band	88 KB	-
Total storage space	42 GB	-
Query execution time		
Query 1	14552.05 ms	-
Query 2	27952.36 ms	-
Query 3	17721.15 ms	-
Total execution time	60225.56 ms	-

3.6 Step 3: Optimizing a Table

Selecting a Storage Mode

Sample tables used in this practice are typical multi-column TPC-DS tables where many statistical analysis queries are performed. Therefore, the column storage mode is recommended.

```
WITH (ORIENTATION = column)
```

Selecting a Compression Level

No compression ratio is specified in **Step 1: Creating an Initial Table and Loading Sample Data**, and the low compression ratio is selected by GaussDB(DWS) by default. Specify **COMPRESSION** to **MIDDLE**, and compare the result to that when **COMPRESSION** is set to **LOW**.

The following is an example of selecting a storage mode and the **MIDDLE** compression ratio for a table.

```
CREATE TABLE store_sales
(
    ss_sold_date_sk           integer                       ,
    ss_sold_time_sk           integer                       ,
    ss_item_sk                integer               not null,
    ss_customer_sk            integer                       ,
    ss_cdemo_sk               integer                       ,
    ss_hdemo_sk               integer                       ,
    ss_addr_sk                integer                       ,
    ss_store_sk               integer                       ,
    ss_promo_sk               integer                       ,
    ss_ticket_number          bigint                not null,
    ss_quantity               integer                       ,
    ss_wholesale_cost         decimal(7,2)                  ,
    ss_list_price             decimal(7,2)                  ,
    ss_sales_price            decimal(7,2)                  ,
    ss_ext_discount_amt       decimal(7,2)                  ,
    ss_ext_sales_price        decimal(7,2)                  ,
    ss_ext_wholesale_cost     decimal(7,2)                  ,
    ss_ext_list_price         decimal(7,2)                  ,
    ss_ext_tax                decimal(7,2)                  ,
    ss_coupon_amt             decimal(7,2)                  ,
    ss_net_paid               decimal(7,2)                  ,
    ss_net_paid_inc_tax       decimal(7,2)                  ,
    ss_net_profit             decimal(7,2)
)
WITH (ORIENTATION = column,COMPRESSION=middle);
```

Selecting a Distribution Mode

Based on table sizes provided in **Step 2: Testing System Performance of the Initial Table and Establishing a Baseline**, set the distribution mode as follows.

Table Name	Number of Rows	Distribution Mode
Store_Sales	287997024	Hash
Date_Dim	73049	Replication
Store	402	Replication
Item	204000	Replication
Time_Dim	86400	Replication
Promotion	1000	Replication
Customer_Demographics	1920800	Hash
Customer_Address	1000000	Hash
Household_Demographics	7200	Replication
Customer	1981703	Hash
Income_Band	20	Replication

Selecting a Distribution Key

If your table is distributed using hash, choose a proper distribution key. You are advised to select a distribution key according to **Selecting a Distribution Key**.

Select the primary key of each table as the distribution key of the hash table.

Table Name	Number of Records	Distribution Mode	Distribution Key
Store_Sales	287997024	Hash	ss_item_sk
Date_Dim	73049	Replication	-
Store	402	Replication	-
Item	204000	Replication	-
Time_Dim	86400	Replication	-
Promotion	1000	Replication	-
Customer_Demographics	1920800	Hash	cd_demo_sk
Customer_Address	1000000	Hash	ca_address_sk
Household_Demographics	7200	Replication	-
Customer	1981703	Hash	c_customer_sk
Income_Band	20	Replication	-

3.7 Step 4: Creating Another Table and Loading Data

After selecting a storage mode, compression level, distribution mode, and distribution key for each table, use these attributes to create tables and reload data. Compare the system performance before and after the table recreation.

Step 1 Delete the tables created before.

```
DROP TABLE store_sales;
DROP TABLE date_dim;
DROP TABLE store;
DROP TABLE item;
DROP TABLE time_dim;
DROP TABLE promotion;
DROP TABLE customer_demographics;
DROP TABLE customer_address;
DROP TABLE household_demographics;
DROP TABLE customer;
DROP TABLE income_band;

DROP FOREIGN TABLE obs_from_store_sales_001;
DROP FOREIGN TABLE obs_from_date_dim_001;
DROP FOREIGN TABLE obs_from_store_001;
DROP FOREIGN TABLE obs_from_item_001;
DROP FOREIGN TABLE obs_from_time_dim_001;
DROP FOREIGN TABLE obs_from_promotion_001;
DROP FOREIGN TABLE obs_from_customer_demographics_001;
DROP FOREIGN TABLE obs_from_customer_address_001;
DROP FOREIGN TABLE obs_from_household_demographics_001;
DROP FOREIGN TABLE obs_from_customer_001;
DROP FOREIGN TABLE obs_from_income_band_001;
```

Step 2 Create tables and specify storage and distribution modes for them.

Only the syntax for recreating the **store_sales** table is provided for simplicity. To recreate all the other tables, copy the syntax in **Creating a Another Table After Design Optimization**.

```
CREATE TABLE store_sales
(
    ss_sold_date_sk           integer                       ,
    ss_sold_time_sk           integer                       ,
    ss_item_sk                integer               not null,
    ss_customer_sk            integer                       ,
    ss_cdemo_sk               integer                       ,
    ss_hdemo_sk               integer                       ,
    ss_addr_sk                integer                       ,
    ss_store_sk               integer                       ,
    ss_promo_sk               integer                       ,
    ss_ticket_number          bigint                not null,
    ss_quantity               integer                       ,
    ss_wholesale_cost         decimal(7,2)                  ,
    ss_list_price             decimal(7,2)                  ,
    ss_sales_price            decimal(7,2)                  ,
    ss_ext_discount_amt       decimal(7,2)                  ,
    ss_ext_sales_price        decimal(7,2)                  ,
    ss_ext_wholesale_cost     decimal(7,2)                  ,
    ss_ext_list_price         decimal(7,2)                  ,
    ss_ext_tax                decimal(7,2)                  ,
    ss_coupon_amt             decimal(7,2)                  ,
    ss_net_paid               decimal(7,2)                  ,
    ss_net_paid_inc_tax       decimal(7,2)                  ,
    ss_net_profit             decimal(7,2)
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY hash (ss_item_sk);
```

Step 3 **Load sample data into these tables.**

Step 4 Record the loading time in the benchmark tables.

Benchmark	Before	After
Loading time (11 tables)	341584 ms	257241 ms
Occupied storage space		
Store_Sales	42 GB	-
Date_Dim	11 MB	-
Store	232 KB	-
Item	110 MB	-
Time_Dim	11 MB	-
Promotion	256 KB	-
Customer_Demographics	171 MB	-
Customer_Address	170 MB	-

Benchmark	Before	After
Household_Demographics	504 KB	-
Customer	441 MB	-
Income_Band	88 KB	-
Total storage space	42 GB	-
Query execution time		
Query 1	14552.05 ms	-
Query 2	27952.36 ms	-
Query 3	17721.15 ms	-
Total execution time	60225.56 ms	-

Step 5 Run the **ANALYZE** command to update statistics.

```
ANALYZE;
```

If **ANALYZE** is returned, the execution is successful.

```
ANALYZE
```

Step 6 Check for data skew.

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

```
SELECT a.count,b.node_name FROM (SELECT count(*) AS count,xc_node_id FROM table_name GROUP BY
xc_node_id) a, pgxc_node b WHERE a.xc_node_id=b.node_id ORDER BY a.count desc;
```

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.** In GaussDB(DWS), you can select multiple distribution keys to distribute data evenly.

----End

3.8 Step 5: Testing System Performance in the New Table

After recreating the test data set with the selected storage modes, compression levels, distribution modes, and distribution keys, you will retest the system performance.

Step 1 Record the storage space usage of each table.

Determine how much disk space is used for each table using the **pg_size_pretty** function and record the results in base tables.

```
SELECT T_NAME, PG_SIZE_PRETTY(PG_RELATION_SIZE(t_name)) FROM (VALUES('store_sales'),('date_dim'),
('store'),('item'),('time_dim'),('promotion'),('customer_demographics'),('customer_address'),
('household_demographics'),('customer'),('income_band')) AS names1(t_name);
         t_name         | pg_size_pretty
------------------------+----------------
 store_sales            | 14 GB
 date_dim               | 27 MB
 store                  | 4352 kB
 item                   | 259 MB
 time_dim               | 14 MB
 promotion              | 3200 kB
 customer_demographics  | 11 MB
 customer_address       | 27 MB
 household_demographics | 1280 kB
 customer               | 111 MB
 income_band            | 896 kB
(11 rows)
```

Step 2 Test the query performance and record the performance data in the benchmark table.

Execute the following queries again and record the time spent on each query.

```
\timing on
SELECT * FROM (SELECT  COUNT(*)
FROM store_sales
    ,household_demographics
    ,time_dim, store
WHERE ss_sold_time_sk = time_dim.t_time_sk
    AND ss_hdemo_sk = household_demographics.hd_demo_sk
    AND ss_store_sk = s_store_sk
    AND time_dim.t_hour = 8
    AND time_dim.t_minute >= 30
    AND household_demographics.hd_dep_count = 5
    AND store.s_store_name = 'ese'
ORDER BY COUNT(*)
 ) LIMIT 100;

SELECT * FROM (SELECT  i_brand_id brand_id, i_brand brand, i_manufact_id, i_manufact,
SUM(ss_ext_sales_price) ext_price
 FROM date_dim, store_sales, item,customer,customer_address,store
 WHERE d_date_sk = ss_sold_date_sk
   AND ss_item_sk = i_item_sk
   AND i_manager_id=8
   AND d_moy=11
   AND d_year=1999
   AND ss_customer_sk = c_customer_sk
   AND c_current_addr_sk = ca_address_sk
   AND substr(ca_zip,1,5) <> substr(s_zip,1,5)
   AND ss_store_sk = s_store_sk
 GROUP BY i_brand
      ,i_brand_id
      ,i_manufact_id
      ,i_manufact
 ORDER BY ext_price desc
         ,i_brand
         ,i_brand_id
         ,i_manufact_id
         ,i_manufact
 ) LIMIT 100;

SELECT * FROM (SELECT  s_store_name, s_store_id,
        SUM(CASE WHEN (d_day_name='Sunday') THEN ss_sales_price ELSE null END) sun_sales,
        SUM(CASE WHEN (d_day_name='Monday') THEN ss_sales_price ELSE null END) mon_sales,
        SUM(CASE WHEN (d_day_name='Tuesday') THEN ss_sales_price ELSE  null END) tue_sales,
        SUM(CASE WHEN (d_day_name='Wednesday') THEN ss_sales_price ELSE null END) wed_sales,
        SUM(CASE WHEN (d_day_name='Thursday') THEN ss_sales_price ELSE null END) thu_sales,
        SUM(CASE WHEN (d_day_name='Friday') THEN ss_sales_price ELSE null END) fri_sales,
        SUM(CASE WHEN (d_day_name='Saturday') THEN ss_sales_price ELSE null END) sat_sales
 FROM date_dim, store_sales, store
 WHERE d_date_sk = ss_sold_date_sk AND
       s_store_sk = ss_store_sk AND
       s_gmt_offset = -5 AND
       d_year = 2000
 GROUP BY s_store_name, s_store_id
 ORDER BY s_store_name, s_store_id,sun_sales,mon_sales,tue_sales,wed_sales,thu_sales,fri_sales,sat_sales
  ) LIMIT 100;
```

The following benchmark table shows the validation results of the cluster used in this tutorial. Your results may vary based on a number of factors, but the relative results should be similar. The execution durations of queries having the same table structure can be different, depending on the OS cache during execution. You are advised to perform several rounds of tests and select a group with average values.

Benchmark	Before	After
Loading time (11 tables)	341584 ms	257241 ms
Occupied storage space		
Store_Sales	42 GB	14 GB
Date_Dim	11 MB	27 MB
Store	232 KB	4352 KB
Item	110 MB	259 MB
Time_Dim	11 MB	14 MB
Promotion	256 KB	3200 KB
Customer_Demographics	171 MB	11 MB
Customer_Address	170 MB	27 MB
Household_Demographics	504 KB	1280 KB
Customer	441 MB	111 MB
Income_Band	88 KB	896 KB
Total storage space	42 GB	15 GB
Query execution time		
Query 1	14552.05 ms	1783.353 ms
Query 2	27952.36 ms	14247.803 ms
Query 3	17721.15 ms	11441.659 ms
Total execution time	60225.56 ms	27472.815 ms

Step 3 If you have higher expectations for the performance after the table design, you can run the **EXPLAIN PERFORMANCE** command to view the execution plan for tuning.

For more details about execution plans and query tuning, see **SQL Execution Plan** and **Query Performance Tuning Overview**.

----End

3.9 Step 6: Evaluating the Performance of the Optimized Table

Compare the loading time, storage space usage, and query execution time before and after the table tuning.

The following table shows the example results of the cluster used in this tutorial. Your results will be different, but should show similar improvement.

Benchmark	Before	After	Change	Percentage (%)
Loading time (11 tables)	341584 ms	257241 ms	-84343 ms	-24.7%
Occupied storage space			-	-
Store_Sales	42 GB	14 GB	-28 GB	-66.7%
Date_Dim	11 MB	27 MB	16 MB	145.5%
Store	232 KB	4352 KB	4120 KB	1775.9%
Item	110 MB	259 MB	149 MB	1354.5%
Time_Dim	11 MB	14 MB	13 MB	118.2%
Promotion	256 KB	3200 KB	2944 KB	1150%
Customer_Demographics	171 MB	11 MB	-160 MB	-93.6
Customer_Address	170 MB	27 MB	-143 MB	-84.1%
Household_Demographics	504 KB	1280 KB	704 KB	139.7%
Customer	441 MB	111 MB	-330 MB	-74.8%
Income_Band	88 KB	896 KB	808 KB	918.2%
Total storage space	42 GB	15 GB	-27 GB	-64.3%
Query execution time			-	-
Query 1	14552.05 ms	1783.353 ms	-12768.697 ms	-87.7%
Query 2	27952.36 ms	14247.803 ms	-13704.557 ms	-49.0%

Benchmark	Before	After	Change	Percentage (%)
Query 3	17721.15 ms	11441.659 ms	-6279.491 ms	-35.4%
Total execution time	60225.56 ms	27472.815 ms	-32752.745 ms	-54.4%

Evaluating the Table After Optimization

- The loading time was reduced by 24.7%.

  The distribution mode has obvious impact on loading data. The hash distribution mode improves the loading efficiency. The replication distribution mode reduces the loading efficiency. When the CPU and I/O are sufficient, the compression level has little impact on the loading efficiency. Typically, the efficiency of loading a column-store table is higher than that of a row-store table.

- The storage usage space was reduced by 64.3%.

  The compression level, column storage, and hash distribution can save the storage space. A replication table increases the storage usage, but reduces the network overhead. Using the replication mode for small tables is a positive way to use small space for performance.

- The query performance (speed) increased by 54.4%, indicating that the query time decreased by 54.4%.

  The query performance is improved by optimizing storage modes, distribution modes, and distribution keys. In a statistical analysis query on multi-column tables, column storage can improve query performance. In a hash table, I/O resources on each node can be used during I/O read/write, which improves the read/write speed of a table.

  Often, query performance can be improved further by rewriting queries and configuring workload management (WLM). For more information, see **Overview of Query Performance Optimization**.

You can adapt the operations in **Table Optimization Practices** to further improve the distribution of tables and the performance of data loading, storage, and query.

Deleting Resources

After the exercise is completed, delete the cluster by referring to **Deleting a Cluster**.

If you want to keep the cluster, but delete the storage space used by the SS tables, run the following commands:

```
DROP TABLE store_sales;
DROP TABLE date_dim;
DROP TABLE store;
DROP TABLE item;
DROP TABLE time_dim;
DROP TABLE promotion;
DROP TABLE customer_demographics;
DROP TABLE customer_address;
DROP TABLE household_demographics;
DROP TABLE customer;
DROP TABLE income_band;
```

3.10 Appendix: Table Creation Syntax

3.10.1 Usage

This section provides SQL test statements used in this tutorial. You are advised to copy the SQL statements in each section and save them as an .sql file. For example, create a file named **create_table_fir.sql** file and paste the SQL statements in section **Creating an Initial Table** to the file. Executing the file on an SQL client tool is efficient, and the total elapsed time of test cases is easy to calculate. Execute the **.sql** file using **gsql** as follows:

```
gsql -d database_name -h dws_ip -U username -p port_number -W password -f XXX.sql
```

Replace the italic parts in the example with actual values in GaussDB(DWS). For example:

```
gsql -d postgres -h 10.10.0.1 -U dbadmin -p 8000 -W password -f create_table_fir.sql
```

Replace the following information in the example based on the site requirements:

- **postgres**: indicates the name of the database to be connected.
- **10.10.0.1**: cluster connection address.
- **dbadmin**: username of the cluster database. The default administrator is **dbadmin**.
- **8000**: database port set during cluster creation.
- **password**: password set during cluster creation.

3.10.2 Creating an Initial Table

This section contains the table creation syntax used when you create a table for the first time in this tutorial. Tables are created without specifying their storage modes, distribution keys, distribution modes, or compression modes.

```
CREATE TABLE store_sales
(
    ss_sold_date_sk           integer                       ,
    ss_sold_time_sk           integer                       ,
    ss_item_sk                integer               not null,
    ss_customer_sk            integer                       ,
    ss_cdemo_sk               integer                       ,
    ss_hdemo_sk               integer                       ,
    ss_addr_sk                integer                       ,
    ss_store_sk               integer                       ,
    ss_promo_sk               integer                       ,
    ss_ticket_number          bigint                not null,
    ss_quantity               integer                       ,
    ss_wholesale_cost         decimal(7,2)                  ,
    ss_list_price             decimal(7,2)                  ,
    ss_sales_price            decimal(7,2)                  ,
    ss_ext_discount_amt       decimal(7,2)                  ,
    ss_ext_sales_price        decimal(7,2)                  ,
    ss_ext_wholesale_cost     decimal(7,2)                  ,
    ss_ext_list_price         decimal(7,2)                  ,
    ss_ext_tax                decimal(7,2)                  ,
    ss_coupon_amt             decimal(7,2)                  ,
    ss_net_paid               decimal(7,2)                  ,
    ss_net_paid_inc_tax       decimal(7,2)                  ,
    ss_net_profit             decimal(7,2)
) ;

CREATE TABLE date_dim
(
    d_date_sk                 integer               not null,
    d_date_id                 char(16)              not null,
    d_date                    date                          ,
    d_month_seq               integer                       ,
    d_week_seq                integer                       ,
    d_quarter_seq             integer                       ,
    d_year                    integer                       ,
    d_dow                     integer                       ,
    d_moy                     integer                       ,
    d_dom                     integer                       ,
    d_qoy                     integer                       ,
    d_fy_year                 integer                       ,
    d_fy_quarter_seq          integer                       ,
    d_fy_week_seq             integer                       ,
    d_day_name                char(9)                       ,
    d_quarter_name            char(6)                       ,
    d_holiday                 char(1)                       ,
    d_weekend                 char(1)                       ,
    d_following_holiday       char(1)                       ,
    d_first_dom               integer                       ,
    d_last_dom                integer                       ,
    d_same_day_ly             integer                       ,
    d_same_day_lq             integer                       ,
    d_current_day             char(1)                       ,
    d_current_week            char(1)                       ,
    d_current_month           char(1)                       ,
    d_current_quarter         char(1)                       ,
    d_current_year            char(1)
) ;

CREATE TABLE store
(
    s_store_sk                integer               not null,
    s_store_id                char(16)              not null,
    s_rec_start_date          date                          ,
    s_rec_end_date            date                          ,
    s_closed_date_sk          integer                       ,
    s_store_name              varchar(50)                   ,
    s_number_employees        integer                       ,
    s_floor_space             integer                       ,
    s_hours                   char(20)                      ,
    s_manager                 varchar(40)                   ,
    s_market_id               integer                       ,
    s_geography_class         varchar(100)                  ,
    s_market_desc             varchar(100)                  ,
    s_market_manager          varchar(40)                   ,
    s_division_id             integer                       ,
    s_division_name           varchar(50)                   ,
    s_company_id              integer                       ,
    s_company_name            varchar(50)                   ,
    s_street_number           varchar(10)                   ,
    s_street_name             varchar(60)                   ,
    s_street_type             char(15)                      ,
    s_suite_number            char(10)                      ,
    s_city                    varchar(60)                   ,
    s_county                  varchar(30)                   ,
    s_state                   char(2)                       ,
    s_zip                     char(10)                      ,
    s_country                 varchar(20)                   ,
    s_gmt_offset              decimal(5,2)                  ,
    s_tax_precentage          decimal(5,2)
) ;
```

```
CREATE TABLE item
(
    i_item_sk                 integer               not null,
    i_item_id                 char(16)              not null,
    i_rec_start_date          date                          ,
    i_rec_end_date            date                          ,
    i_item_desc               varchar(200)                  ,
    i_current_price           decimal(7,2)                  ,
    i_wholesale_cost          decimal(7,2)                  ,
    i_brand_id                integer                       ,
    i_brand                   char(50)                      ,
    i_class_id                integer                       ,
    i_class                   char(50)                      ,
    i_category_id             integer                       ,
    i_category                char(50)                      ,
    i_manufact_id             integer                       ,
    i_manufact                char(50)                      ,
    i_size                    char(20)                      ,
    i_formulation             char(20)                      ,
    i_color                   char(20)                      ,
    i_units                   char(10)                      ,
    i_container               char(10)                      ,
    i_manager_id              integer                       ,
    i_product_name            char(50)
) ;

CREATE TABLE time_dim
(
    t_time_sk                 integer               not null,
    t_time_id                 char(16)              not null,
    t_time                    integer                       ,
    t_hour                    integer                       ,
    t_minute                  integer                       ,
    t_second                  integer                       ,
    t_am_pm                   char(2)                       ,
    t_shift                   char(20)                      ,
    t_sub_shift               char(20)                      ,
    t_meal_time               char(20)
) ;

CREATE TABLE promotion
(
    p_promo_sk                integer               not null,
    p_promo_id                char(16)              not null,
    p_start_date_sk           integer                       ,
    p_end_date_sk             integer                       ,
    p_item_sk                 integer                       ,
    p_cost                    decimal(15,2)                 ,
    p_response_target         integer                       ,
    p_promo_name              char(50)                      ,
    p_channel_dmail           char(1)                       ,
    p_channel_email           char(1)                       ,
    p_channel_catalog         char(1)                       ,
    p_channel_tv              char(1)                       ,
    p_channel_radio           char(1)                       ,
    p_channel_press           char(1)                       ,
    p_channel_event           char(1)                       ,
    p_channel_demo            char(1)                       ,
    p_channel_details         varchar(100)                  ,
    p_purpose                 char(15)                      ,
    p_discount_active         char(1)
) ;

CREATE TABLE customer_demographics
(
    cd_demo_sk                integer               not null,
    cd_gender                 char(1)                       ,
    cd_marital_status         char(1)                       ,
    cd_education_status       char(20)                      ,
    cd_purchase_estimate      integer                       ,
    cd_credit_rating          char(10)                      ,
    cd_dep_count              integer                       ,
    cd_dep_employed_count     integer                       ,
    cd_dep_college_count      integer
) ;

CREATE TABLE customer_address
(
    ca_address_sk             integer               not null,
    ca_address_id             char(16)              not null,
    ca_street_number          char(10)                      ,
    ca_street_name            varchar(60)                   ,
    ca_street_type            char(15)                      ,
    ca_suite_number           char(10)                      ,
    ca_city                   varchar(60)                   ,
    ca_county                 varchar(30)                   ,
    ca_state                  char(2)                       ,
    ca_zip                    char(10)                      ,
    ca_country                varchar(20)                   ,
    ca_gmt_offset             decimal(5,2)                  ,
    ca_location_type          char(20)
) ;

CREATE TABLE household_demographics
(
    hd_demo_sk                integer               not null,
    hd_income_band_sk         integer                       ,
    hd_buy_potential          char(15)                      ,
    hd_dep_count              integer                       ,
    hd_vehicle_count          integer
) ;

CREATE TABLE customer
(
    c_customer_sk             integer               not null,
    c_customer_id             char(16)              not null,
    c_current_cdemo_sk        integer                       ,
    c_current_hdemo_sk        integer                       ,
    c_current_addr_sk         integer                       ,
    c_first_shipto_date_sk    integer                       ,
    c_first_sales_date_sk     integer                       ,
    c_salutation              char(10)                      ,
    c_first_name              char(20)                      ,
    c_last_name               char(30)                      ,
    c_preferred_cust_flag     char(1)                       ,
    c_birth_day               integer                       ,
    c_birth_month             integer                       ,
    c_birth_year              integer                       ,
    c_birth_country           varchar(20)                   ,
    c_login                   char(13)                      ,
    c_email_address           char(50)                      ,
    c_last_review_date        char(10)
) ;

CREATE TABLE income_band
(
    ib_income_band_sk         integer               not null,
    ib_lower_bound            integer                       ,
    ib_upper_bound            integer
) ;
```

3.10.3 Creating a Another Table After Design Optimization

This section contains the syntax of creating another table after the storage modes, compression levels, distribution modes, and distribution keys are selected in this practice.

```
CREATE TABLE store_sales
(
    ss_sold_date_sk           integer                       ,
    ss_sold_time_sk           integer                       ,
    ss_item_sk                integer               not null,
    ss_customer_sk            integer                       ,
    ss_cdemo_sk               integer                       ,
    ss_hdemo_sk               integer                       ,
    ss_addr_sk                integer                       ,
    ss_store_sk               integer                       ,
    ss_promo_sk               integer                       ,
    ss_ticket_number          bigint                not null,
    ss_quantity               integer                       ,
    ss_wholesale_cost         decimal(7,2)                  ,
    ss_list_price             decimal(7,2)                  ,
    ss_sales_price            decimal(7,2)                  ,
    ss_ext_discount_amt       decimal(7,2)                  ,
    ss_ext_sales_price        decimal(7,2)                  ,
    ss_ext_wholesale_cost     decimal(7,2)                  ,
    ss_ext_list_price         decimal(7,2)                  ,
    ss_ext_tax                decimal(7,2)                  ,
    ss_coupon_amt             decimal(7,2)                  ,
    ss_net_paid               decimal(7,2)                  ,
    ss_net_paid_inc_tax       decimal(7,2)                  ,
    ss_net_profit             decimal(7,2)
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY hash (ss_item_sk);

CREATE TABLE date_dim
(
    d_date_sk                 integer               not null,
    d_date_id                 char(16)              not null,
    d_date                    date                          ,
    d_month_seq               integer                       ,
    d_week_seq                integer                       ,
    d_quarter_seq             integer                       ,
    d_year                    integer                       ,
    d_dow                     integer                       ,
    d_moy                     integer                       ,
    d_dom                     integer                       ,
    d_qoy                     integer                       ,
    d_fy_year                 integer                       ,
    d_fy_quarter_seq          integer                       ,
    d_fy_week_seq             integer                       ,
    d_day_name                char(9)                       ,
    d_quarter_name            char(6)                       ,
    d_holiday                 char(1)                       ,
    d_weekend                 char(1)                       ,
    d_following_holiday       char(1)                       ,
    d_first_dom               integer                       ,
    d_last_dom                integer                       ,
    d_same_day_ly             integer                       ,
    d_same_day_lq             integer                       ,
    d_current_day             char(1)                       ,
    d_current_week            char(1)                       ,
    d_current_month           char(1)                       ,
    d_current_quarter         char(1)                       ,
    d_current_year            char(1)
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY replication;

CREATE TABLE store
(
    s_store_sk                integer               not null,
    s_store_id                char(16)              not null,
    s_rec_start_date          date                          ,
    s_rec_end_date            date                          ,
    s_closed_date_sk          integer                       ,
    s_store_name              varchar(50)                   ,
    s_number_employees        integer                       ,
    s_floor_space             integer                       ,
    s_hours                   char(20)                      ,
    s_manager                 varchar(40)                   ,
    s_market_id               integer                       ,
    s_geography_class         varchar(100)                  ,
    s_market_desc             varchar(100)                  ,
    s_market_manager          varchar(40)                   ,
    s_division_id             integer                       ,
    s_division_name           varchar(50)                   ,
    s_company_id              integer                       ,
    s_company_name            varchar(50)                   ,
    s_street_number           varchar(10)                   ,
    s_street_name             varchar(60)                   ,
    s_street_type             char(15)                      ,
    s_suite_number            char(10)                      ,
    s_city                    varchar(60)                   ,
    s_county                  varchar(30)                   ,
    s_state                   char(2)                       ,
    s_zip                     char(10)                      ,
    s_country                 varchar(20)                   ,
    s_gmt_offset              decimal(5,2)                  ,
    s_tax_precentage          decimal(5,2)
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY replication;

CREATE TABLE item
(
    i_item_sk                 integer               not null,
    i_item_id                 char(16)              not null,
    i_rec_start_date          date                          ,
    i_rec_end_date            date                          ,
    i_item_desc               varchar(200)                  ,
    i_current_price           decimal(7,2)                  ,
    i_wholesale_cost          decimal(7,2)                  ,
    i_brand_id                integer                       ,
    i_brand                   char(50)                      ,
    i_class_id                integer                       ,
    i_class                   char(50)                      ,
    i_category_id             integer                       ,
    i_category                char(50)                      ,
    i_manufact_id             integer                       ,
    i_manufact                char(50)                      ,
    i_size                    char(20)                      ,
    i_formulation             char(20)                      ,
    i_color                   char(20)                      ,
    i_units                   char(10)                      ,
    i_container               char(10)                      ,
    i_manager_id              integer                       ,
    i_product_name            char(50)
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY replication;

CREATE TABLE time_dim
(
    t_time_sk                 integer               not null,
    t_time_id                 char(16)              not null,
    t_time                    integer                       ,
    t_hour                    integer                       ,
    t_minute                  integer                       ,
    t_second                  integer                       ,
    t_am_pm                   char(2)                       ,
    t_shift                   char(20)                      ,
    t_sub_shift               char(20)                      ,
    t_meal_time               char(20)
```

```
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY replication;

CREATE TABLE promotion
(
    p_promo_sk                integer               not null,
    p_promo_id                char(16)              not null,
    p_start_date_sk           integer                       ,
    p_end_date_sk             integer                       ,
    p_item_sk                 integer                       ,
    p_cost                    decimal(15,2)                 ,
    p_response_target         integer                       ,
    p_promo_name              char(50)                      ,
    p_channel_dmail           char(1)                       ,
    p_channel_email           char(1)                       ,
    p_channel_catalog         char(1)                       ,
    p_channel_tv              char(1)                       ,
    p_channel_radio           char(1)                       ,
    p_channel_press           char(1)                       ,
    p_channel_event           char(1)                       ,
    p_channel_demo            char(1)                       ,
    p_channel_details         varchar(100)                  ,
    p_purpose                 char(15)                      ,
    p_discount_active         char(1)
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY replication;

CREATE TABLE customer_demographics
(
    cd_demo_sk                integer               not null,
    cd_gender                 char(1)                       ,
    cd_marital_status         char(1)                       ,
    cd_education_status       char(20)                      ,
    cd_purchase_estimate      integer                       ,
    cd_credit_rating          char(10)                      ,
    cd_dep_count              integer                       ,
    cd_dep_employed_count     integer                       ,
    cd_dep_college_count      integer
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY hash (cd_demo_sk);

CREATE TABLE customer_address
(
    ca_address_sk             integer               not null,
    ca_address_id             char(16)              not null,
    ca_street_number          char(10)                      ,
    ca_street_name            varchar(60)                   ,
    ca_street_type            char(15)                      ,
    ca_suite_number           char(10)                      ,
    ca_city                   varchar(60)                   ,
    ca_county                 varchar(30)                   ,
    ca_state                  char(2)                       ,
    ca_zip                    char(10)                      ,
    ca_country                varchar(20)                   ,
    ca_gmt_offset             decimal(5,2)                  ,
    ca_location_type          char(20)
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY hash (ca_address_sk);

CREATE TABLE household_demographics
(
    hd_demo_sk                integer               not null,
    hd_income_band_sk         integer                       ,
    hd_buy_potential          char(15)                      ,
    hd_dep_count              integer                       ,
    hd_vehicle_count          integer
)
 WITH (ORIENTATION = column,COMPRESSION=middle)
 DISTRIBUTE BY replication;

 CREATE TABLE customer
(
    c_customer_sk             integer               not null,
    c_customer_id             char(16)              not null,
    c_current_cdemo_sk        integer                       ,
    c_current_hdemo_sk        integer                       ,
    c_current_addr_sk         integer                       ,
    c_first_shipto_date_sk    integer                       ,
    c_first_sales_date_sk     integer                       ,
    c_salutation              char(10)                      ,
    c_first_name              char(20)                      ,
    c_last_name               char(30)                      ,
    c_preferred_cust_flag     char(1)                       ,
    c_birth_day               integer                       ,
    c_birth_month             integer                       ,
    c_birth_year              integer                       ,
    c_birth_country           varchar(20)                   ,
    c_login                   char(13)                      ,
    c_email_address           char(50)                      ,
    c_last_review_date        char(10)
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY hash (c_customer_sk);

CREATE TABLE income_band
(
    ib_income_band_sk         integer               not null,
    ib_lower_bound            integer                       ,
    ib_upper_bound            integer
)
WITH (ORIENTATION = column,COMPRESSION=middle)
DISTRIBUTE BY replication;
```

3.10.4 Creating a Foreign Table

This section contains the syntax of foreign tables for obtaining sample data used in this tutorial. The sample data is stored in an OBS bucket accessible to all authenticated cloud users.

NOTE

- Note that *<obs_bucket_name>* in the following statement indicates the OBS bucket name. Only some regions are supported. For details about the supported regions and OBS bucket names, see **Supported Regions**. GaussDB(DWS) clusters do not support cross-region access to OBS bucket data.
- You can replace **ACCESS_KEY** and **SECRET_ACCESS_KEY** with your own credentials in this example.
- When an OBS foreign table is created, only the mapping relationship is created, and data is not pulled to the GaussDB (DWS) disk.

```
CREATE FOREIGN TABLE obs_from_store_sales_001
(
    ss_sold_date_sk           integer                       ,
    ss_sold_time_sk           integer                       ,
    ss_item_sk                integer               not null,
    ss_customer_sk            integer                       ,
    ss_cdemo_sk               integer                       ,
    ss_hdemo_sk               integer                       ,
    ss_addr_sk                integer                       ,
    ss_store_sk               integer                       ,
    ss_promo_sk               integer                       ,
    ss_ticket_number          bigint               not null,
    ss_quantity               integer                       ,
    ss_wholesale_cost         decimal(7,2)                  ,
    ss_list_price             decimal(7,2)                  ,
    ss_sales_price            decimal(7,2)                  ,
    ss_ext_discount_amt       decimal(7,2)                  ,
    ss_ext_sales_price        decimal(7,2)                  ,
    ss_ext_wholesale_cost     decimal(7,2)                  ,
    ss_ext_list_price         decimal(7,2)                  ,
    ss_ext_tax                decimal(7,2)                  ,
    ss_coupon_amt             decimal(7,2)                  ,
    ss_net_paid               decimal(7,2)                  ,
    ss_net_paid_inc_tax       decimal(7,2)                  ,
    ss_net_profit             decimal(7,2)
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/store_sales',
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_store_sales_001;

CREATE FOREIGN TABLE obs_from_date_dim_001
(
    d_date_sk                 integer               not null,
    d_date_id                 char(16)              not null,
    d_date                    date                          ,
    d_month_seq               integer                       ,
    d_week_seq                integer                       ,
    d_quarter_seq             integer                       ,
    d_year                    integer                       ,
    d_dow                     integer                       ,
    d_moy                     integer                       ,
    d_dom                     integer                       ,
    d_qoy                     integer                       ,
    d_fy_year                 integer                       ,
    d_fy_quarter_seq          integer                       ,
    d_fy_week_seq             integer                       ,
    d_day_name                char(9)                       ,
    d_quarter_name            char(6)                       ,
    d_holiday                 char(1)                       ,
    d_weekend                 char(1)                       ,
    d_following_holiday       char(1)                       ,
    d_first_dom               integer                       ,
    d_last_dom                integer                       ,
    d_same_day_ly             integer                       ,
    d_same_day_lq             integer                       ,
    d_current_day             char(1)                       ,
    d_current_week            char(1)                       ,
    d_current_month           char(1)                       ,
    d_current_quarter         char(1)                       ,
    d_current_year            char(1)
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/date_dim' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_date_dim_001;

CREATE FOREIGN TABLE obs_from_store_001
(
    s_store_sk                integer               not null,
    s_store_id                char(16)              not null,
    s_rec_start_date          date                          ,
    s_rec_end_date            date                          ,
    s_closed_date_sk          integer                       ,
    s_store_name              varchar(50)                   ,
    s_number_employees        integer                       ,
    s_floor_space             integer                       ,
    s_hours                   char(20)                      ,
    s_manager                 varchar(40)                   ,
    s_market_id               integer                       ,
    s_geography_class         varchar(100)                  ,
    s_market_desc             varchar(100)                  ,
    s_market_manager          varchar(40)                   ,
    s_division_id             integer                       ,
    s_division_name           varchar(50)                   ,
    s_company_id              integer                       ,
    s_company_name            varchar(50)                   ,
    s_street_number           varchar(10)                   ,
    s_street_name             varchar(60)                   ,
    s_street_type             char(15)                      ,
    s_suite_number            char(10)                      ,
    s_city                    varchar(60)                   ,
    s_county                  varchar(30)                   ,
    s_state                   char(2)                       ,
    s_zip                     char(10)                      ,
    s_country                 varchar(20)                   ,
    s_gmt_offset              decimal(5,2)                  ,
    s_tax_precentage          decimal(5,2)
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/store' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_store_001;

CREATE FOREIGN TABLE obs_from_item_001
(
    i_item_sk                 integer               not null,
    i_item_id                 char(16)              not null,
    i_rec_start_date          date                          ,
    i_rec_end_date            date                          ,
    i_item_desc               varchar(200)                  ,
    i_current_price           decimal(7,2)                  ,
    i_wholesale_cost          decimal(7,2)                  ,
    i_brand_id                integer                       ,
    i_brand                   char(50)                      ,
    i_class_id                integer                       ,
    i_class                   char(50)                      ,
    i_category_id             integer                       ,
    i_category                char(50)                      ,
    i_manufact_id             integer                       ,
    i_manufact                char(50)                      ,
    i_size                    char(20)                      ,
    i_formulation             char(20)                      ,
    i_color                   char(20)                      ,
    i_units                   char(10)                      ,
    i_container               char(10)                      ,
    i_manager_id              integer                       ,
    i_product_name            char(50)
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/item' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_item_001;

CREATE FOREIGN TABLE obs_from_time_dim_001
(
    t_time_sk                 integer               not null,
    t_time_id                 char(16)              not null,
    t_time                    integer                       ,
    t_hour                    integer                       ,
    t_minute                  integer                       ,
    t_second                  integer                       ,
    t_am_pm                   char(2)                       ,
    t_shift                   char(20)                      ,
    t_sub_shift               char(20)                      ,
    t_meal_time               char(20)
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/time_dim' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_time_dim_001;

CREATE FOREIGN TABLE obs_from_promotion_001
(
    p_promo_sk                integer               not null,
    p_promo_id                char(16)              not null,
    p_start_date_sk           integer                       ,
    p_end_date_sk             integer                       ,
    p_item_sk                 integer                       ,
    p_cost                    decimal(15,2)                 ,
    p_response_target         integer                       ,
    p_promo_name              char(50)                      ,
    p_channel_dmail           char(1)                       ,
    p_channel_email           char(1)                       ,
    p_channel_catalog         char(1)                       ,
    p_channel_tv              char(1)                       ,
    p_channel_radio           char(1)                       ,
    p_channel_press           char(1)                       ,
    p_channel_event           char(1)                       ,
    p_channel_demo            char(1)                       ,
    p_channel_details         varchar(100)                  ,
    p_purpose                 char(15)                      ,
    p_discount_active         char(1)
```

```
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/promotion' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_promotion_001;

CREATE FOREIGN TABLE obs_from_customer_demographics_001
(
    cd_demo_sk          integer          not null,
    cd_gender          char(1)               ,
    cd_marital_status    char(1)               ,
    cd_education_status   char(20)              ,
    cd_purchase_estimate   integer               ,
    cd_credit_rating    char(10)              ,
    cd_dep_count        integer               ,
    cd_dep_employed_count    integer              ,
    cd_dep_college_count   integer
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/customer_demographics' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_customer_demographics_001;

CREATE FOREIGN TABLE obs_from_customer_address_001
(
ca_address_sk integer not null,
ca_address_id char(16) not null,
ca_street_number char(10) ,
ca_street_name varchar(60) ,
ca_street_type char(15) ,
ca_suite_number char(10) ,
ca_city varchar(60) ,
ca_county varchar(30) ,
ca_state char(2) ,
ca_zip char(10) ,
ca_country varchar(20) ,
ca_gmt_offset float4 ,
ca_location_type char(20)
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/customer_address' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
```

```
WITH err_obs_from_customer_address_001;

CREATE FOREIGN TABLE obs_from_household_demographics_001
(
    hd_demo_sk                integer               not null,
    hd_income_band_sk         integer                       ,
    hd_buy_potential          char(15)                      ,
    hd_dep_count              integer                       ,
    hd_vehicle_count          integer
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/household_demographics' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_household_demographics_001;

CREATE FOREIGN TABLE obs_from_customer_001
(
    c_customer_sk             integer               not null,
    c_customer_id             char(16)              not null,
    c_current_cdemo_sk        integer                       ,
    c_current_hdemo_sk        integer                       ,
    c_current_addr_sk         integer                       ,
    c_first_shipto_date_sk    integer                       ,
    c_first_sales_date_sk     integer                       ,
    c_salutation              char(10)                      ,
    c_first_name              char(20)                      ,
    c_last_name               char(30)                      ,
    c_preferred_cust_flag     char(1)                       ,
    c_birth_day               integer                       ,
    c_birth_month             integer                       ,
    c_birth_year              integer                       ,
    c_birth_country           varchar(20)                   ,
    c_login                   char(13)                      ,
    c_email_address           char(50)                      ,
    c_last_review_date        char(10)
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/customer' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_customer_001;

CREATE FOREIGN TABLE obs_from_income_band_001
(
    ib_income_band_sk         integer               not null,
    ib_lower_bound            integer                       ,
    ib_upper_bound            integer
)
SERVER gsmpp_server
OPTIONS (
LOCATION 'obs://<obs_bucket_name>/tpcds/income_band' ,
FORMAT 'text',
DELIMITER '|',
ENCODING 'utf8',
NOESCAPING 'true',
ACCESS_KEY 'access_key_value_to_be_replaced',
SECRET_ACCESS_KEY 'secret_access_key_value_to_be_replaced',
REJECT_LIMIT 'unlimited',
CHUNKSIZE '64'
)
WITH err_obs_from_income_band_001;
```

4 Advanced Features

4.1 Creating a Time Series Table

Scenarios

Time series tables inherit the syntax of common column-store and row-store tables, making it easier to understand and use.

Time series tables can be managed through out data life cycle. Data increases explosively every day with a lot of dimensions. New partitions need to be added to the table periodically to store new data. Data generated a long time ago usually is of low value and is not frequently accessed. Therefore, it can be periodically deleted. Therefore, time series tables must have the capabilities of periodically adding and deleting partitions.

This practice demonstrates how to quickly create your time series tables and manage them by partitions. Specifying a proper type for a column helps improve the performance of operations such as import and query, making your service more efficient. The following figure uses genset data sampling as an example.

Figure 4-1 Genset data sample

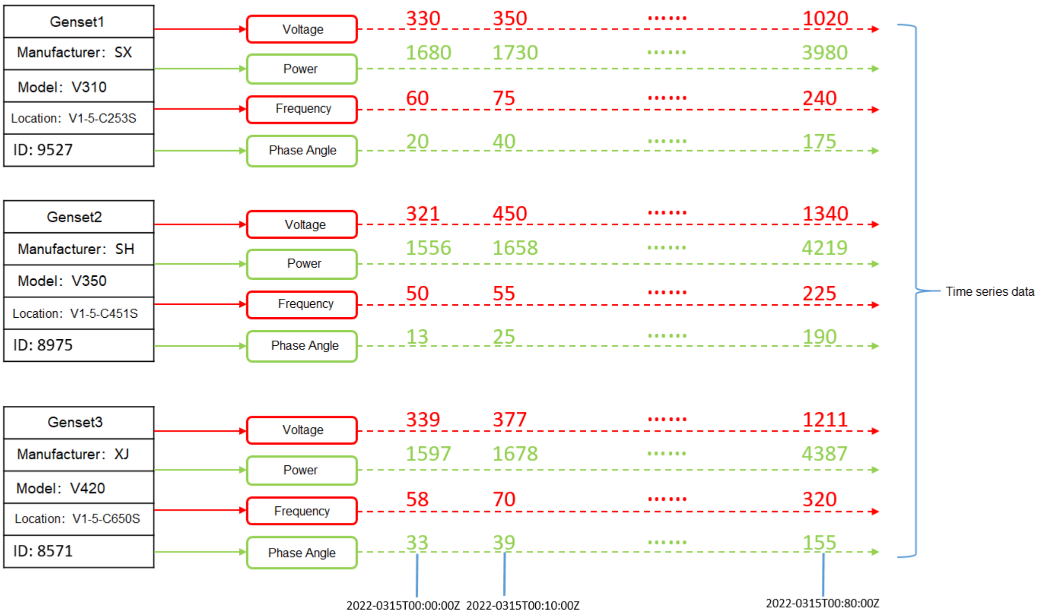
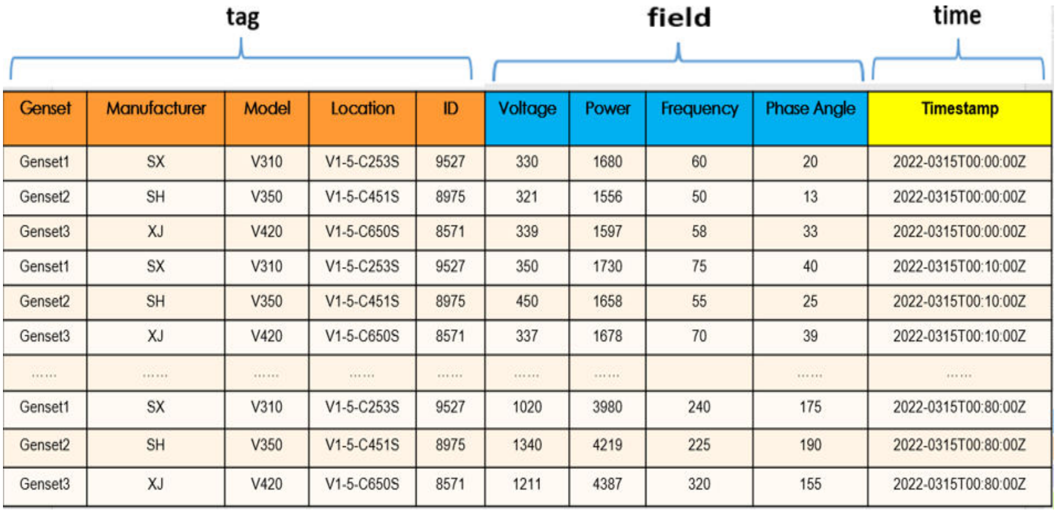


Figure 4-2 Genset data table



tag					field				time
Genset	Manufacturer	Model	Location	ID	Voltage	Power	Frequency	Phase Angle	Timestamp
Genset1	SX	V310	V1-5-C253S	9527	330	1680	60	20	2022-0315T00:00:00Z
Genset2	SH	V350	V1-5-C451S	8975	321	1556	50	13	2022-0315T00:00:00Z
Genset3	XJ	V420	V1-5-C650S	8571	339	1597	58	33	2022-0315T00:00:00Z
Genset1	SX	V310	V1-5-C253S	9527	350	1730	75	40	2022-0315T00:10:00Z
Genset2	SH	V350	V1-5-C451S	8975	450	1658	55	25	2022-0315T00:10:00Z
Genset3	XJ	V420	V1-5-C650S	8571	337	1678	70	39	2022-0315T00:10:00Z
......	......	......	......	......	......	......		......	......
Genset1	SX	V310	V1-5-C253S	9527	1020	3980	240	175	2022-0315T00:80:00Z
Genset2	SH	V350	V1-5-C451S	8975	1340	4219	225	190	2022-0315T00:80:00Z
Genset3	XJ	V420	V1-5-C650S	8571	1211	4387	320	155	2022-0315T00:80:00Z

- The columns that describe generator attributes (generator information, manufacturer, model, location, and ID) are set as tag columns. During table creation, they are specified as **TSTag**
- The values of the sampling data metrics (voltage, power, frequency, and current phase angle) vary with time. During table creation, they are specified as **TSField**.
- The last column is specified as the time column, which stores the time information corresponding to the data in the field columns. During table creation, it is specified as **TSTime**.

Procedure

This practice takes about 30 minutes. The basic process is as follows:

1. **Creating an ECS**.
2. **Creating a Stream Data Warehouse**.
3. **Using the gsql CLI Client to Connect to a Cluster**.
4. **Creating a time series table**.

Creating an ECS

For details, see "Creating an ECS" in the *lastic Cloud Server User Guide*. When the ECS is created, log in to the ECS. For details, see "Remotely Logging In to a Linux ECS Using a Password (SSH)".

NOTICE

When creating an ECS, ensure that the ECS is in the same region, AZ, and VPC subnet as the stream data warehouse. Select the OS used by the gsql client (CentOS 7.6 is used as an example) as the ECS OS, and select using passwords to log in.

Creating a Stream Data Warehouse

Step 1 Log in to the Huawei Cloud management console.

Step 2 Choose **Service List** > **Analytics** > **Data Warehouse Service**. On the page that is displayed, click **Create Cluster** in the upper right corner.

Step 3 Configure the parameters according to **Table 4-1**.

Table 4-1 Software configuration

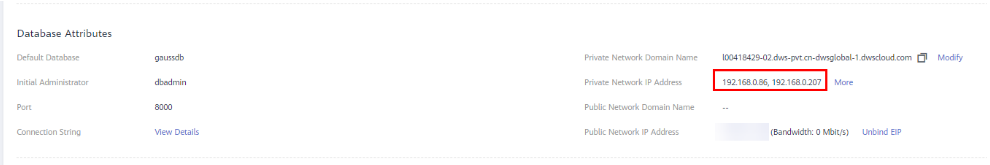
Parameter	Configuration
Region	Select **Europe-Dublin**. **NOTE** ● **CN North-Beijing4** is used as an example. You can select other regions as required. Ensure that all operations are performed in the same region. ● Ensure that GaussDB(DWS) and the ECS are in the same region, AZ, and VPC subnet.
AZ	AZ2
Product	Stream data warehouse
Compute Resource	ECS
Storage Type	Cloud SSD
CPU Architecture	X86

Parameter	Configuration
Node Flavor	dwsx2.rt.2xlarge.m6 (8 vCPU | 64GB | 100-4,000 GB SSD) **NOTE** If this flavor is sold out, select other AZs or flavors.
Hot Storage	200 GB/node
Nodes	3
Cluster Name	dws-demo01
Administrator Account	dbadmin
Administrator Password	*User-defined*
Confirm Password	Enter the user-defined administrator password again.
Database Port	8000
VPC	vpc-default
Subnet	subnet-default(192.168.0.0/24) **NOTICE** Ensure that the cluster and the ECS are in the same VPC subnet.
Security Group	Automatic creation
EIP	Buy now
Enterprise Project	default
Advanced settings	Default

Step 4 Confirm the information, click **Next**, and then click **Submit**.

Step 5 Wait for about 10 minutes. After the cluster is created, click the cluster name to go to the **Basic Information** page. Choose **Network**, click a security group name, and verify that a security group rule has been added. In this example, the client IP address is 192.168.0.*x* (the private network IP address of the ECS where gsql is located is 192.168.0.90). Therefore, you need to add a security group rule in which the IP address is 192.168.0.0/24 and port number is 8000.

Step 6 Return to the **Basic Information** tab of the cluster and record the value of **Private Network IP Address**.



Database Attributes

Default Database	gaussdb	Private Network Domain Name	l00418429-02.dws-pvt.cn-dwsglobal-1.dwscloud.com Modify
Initial Administrator	dbadmin	Private Network IP Address	192.168.0.86, 192.168.0.207 More
Port	8000	Public Network Domain Name	--
Connection String	View Details	Public Network IP Address	[redacted] (Bandwidth: 0 Mbit/s) Unbind EIP

----End

Using the gsql CLI Client to Connect to a Cluster

Step 1 Remotely log in to the Linux server where gsql is to be installed as user **root**, and run the following command in the Linux command window to download the gsql client:

```
wget https://obs.eu-west-101.myhuaweicloud.com/dws/download/dws_client_8.1.x_redhat_x64.zip --no-check-certificate
```

Step 2 Decompress the client.

```
cd <Path_for_storing_the_client> unzip dws_client_8.1.x_redhat_x64.zip
```

Where,

- *<Path_for_storing_the_client>*: Replace it with the actual path.
- *dws_client_8.1.x_redhat_x64.zip*: This is the client tool package name of **RedHat x64**. Replace it with the actual name.

Step 3 Configure the GaussDB(DWS) client.

```
source gsql_env.sh
```

If the following information is displayed, the gsql client is successfully configured:

```
All things done.
```

Step 4 Use the gsql client to connect to a GaussDB(DWS) database (using the password you defined when creating the cluster).

```
gsql -d gaussdb -p 8000 -h 192.168.0.86 -U dbadmin -W password -r
```

If the following information is displayed, the connection succeeded:

```
gaussdb=>
```

----End

Creating a Time Series Table

1. The following describes how to create a time series table **GENERATOR** for storing the sample data of gensets.

```
CREATE TABLE IF NOT EXISTS GENERATOR(
genset text TSTag,
manufacturer text TSTag,
model text TSTag,
location text TSTag,
ID bigint TSTag,
voltage numeric TSField,
power bigint TSField,
frequency numeric TSField,
angle numeric TSField,
time timestamptz TSTime) with (orientation=TIMESERIES, period='1 hour', ttl='1 month') distribute by hash(model);
```

2. Query the current time.

```
select now();
            now
```

```
-------------------------------
2022-05-25 15:28:38.520757+08
(1 row)
```

3. Query the default partition and partition boundary.

```
SELECT relname, boundaries FROM pg_partition where parentid=(SELECT oid FROM pg_class where
relname='generator') order by boundaries ;
    relname     |         boundaries
 ----------------+----------------------------
default_part_1 | {"2022-05-25 16:00:00+08"}
default_part_2 | {"2022-05-25 17:00:00+08"}
p1653505200    | {"2022-05-25 18:00:00+08"}
p1653541200    | {"2022-05-25 19:00:00+08"}
p1653577200    | {"2022-05-25 20:00:00+08"}
......
```

The **TSTAG** columns support the text, char, bool, int, and big int types.

The **TSTime** column supports the timestamp with time zone and timestamp without time zone types. It also supports the date type in databases compatible with the Oracle syntax. If time zone-related operations are involved, select a time type with time zone.

The data types supported by **TSField** columns are the same as those supported by column-store tables.

NOTE

- When writing table creation statements, you can optimize the sequence of tag columns. More unique columns (more distinct values) are written in the front to improve the performance in time sequence scenarios.
- When creating a time series table, set the table-level parameter **orientation** to **timeseries**.
- You do not need to manually specify **DISTRIBUTE BY** and **PARTITION BY** for a time series table. By default, data is distributed based on all tag columns, and the partition key is the TStime column.
- In the **create table like** syntax, the column names and the **kv_type** types are automatically inherited from the source table. If the source table is a non-time series table and the new table is a time series table, the **kv_type** type of the corresponding column cannot be determined. As a result, the creation fails.
- One and only one **TSTIME** attribute must be specified. Columns of the TSTIME type cannot be deleted. There must be at least one **TSTag** and **TSField** columns. Otherwise, an error will be reported during table creation.

Time series tables use the TSTIME column as the partition key and have the function of automatic partition management. Partition tables with the automatic partition management function help users greatly reduce O&M time. In the preceding table creation statement, you can see in the table-level parameters that two parameters **period** and **ttl** are specified for the time series table.

– **period**: interval for automatically creating partitions. The default value is 1 day. The value range is 1 hour ~ 100 years. By default, an auto-increment partition task is created for the time series table. The auto-increment partition task dynamically creates partitions to ensure that sufficient partitions are available for importing data.

– **ttl**: time for automatically eliminate partitions. The value range is 1 hour ~ 100 years. By default, no partition elimination task is created. You need to manually specify the partition elimination task when creating a table or use the ALTER TABLE syntax to set the partition elimination task after creating a table. The partition elimination policy is based on the condition that nowtime - partition boundary > ttl. Partitions that meet this condition will be eliminated. This feature helps users periodically delete obsolete data.

NOTE

For partition boundaries

- If the **period** unit is hour, the start boundary value is the coming hour, and the partition interval is the value of **period**.
- If the **period** unit is day, the start boundary value is 00:00 of the coming day, and the partition interval is the value of **period**.
- If the **period** unit is month, the start boundary value is 00:00 of the coming month, and the partition interval is the value of **period**.
- If the **period** unit is year, the start boundary value is 00:00 of the next year, and the partition interval is the value of period.

Creating a Time Series Table (Manually Setting Partition Boundaries)

1. Manually specify the start boundary value. For example, create the time series table **GENERATOR1** with the default start boundary of partition **P1** as **2022-05-30 16:32:45** and partition **P2** as **2022-05-31 16:56:12**.
```
CREATE TABLE IF NOT EXISTS GENERATOR1(
genset text TSTag,
manufacturer text TSTag,
model text TSTag,
location text TSTag,
ID bigint TSTag,
voltage numeric TSField,
power bigint TSField,
frequency numeric TSField,
angle numeric TSField,
time timestamptz TSTime) with (orientation=TIMESERIES, period='1 day') distribute by hash(model)
partition by range(time)
(
PARTITION P1 VALUES LESS THAN('2022-05-30 16:32:45'),
PARTITION P2 VALUES LESS THAN('2022-05-31 16:56:12')
);
```
2. Query the current time:
```
select now();
            now
-------------------------------
2022-05-31 20:36:09.700096+08(1 row)
```
3. Run the following command to query partitions and partition boundaries:
```
SELECT relname, boundaries FROM pg_partition where parentid=(SELECT oid FROM pg_class where
relname='generator1') order by boundaries ;
   relname   |         boundaries
-------------+---------------------------
p1          | {"2022-05-30 16:32:45+08"}
p2          | {"2022-05-31 16:56:12+08"}
p1654073772 | {"2022-06-01 16:56:12+08"}
p1654160172 | {"2022-06-02 16:56:12+08"}
......
```

4.2 Best Practices of Hot and Cold Data Management

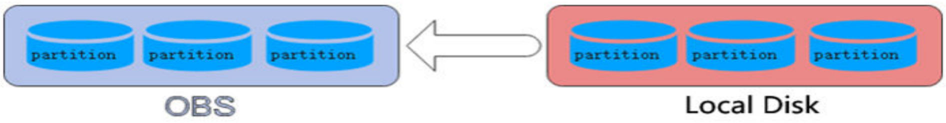
Scenarios

In massive big data scenarios, with the growing of data, data storage and consumption increase rapidly. 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. In some data usage scenarios, data can be classified into hot data and cold data by accessing frequency.

Hot and cold data is classified based on the data access frequency and update frequency.

- Hot data: Data that is frequently accessed and updated and requires fast response.
- Cold data: Data that cannot be updated or is seldom accessed and does not require fast response

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.



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.
- HPN: indicates the number of hot partitions to be reserved. During the cold and hot switchover, data needs to be migrated to OBS. HPN is an integer ranging from 0 to 1600.

Constraints

- 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.
- Currently, cold and hot tables support only column-store partitioned tables of version 2.0. Foreign tables do not support cold and hot partitions.
- Only hot data can be switched to cold data. Cold data cannot be switched to hot data.

Procedure

This practice takes about 30 minutes. The basic process is as follows:

1. **Creating a cluster**.
2. **Using the gsql CLI Client to Connect to a Cluster**.
3. **Creating Hot and Cold Tables**.
4. **Hot and Cold Data Switchover**.
5. **Viewing Data Distribution in Hot and Cold Tables**.

Creating a cluster

Step 1 Log in to the Huawei Cloud management console.

Step 2 Choose **Service List** > **Analytics** > **Data Warehouse Service**. On the page that is displayed, click **Create Cluster** in the upper right corner.

Step 3 Configure the parameters according to **Table 4-2**.

Table 4-2 Software configuration

Parameter	Configuration
Region	Select EU-Dublin. **NOTE** **EU-Dublin** is used as an example. You can select other regions as required. Ensure that all operations are performed in the same region.
AZ	AZ2
Product	Standard data warehouse
CPU Architecture	X86
Node Flavor	dws2.m6.4xlarge.8 (16 vCPUs | 128 GB | 2000 GB SSD) **NOTE** If this flavor is sold out, select other AZs or flavors.
Nodes	3
Cluster Name	dws-demo
Administrator Account	dbadmin
Administrator Password	-
Confirm Password	-
Database Port	8000
VPC	vpc-default
Subnet	subnet-default(192.168.0.0/24)
Security Group	Automatic creation
EIP	Buy now

Parameter	Configuration
Bandwidth	1Mbit/s
Advanced Settings	Default

Step 4 Confirm the information, click **Next**, and then click **Submit**.

Step 5 Wait about 6 minutes. After the cluster is created, click ⌄ next to the cluster name. On the displayed cluster information page, record the value of **Public Network Address**.

----End

Using the gsql CLI Client to Connect to a Cluster

Step 1 Remotely log in to the Linux server where gsql is to be installed as user **root**, and run the following command in the Linux command window to download the gsql client:

```
wget https://obs.eu-west-101.myhuaweicloud.com/dws/download/dws_client_8.1.x_redhat_x64.zip --no-check-certificate
```

Step 2 Decompress the client.

```
cd <Path_for_storing_the_client> unzip dws_client_8.1.x_redhat_x64.zip
```

Where,

- *<Path_for_storing_the_client>*: Replace it with the actual path.
- *dws_client_8.1.x_redhat_x64.zip*: This is the client tool package name of **RedHat x64**. Replace it with the actual name.

Step 3 Configure the GaussDB(DWS) client.

```
source gsql_env.sh
```

If the following information is displayed, the gsql client is successfully configured:

```
All things done.
```

Step 4 Use the gsql client to connect to a GaussDB(DWS) database (using the password you defined when creating the cluster).

```
gsql -d gaussdb -p 8000 -h 192.168.0.86 -U dbadmin -W password -r
```

If the following information is displayed, the connection succeeded:

```
gaussdb=>
```

----End

Creating Hot and Cold Tables

Create a column-store cold and hot data management table **lifecycle_table** 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;
```

Hot and Cold Data Switchover

Switch cold data to the OBS tablespace.

- Automatic switchover: The scheduler automatically triggers the switchover at 00:00 every day.

  You can use the pg_obs_cold_refresh_time(table_name, time) function to customize the automatic switchover time. For example, set the automatic triggering time to 06:30 every morning based on service requirements.

  ```
  SELECT * FROM pg_obs_cold_refresh_time('lifecycle_table', '06:30:00');
  pg_obs_cold_refresh_time
  --------------------------
   SUCCESS
  (1 row)
  ```

- Manual

  Run the ALTER TABLE statement to manually switch a single table.

  ```
  ALTER TABLE lifecycle_table refresh storage;
  ALTER TABLE
  ```

  Use the pg_refresh_storage() function to switch all hot and cold tables in batches.

  ```
  SELECT pg_catalog.pg_refresh_storage();
   pg_refresh_storage
  --------------------
   (1,0)
  (1 row)
  ```

Viewing 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');
  schemaname |    tablename    |   nodename   | hotpartition | coldpartition | switchablepartition |
  hotdatasize | colddatasize | switchabledatasize
  ------------+-----------------+--------------+--------------+---------------+---------------------+-------------
  +--------------+--------------------
   public     | lifecycle_table | dn_6001_6002 | p1,p2,p3,p8  |               |                     | 96 KB       | 0
  bytes       | 0 bytes
   public     | lifecycle_table | dn_6003_6004 | p1,p2,p3,p8  |               |                     | 96 KB       | 0
  bytes       | 0 bytes
   public     | lifecycle_table | dn_6005_6006 | p1,p2,p3,p8  |               |                     | 96 KB       | 0
  bytes       | 0 bytes
  (3 rows)
  ```

- View data distribution in all hot and cold tables:

  ```
  SELECT * FROM pg_catalog.pg_lifecycle_node_data_distribute();
  schemaname |    tablename    |   nodename   | hotpartition | coldpartition | switchablepartition |
  hotdatasize | colddatasize | switchabledatasize
  ------------+-----------------+--------------+--------------+---------------+---------------------+-------------
  +--------------+--------------------
   public     | lifecycle_table | dn_6001_6002 | p1,p2,p3,p8  |               |                     |       98304 |
  0 |                  0
   public     | lifecycle_table | dn_6003_6004 | p1,p2,p3,p8  |               |                     |       98304 |
  0 |                  0
   public     | lifecycle_table | dn_6005_6006 | p1,p2,p3,p8  |               |                     |       98304 |
  0 |                  0
  (3 rows)
  ```

4.3 Best Practices for Automatic Partition Management

Scenarios

For partition tables whose partition columns are time, the automatic partition management function can be added to automatically create partitions and delete expired partitions, reducing partition table maintenance costs and improving query performance. To facilitate data query and maintenance, the time column is often used as the partition column of a partitioned table that stores time-related data, such as e-commerce order information and real-time IoT data. When the time-related data is imported to a partitioned table, the table should have partitions of the corresponding time ranges. Common partition tables do not automatically create new partitions or delete expired partitions. Therefore, maintenance personnel need to periodically create new partitions and delete expired partitions, leading to increased O&M costs.

Addressing this, GaussDB(DWS) introduces the automatic partition management feature. You can set the table-level parameters **period** and **ttl** to enable the automatic partition management function, which automatically creates partitions and deletes expired partitions, reducing partition table maintenance costs and improving query performance.

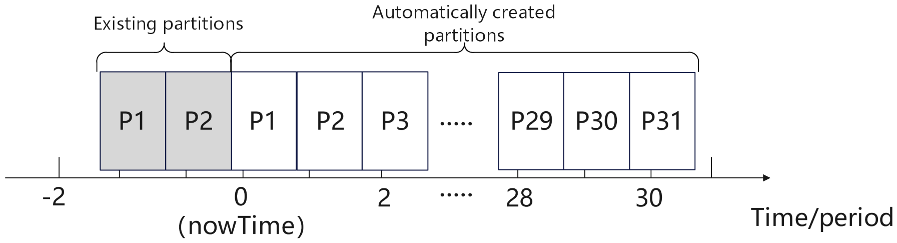
period: interval for automatically creating partitions. The default value is 1 day. The value range is 1 hour ~ 100 years.

ttl: time for automatically eliminate partitions. The value range is 1 hour ~ 100 years. The partition elimination policy is based on the condition that nowtime - partition boundary > ttl. Partitions that meet this condition will be eliminated.

- Automatic partition creation

  One or more partitions are automatically created at the interval specified by **period** to make the maximum partition boundary time greater than nowTime + 30 x period. As long as there is an automatically created partition, real-time data will not fail to be imported within the next 30 periods.

  Figure 4-3 Automatic partition creation

- Automatically deleting expired partitions

  Partitions whose boundary time is earlier than **nowTime-ttl** are considered expired partitions. The automatic partition management function traverses all partitions and deletes expired partitions after each **period**. If all partitions are expired partitions, the system retains one partition and truncates the table.

Constraints

When using the partition management function, ensure that the following requirements are met:

- It cannot be used on midrange servers, acceleration clusters, or stand-alone clusters.
- It can be used in clusters of version 8.1.3 or later.
- It can only be used for row-store range partitioned tables, column-store range partitioned tables, time series tables, and cold and hot tables.
- The partition key must be unique and its type must be timestamp, timestamptz, or date.
- The maxvalue partition is not supported.
- The value of (nowTime - boundaryTime)/period must be less than the maximum number of partitions. **nowTime** indicates the current time, and **boundaryTime** indicates the earliest partition boundary time.
- The values of **period** and **ttl** range from 1 hour to 100 years. In addition, in a database compatible with Teradata or MySQL, if the partition key type is date, the value of period cannot be less than 1day.
- The table-level parameter **ttl** cannot exist independently. You must set **period** in advance or at the same time, and the value of **ttl** must be greater than or equal to that of **period**.
- During online cluster scale-out, partitions cannot be automatically added. Partitions reserved each time partitions are added will ensure that services are not affected.

Creating an ECS

For details, see "Creating an ECS" in the *lastic Cloud Server User Guide*. When the ECS is created, log in to the ECS. For details, see "Remotely Logging In to a Linux ECS Using a Password (SSH)".

NOTICE

When creating an ECS, ensure that the ECS is in the same region, AZ, and VPC subnet as the stream data warehouse. Select the OS used by the gsql client (CentOS 7.6 is used as an example) as the ECS OS, and select using passwords to log in.

Creating a cluster

Step 1 Log in to the Huawei Cloud management console.

Step 2 Choose **Service List** > **Analytics** > **Data Warehouse Service**. On the page that is displayed, click **Create Cluster** in the upper right corner.

Step 3 Configure the parameters according to **Table 4-3**.

Table 4-3 Software configuration

Parameter	Configuration
Region	Select EU-Dublin. **NOTE** **EU-Dublin** is used as an example. You can select other regions as required. Ensure that all operations are performed in the same region.
AZ	AZ2
Product	Standard data warehouse
CPU Architecture	X86
Node Flavor	dws2.m6.4xlarge.8 (16 vCPUs | 128 GB | 2000 GB SSD) **NOTE** If this flavor is sold out, select other AZs or flavors.
Nodes	3
Cluster Name	dws-demo
Administrator Account	dbadmin
Administrator Password	-
Confirm Password	-
Database Port	8000
VPC	vpc-default
Subnet	subnet-default(192.168.0.0/24)
Security Group	Automatic creation
EIP	Buy now
Bandwidth	1Mbit/s
Advanced Settings	Default

Step 4 Confirm the information, click **Next**, and then click **Submit**.

Step 5 Wait about 6 minutes. After the cluster is created, click ⌄ next to the cluster name. On the displayed cluster information page, record the value of **Public Network Address**.

----End

Using the gsql CLI Client to Connect to a Cluster

Step 1 Remotely log in to the Linux server where gsql is to be installed as user **root**, and run the following command in the Linux command window to download the gsql client:

```
wget https://obs.eu-west-101.myhuaweicloud.com/dws/download/dws_client_8.1.x_redhat_x64.zip --no-check-certificate
```

Step 2 Decompress the client.

```
cd <Path_for_storing_the_client> unzip dws_client_8.1.x_redhat_x64.zip
```

Where,

- *<Path_for_storing_the_client>*: Replace it with the actual path.
- *dws_client_8.1.x_redhat_x64.zip*: This is the client tool package name of **RedHat x64**. Replace it with the actual name.

Step 3 Configure the GaussDB(DWS) client.

```
source gsql_env.sh
```

If the following information is displayed, the gsql client is successfully configured:

```
All things done.
```

Step 4 Use the gsql client to connect to a GaussDB(DWS) database (using the password you defined when creating the cluster).

```
gsql -d gaussdb -p 8000 -h 192.168.0.86 -U dbadmin -W password -r
```

If the following information is displayed, the connection succeeded:

```
gaussdb=>
```

----End

Automatic partition management

The partition management function is bound to the table-level parameters **period** and **ttl**. Automatic partition creation is enabled with the enabling of **period**, and automatic partition deletion is enabled with the enabling of **ttl**. 30 seconds after **period** or **ttl** is set, the automatic partition creation or deletion works for the first time.

You can enable the partition management function in either of the following ways:

- Specify **period** and **ttl** when creating a table.

  This way is applicable when you create a partition management table. There are two syntaxes for creating a partition management table. One specifies partitions, and the other does not.

If partitions are specified when a partition management table is created, the syntax rules are the same as those for creating an ordinary partition table. The only difference is that the syntax specifies the table-level parameters **period** and **ttl**.

The following example shows how to create a partition management table **CPU1** and specify partitions.

```
CREATE TABLE CPU1(
    id integer,
    IP text,
    time timestamp
) with (TTL='7 days',PERIOD='1 day')
partition by range(time)
(
    PARTITION P1 VALUES LESS THAN('2023-02-13 16:32:45'),
    PARTITION P2 VALUES LESS THAN('2023-02-15 16:48:12')
);
```

When creating a partition management table, you can specify only the partition key but not partitions. In this case, two default partitions will be created with **period** as the partition time range. The boundary time of the first default partition is the first hour, day, week, month, or year past the current time. The time unit is selected based on the maximum unit of PERIOD. The boundary time of the second default partition is the boundary time of the first partition plus PERIOD. Assume that the current time is 2023-02-17 16:32:45, and the boundary of the first default partition is described in the following table.

Table 4-4 Description of the period parameter

period	Maximum PERIOD Unit	Boundary of First Default Partition
1hour	Hour	2023-02-17 17:00:00
1day	Day	2023-02-18 00:00:00
1month	Month	2023-03-01 00:00:00
13months	Year	2024-01-01 00:00:00

Run the following command to create the partition management table **CPU2** with no partitions specified:

```
CREATE TABLE CPU2(
    id integer,
    IP text,
    time timestamp
) with (TTL='7 days',PERIOD='1 day')
partition by range(time);
```

- Run the **ALTER TABLE RESET** command to set **period** and **ttl**.

  This method is used to add the partition management function to an ordinary partitioned table that meets the partition management constraints.

  – Run the following command to create an ordinary partition table **CPU3**:

    ```
    CREATE TABLE CPU3(
        id integer,
        IP text,
        time timestamp
    ```

```
)
partition by range(time)
(
    PARTITION P1 VALUES LESS THAN('2023-02-14 16:32:45'),
    PARTITION P2 VALUES LESS THAN('2023-02-15 16:56:12')
);
```

- To enable the automatic partition creation and deletion functions, run the following command:

  ```
  ALTER TABLE CPU3 SET (PERIOD='1 day',TTL='7 days');
  ```

- To enable only the automatic partition creation function, run the following command:

  ```
  ALTER TABLE CPU3 SET (PERIOD='1 day');
  ```

- To enable only the automatic partition deletion function, run the following command (If automatic partition creation is not enabled in advance, the operation will fail):

  ```
  ALTER TABLE CPU3 SET (TTL='7 days');
  ```

- Modify the **period** and **ttl** parameters to modify the partition management function.

  ```
  ALTER TABLE CPU3 SET (TTL='10 days',PERIOD='2 days');
  ```

- Disabling the partition management function

  You can run the **ALTER TABLE RESET** command to delete the table-level parameters **period** and **ttl** to disable the partition management function.

  NOTE

  - The **period** cannot be deleted separately with **TTL**.
  - The time series table does not support **ALTER TABLE RESET**.

  - Run the following command to disable the automatic partition creation and deletion functions:

    ```
    ALTER TABLE CPU1 RESET (PERIOD,TTL);
    ```

  - To disable only the automatic partition deletion, run the following command:

    ```
    ALTER TABLE CPU3 RESET (TTL);
    ```

  - To disable only the automatic partition creation function, run the following command (If the table contains the **ttl** parameter, the operation will fail):

    ```
    ALTER TABLE CPU3 RESET (PERIOD);
    ```

4.4 GaussDB (DWS) View Decoupling and Automatic Rebuilding

To solve the problem that base table objects cannot be modified independently due to view and table dependency, GaussDB(DWS) implements view decoupling and rebuilding. This document describes the application scenarios and use methods of the automatic view rebuilding function.

Scenario

GaussDB(DWS) uses object identifiers (OIDs) to store reference relationships between objects. When a view is defined, the OID of the database object on which the view depends is bound to it. No matter how the view name changes, the dependency does not change. If you modify some columns in the base table, an error will be reported because the columns are strongly bound some objects. If you want to delete a table column or the entire table, you need to use the **cascade** keyword to delete the associated views. After the table column is deleted or the table is re-created, you need to re-create the views of different levels one by one. This increases the workload and deteriorates the usability.

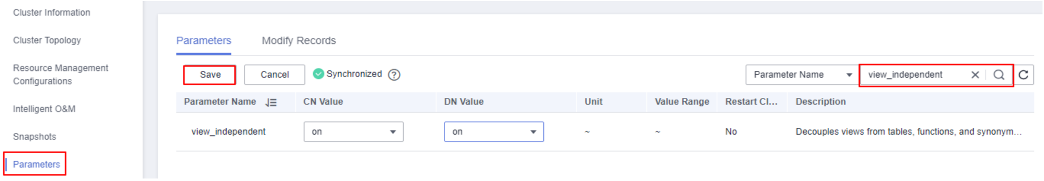
To solve this problem, GaussDB(DWS) 8.1.0 decouples views from their dependent base tables or other database objects (views, synonyms, functions, and table columns), so that these objects can be deleted independently. After the base table is rebuilt, you can run the **ALTER VIEW view_name REBUILD** command to rebuild the dependency. In 8.1.1, automatic rebuilding is implemented. Dependency relationships can be automatically rebuilt without being perceived. After automatic rebuilding is enabled, lock conflicts may occur. Therefore, you are not advised to enable automatic rebuilding.

Usage

Step 1 Create a cluster on the management console. For details, see section **Creating a Cluster**.

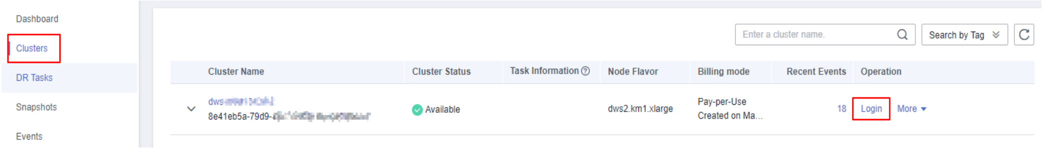
Step 2 Enable the GUC parameter **view_independent**.

The GUC parameter **view_independent** controls whether to decouple a view from its objects. This parameter is disabled by default. You need to manually enable the parameter. To enable the **view_independent** parameter, log in to the management console and click the cluster name. On the displayed **Cluster Details** page, click the **Parameters** tab, search for **view_independent**, modify the parameter, and save the modification.



Parameter Name	CN Value	DN Value	Unit	Value Range	Restart Cl...	Description
view_independent	on	on	~	~	No	Decouples views from tables, functions, and synonym...

Step 3 Use DAS to connect to a cluster. Locate the required cluster in the cluster list and click **Log In** in the **Operation** column. On the DAS page that is displayed, enter the username, database name, and password, and test the connection. If the connection is successful, log in to the cluster. For details, see **Using DAS to Connect to a Cluster**.



Cluster Name	Cluster Status	Task Information	Node Flavor	Billing mode	Recent Events	Operation
dws[redacted] 8e41eb5a-79d9-[redacted]	Available		dws2.km1.xlarge	Pay-per-Use Created on Ma...	18	Login More

Step 4 Create a sample table **t1** and insert data into the table.

```
SET current_schema='public';
CREATE TABLE t1 (a int, b int, c char(10)) DISTRIBUTE BY HASH (a);
INSERT INTO t1 VALUES(1,1,'a'),(2,2,'b');
```

Step 5 Create view **v1** that depends on table **t1**, and create view **v11** that depends on view **v1**. Query view **v11**.

```
CREATE VIEW v1 AS SELECT a, b FROM t1;
CREATE VIEW v11 AS SELECT a FROM v1;
```

```
SELECT * FROM v11;
 a
---
 1
 2
(2 rows)
```

Step 6 After table **t1** is deleted, an error is reported when you query the view **v11**. However, the views still exist.

GaussDB(DWS) provides the **GS_VIEW_INVALID** view to query all invalid views visible to the 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".

```
DROP TABLE t1;

SELECT * FROM v11;
ERROR:  relation "public.t1" does not exist

SELECT * FROM gs_view_invalid;
  oid   | schemaname | viewname | viewowner |          definition          | validtype
--------+------------+----------+-----------+------------------------------+-----------
 213563 | public     | v1       | dbadmin   | SELECT a, b FROM public.t1; | invalid
 213567 | public     | v11      | dbadmin   | SELECT a FROM public.v1;    | invalid
(2 rows)
```

Step 7 In a cluster of a version earlier than recreates table t1, the view is automatically recreated. The views are automatically refreshed only when they are used.

```
CREATE TABLE t1 (a int, b int, c char(10)) DISTRIBUTE BY HASH (a);
INSERT INTO t1 VALUES(1,1,'a'),(2,2,'b');

SELECT * from v1;
 a | b
---+---
 1 | 1
 2 | 2
(2 rows)

SELECT * FROM gs_view_invalid;
  oid   | schemaname | viewname | viewowner |        definition        | validtype
--------+------------+----------+-----------+--------------------------+-----------
 213567 | public     | v11      | dbadmin   | SELECT a FROM public.v1; | invalid
(1 row)

SELECT * from v11;
 a
---
 1
 2
(2 rows)

SELECT * FROM gs_view_invalid;
 oid | schemaname | viewname | viewowner | definition | validtype
-----+------------+----------+-----------+------------+-----------
(0 rows)
```

----End

4.5 Best Practices of Column-Store Delta Tables

Working Principles

In GaussDB(DWS), data in a column-store table is stored by column. By default, 60,000 rows in each column are stored in a CU. A CU is the minimum unit for storing data in a column-store table. After a CU is generated, data in it is fixed and cannot be modified. No matter whether one or 60,000 data records are inserted into a column-store table, only one CU is generated. When a small amount of data is inserted into a column-store table for multiple times, it cannot be well depressed. As a result, data bloating occurs, which affects the query performance and disk usage.

Data in a CU file cannot be modified and can only be appended. Deleting the CU file data is to mark the old data as invalid in the dictionary. Updating the CU file data is to mark the old data as invalid and write a new record to the new CU. If a column-store table is updated or deleted for multiple times or only a small amount of data is inserted each time, the column-store table space bloats and a large amount of space cannot be effectively used.

Column-store tables are designed to import a large amount of data and store it by column for query. To solve the preceding problems, the delta table is introduced, which is a row-store table attached to a column-store table. After the delta table is enabled, when a single piece of data or a small batch of data is imported, the data is stored in the delta table to avoid small CUs. The addition, deletion, modification, and query of the delta table are the same as those of row-store tables. After the delta table is enabled, the performance of importing column-store tables is greatly improved.

Use Cases

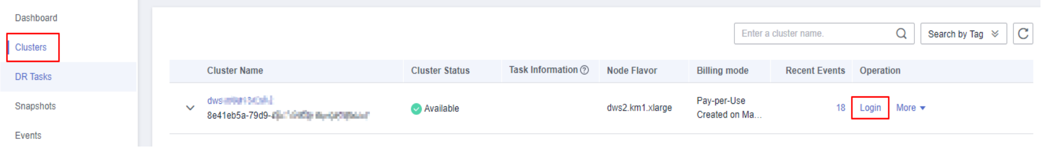
The column-store delta table is used for hybrid row-column storage and is suitable for real-time analysis and statistics. It solves the performance problem caused by importing small batches of data and periodically merges the data to the primary table to ensure the analysis and query performance. You need to determine whether to enable delta tables based on the actual situation. Otherwise, the advantages of GaussDB(DWS) column-store tables cannot be fully utilized, wasting extra space and time.

Preparations

- You have registered a GaussDB(DWS) account and checked the account status before using GaussDB(DWS). The account cannot be in arrears or frozen.
- You have obtained the AK and SK of the account.
- The sample data has been uploaded to the **traffic-data** folder in an OBS bucket, and all Huawei Cloud accounts have been granted the read-only permission for accessing the OBS bucket. For details, see **Checkpoint Vehicle Analysis**.

Procedure

Step 1 Use DAS to connect to a cluster. Locate the required cluster in the cluster list and click **Log In** in the **Operation** column. On the DAS page that is displayed, enter the username, database name, and password, and test the connection. If the connection is successful, log in to the cluster. For details, see **Using DAS to Connect to a Cluster**.



Cluster Name	Cluster Status	Task Information	Node Flavor	Billing mode	Recent Events	Operation
dws-[redacted] 8e41eb5a-79d9-[redacted]	Available		dws2.km1.xlarge	Pay-per-Use Created on Ma...	18	Login More

Step 2 Execute the following statement to create the **traffic** database:

```
CREATE DATABASE traffic encoding 'utf8' template template0;
```

Step 3 Run the following statements to create database tables **GCJL** and **GCJL2** for storing checkpoint vehicle information: By default, the delta table is not enabled for **GCJL** but is enabled for **GCJL2**.

```
CREATE SCHEMA traffic_data;
SET current_schema= traffic_data;
DROP TABLE if exists GCJL;
CREATE TABLE GCJL
(
        kkbh   VARCHAR(20),
        hphm   VARCHAR(20),
        gcsj   DATE ,
        cplx   VARCHAR(8),
        cllx   VARCHAR(8),
        csys   VARCHAR(8)
)
with (orientation = column, COMPRESSION=MIDDLE)
distribute by hash(hphm);

DROP TABLE if exists GCJL2;
CREATE TABLE GCJL2
(
        kkbh   VARCHAR(20),
        hphm   VARCHAR(20),
        gcsj   DATE ,
        cplx   VARCHAR(8),
        cllx   VARCHAR(8),
        csys   VARCHAR(8)
)
with (orientation = column, COMPRESSION=MIDDLE, ENABLE_DELTA = TRUE)
distribute by hash(hphm);
```

NOTE

- Delta tables are disabled by default. To enable delta tables, set **enable_delta** to **true** when creating column-store tables.
- You can also run the following command to enable delta tables:
  ```
  ALTER TABLE table_name SET (enable_delta=TRUE);
  ```
- If the delta table has been enabled, you can run the following command to disable it when required:
  ```
  ALTER TABLE table_name SET (enable_delta=FALSE);
  ```

Step 4 Create a foreign table, which is used to identify and associate the source data on OBS.

NOTICE

- *<obs_bucket_name>* indicates the OBS bucket name. Only some regions are supported. For details about the supported regions and OBS bucket names, see **Supported Regions**. GaussDB(DWS) clusters do not support cross-region access to OBS bucket data.
- , and replace *<Access_Key_Id>* and *<Secret_Access_Key>* with the actual value.
- If the message "ERROR: schema "*xxx*" does not exist Position" is displayed when you create a foreign table, the schema does not exist. Perform the previous step to create a schema.

```
DROP FOREIGN table if exists GCJL_OBS;
CREATE FOREIGN TABLE GCJL_OBS
(
        like traffic_data.GCJL
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/traffic-data/gcxx',
        format 'text',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);
```

Step 5 Execute the following statement to import data from the foreign table to the database table:

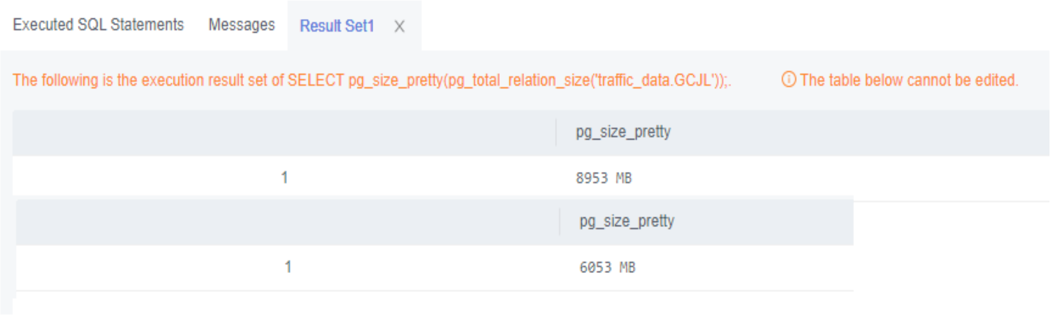
```
INSERT INTO traffic_data.GCJL select * from GCJL_OBS;
INSERT INTO traffic_data.GCJL2 select * from GCJL_OBS;
```

It takes some time to import data.

Step 6 Run the following statement to check the size of the storage space after the database table is imported:

```
SELECT pg_size_pretty(pg_total_relation_size('traffic_data.GCJL'));
SELECT pg_size_pretty(pg_total_relation_size('traffic_data.GCJL2'));
```

After the delta table is enabled, the storage space usage is reduced from 8953 MB to 6053 MB, greatly improving the import performance.



The following is the execution result set of SELECT pg_size_pretty(pg_total_relation_size('traffic_data.GCJL'));.

ⓘ The table below cannot be edited.

	pg_size_pretty
1	8953 MB

	pg_size_pretty
1	6053 MB

Step 7 Run the following statement to query data in the table. The query speed is improved after the delta table is enabled.

```
SELECT * FROM traffic_data.GCJL where hphm =  'YD38641';
SELECT * FROM traffic_data.GCJL2 where hphm =  'YD38641';
```

----End

Impact of Enabling the Delta Table

- Enabling the delta table function of a column-store table can prevent small CUs from being generated when a single piece of data or a small amount of data is imported to the table, hence improving performance. For example, if 100 pieces of data are imported each time in a cluster with 3 CNs and 6 DNs, the import time can be reduced by 25%, the storage space usage can be reduced by 97%. Therefore, you need to enable the delta table before inserting a small batch of data for multiple times and disable the delta table after confirming that no small batch of data needs to be imported.
- A delta table is a row-store table attached to a column-store table. After data is inserted into a delta table, the high compression ratio of the column-store table is lost. In normal cases, column-store tables are used to import a large amount of data. Therefore, the delta table is disabled by default, if the delta table is enabled when a large amount of data is imported, more time and space are consumed. If the delta table is enabled when 10,000 data records each time are imported in a cluster with 3 DNs and 6 DNs, the import speed is four times slower and more than 10 times of the space is consumed than that when the delta table is disabled. Therefore, exercise caution when enabling the delta table.

5 Database Management

5.1 Best Practices of Resource Management

This practice demonstrates how to use GaussDB(DWS) for resource management, helping enterprises eliminate bottlenecks in concurrent query performance. SQL jobs can run smoothly without affecting each other and consume less resources than before.

Before the experiment preparation, if you do not have knowledge about resource management, you are advised to read **Resource Management Page Overview**.

This practice takes about 60 minutes. The process is as follows:

1. **Step 1: Create a Cluster**
2. **Step 2: Connect to a Cluster and Import Data**
3. **Step 3: Creating a Resource Pool**
4. **Step 4: Verify Exception Rules**

Scenarios

When multiple database users execute SQL jobs on GaussDB(DWS) at the same time, the following situations may occur:

1. Some complex SQL statements occupy cluster resources for a long time, affecting the performance of other queries. For example, a group of database users continuously submit complex and time-consuming queries, and another group of users frequently submit short queries. In this case, short queries may have to wait in the resource pool for the time-consuming queries to complete.
2. Some SQL statements occupy too much memory or disk space due to data skew or unoptimized execution plans. As a result, the statements that fail to apply for memory report errors, or the cluster switches to the read-only mode.

To increase the system throughput and improve SQL performance, you can use workload management of GaussDB(DWS). For example, create a resource pool for users who frequently submit complex query jobs, and allocate more resources to this resource pool. The complex jobs submitted by these users can use only the resources of this resource pool. Create another resource pool that occupies less resources and add users who submit short queries to this resource pool. In this way, the two types of jobs can be smoothly executed at the same time.

For example, a bank processes online transaction processing (OLTP) and online analytical processing (OLAP) services. The priority of the OLAP service is lower than that of OLTP service. A large number of concurrent complex SQL queries may cause server resource contention, whereas a large number of concurrent simple SQL queries can be quickly processed without being queued. Resources must be properly allocated and managed to ensure both OLAP and OLTP services can run smoothly.

OLAP services are often complex, and do not require high priority or real-time response. OLAP and OLTP services are operated by different users. For example, the database user **budget_config_user** is used for core transaction services, and the database user **report_user** is used for report services. The users are under independent CPU and concurrency management to improve database stability.

Based on the workload survey, routine monitoring, and test and verification of OLAP services, it is found that less than 50 concurrent SQL queries do not cause server resource contention or slow service system response. OLAP users can use 20% CPU resources.

Based on the workload survey, routine monitoring, and test and verification of OLTP services, it is found that less than 100 concurrent SQL queries do not pose continuous pressure onto the system. OLTP users can use 60% of CPU resources.

- Resource configuration for OLAP users (corresponding to **pool_1**): CPU = 20%, memory = 20%, storage = 1,024,000 MB, concurrency = 20.
- Resource configuration for OLTP users (corresponding to **pool_2**): CPU = 60%, memory = 60%, storage = 1,024,000 MB, concurrency = 200.

Set the maximum memory that can be used by a single statement. An error will be reported if the memory usage exceeds the value.

In **Exception Rule**, set **Blocking Time** to 1200s and **Execution Time** to 1800s. A query job will be terminated after being executed for more than 1800 seconds.

Step 1: Create a Cluster

Create a cluster by referring to **Creating a cluster**.

Step 2: Connect to a Cluster and Import Data

Step 1 For details, see **Using the gsql CLI Client to Connect to a Cluster** Connecting to a Cluster.

Step 2 Import sample data. For details, see **Importing TPC-H Data**.

Step 3 Run the following statements to create the OLTP user **budget_config_user** and OLAP user **report_user**.

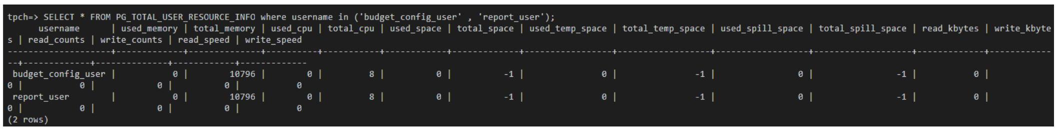
```
CREATE USER budget_config_user PASSWORD 'password';
CREATE USER report_user PASSWORD 'password';
```

Step 4 For test purposes, grant all permissions on all tables in schema **tpch** to both users.

```
GRANT ALL PRIVILEGES ON ALL TABLES IN SCHEMA tpch to budget_config_user,report_user;
```

Step 5 Check the resource allocation of the two users.

SELECT * FROM PG_TOTAL_USER_RESOURCE_INFO where username in ('*budget_config_user*' , '*report_user*');



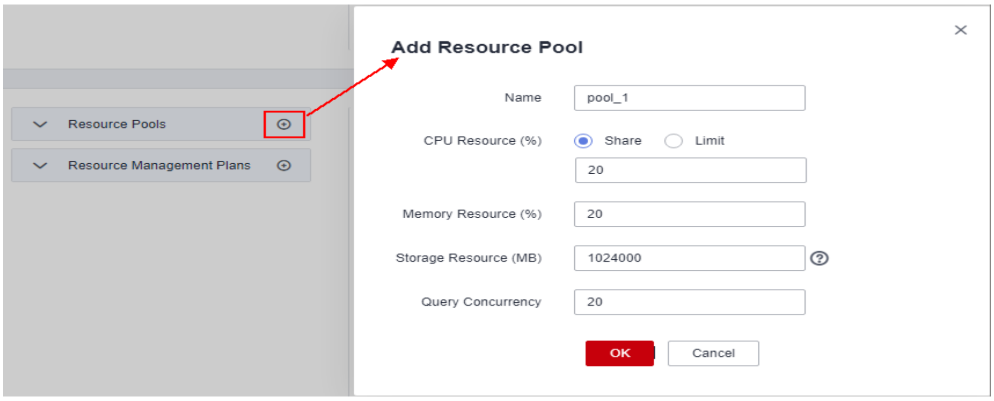
```
tpch=> SELECT * FROM PG_TOTAL_USER_RESOURCE_INFO where username in ('budget_config_user' , 'report_user');
      username      | used_memory | total_memory | used_cpu | total_cpu | used_space | total_space | used_temp_space | total_temp_space | used_spill_space | total_spill_space | read_kbytes | write_kbyte
s | read_counts | write_counts | read_speed | write_speed
--------------------+-------------+--------------+----------+-----------+------------+-------------+-----------------+------------------+------------------+-------------------+-------------+------------
--+-------------+--------------+------------+-------------
 budget_config_user |           0 |        10796 |        0 |         8 |          0 |          -1 |               0 |               -1 |                0 |                -1 |           0 |
0 |           0 |            0 |          0 |           0
 report_user        |           0 |        10796 |        0 |         8 |          0 |          -1 |               0 |               -1 |                0 |                -1 |           0 |
0 |           0 |            0 |          0 |           0
(2 rows)
```

----End

Step 3: Creating a Resource Pool

Step 1 Log in to the GaussDB(DWS) management console, click a cluster name in the cluster list. The **Resource Management Configurations** page is displayed.

Step 2 Click **Add Resource Pool** to create a resource pool. Create the report resource pool **pool_1** and transaction resource pool **pool_2** by referring to **Scenarios**.



Add Resource Pool

Name: pool_1

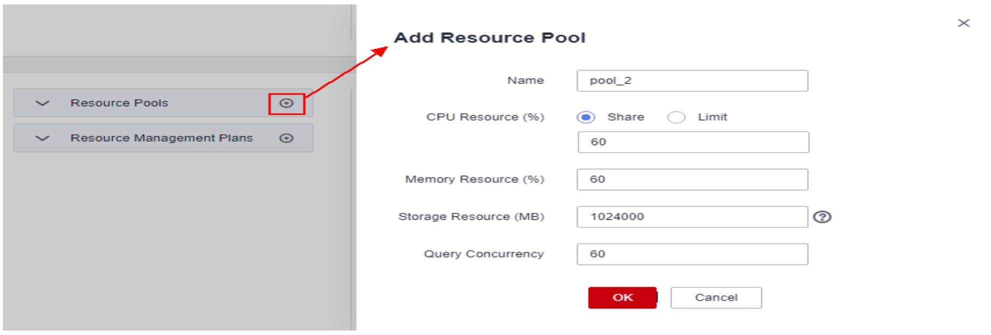
CPU Resource (%): ● Share ○ Limit

20

Memory Resource (%): 20

Storage Resource (MB): 1024000

Query Concurrency: 20



Add Resource Pool

Name: pool_2

CPU Resource (%): ● Share ○ Limit

60

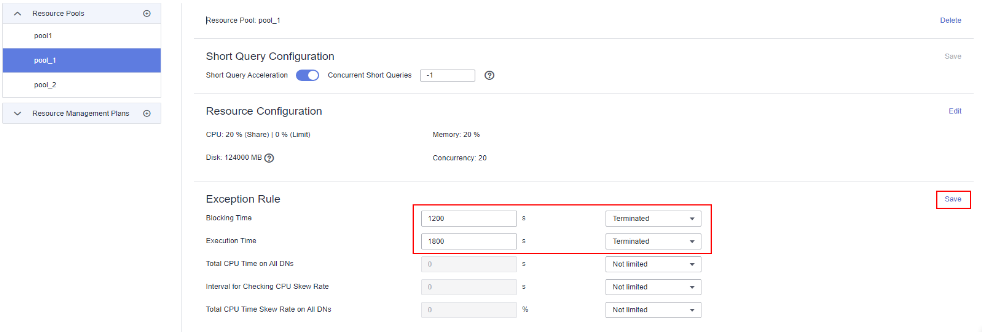
Memory Resource (%): 60

Storage Resource (MB): 1024000

Query Concurrency: 60

Step 3 Modify the exception rules.

1. Click the created **pool_1**.
2. In the **Exception Rule** area, set **Blocking Time** to 1200s and **Execution Time** to 1800s.
3. Click **Save**.
4. Repeat the preceding steps to configure **pool_2**.



Resource Pool: pool_1

Short Query Configuration

Short Query Acceleration: on | Concurrent Short Queries: -1

Resource Configuration

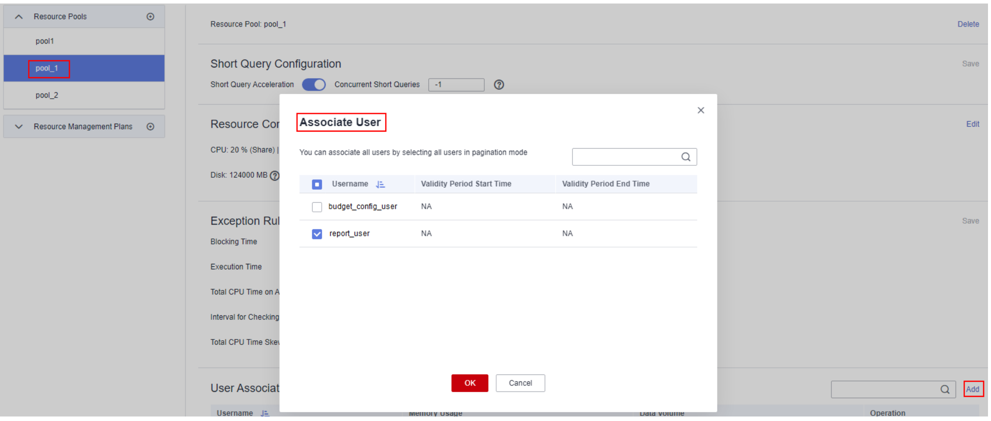
CPU: 20 % (Share) | 0 % (Limit) | Memory: 20 %
Disk: 124000 MB | Concurrency: 20

Exception Rule

Blocking Time	1200	s	Terminated
Execution Time	1800	s	Terminated
Total CPU Time on All DNs	0	s	Not limited
Interval for Checking CPU Skew Rate	0	s	Not limited
Total CPU Time Skew Rate on All DNs	0	%	Not limited

Step 4 Associate users.

1. Click **pool_1** on the left.
2. Click **Add** on the right of **User Association**.
3. Select **report_user** and click **OK**.
4. Repeat the preceding steps to add **budget_config_user** to **pool_2**.

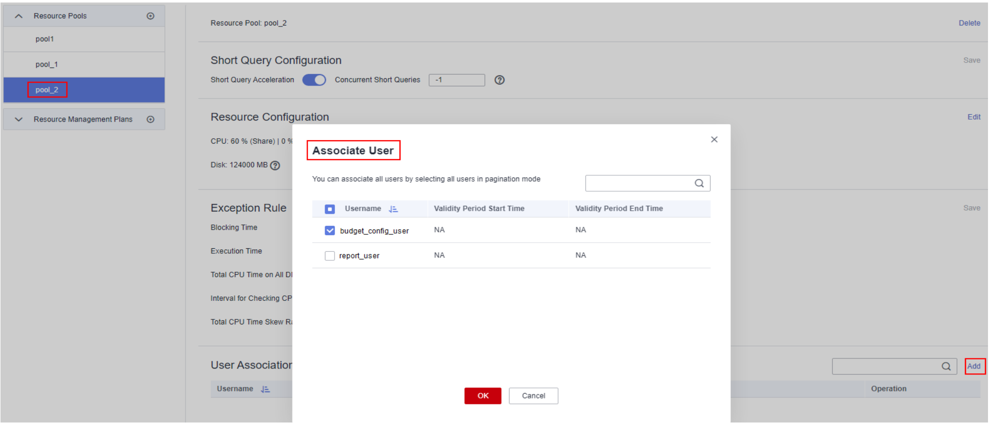


Resource Pool: pool_1

Associate User

You can associate all users by selecting all users in pagination mode

	Username	Validity Period Start Time	Validity Period End Time
□	budget_config_user	NA	NA
☑	report_user	NA	NA



Resource Pool: pool_2

Associate User

You can associate all users by selecting all users in pagination mode

	Username	Validity Period Start Time	Validity Period End Time
☑	budget_config_user	NA	NA
□	report_user	NA	NA

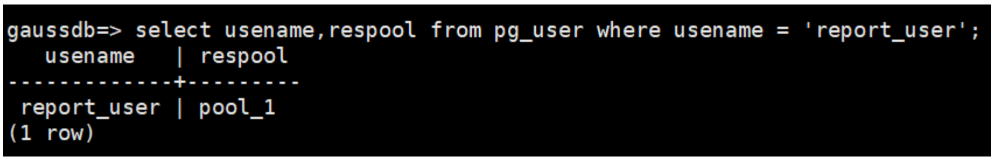
----End

Step 4: Verify Exception Rules

Step 1 Log in to the database as user **report_user**.

Step 2 Run the following command to check the resource pool to which the **report_user** user belongs:

```
SELECT usename,respool FROM pg_user WHERE usename = 'report_user';
```

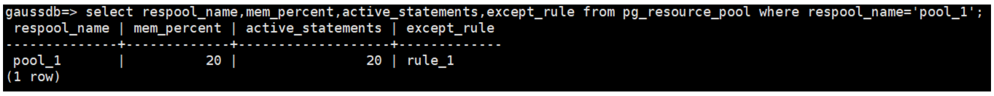


```
gaussdb=> select usename,respool from pg_user where usename = 'report_user';
   usename   | respool
-------------+---------
 report_user | pool_1
(1 row)
```

The query result shows that the resource pool to which the **report_user** user belongs is **pool_1**.

Step 3 Verify the exception rule bound to the resource pool **pool_1**.

```
SELECT respool_name,mem_percent,active_statements,except_rule FROM pg_resource_pool WHERE respool_name='pool_1';
```

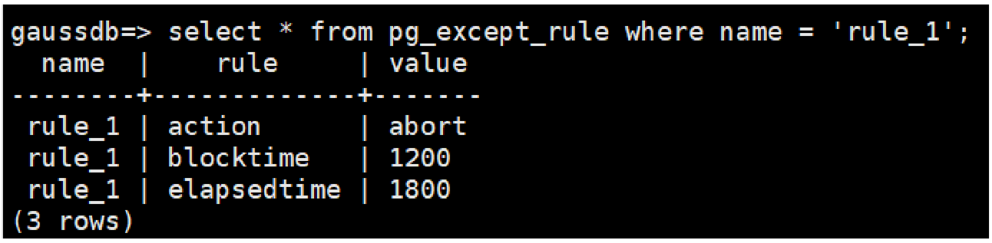


```
gaussdb=> select respool_name,mem_percent,active_statements,except_rule from pg_resource_pool where respool_name='pool_1';
 respool_name | mem_percent | active_statements | except_rule
--------------+-------------+-------------------+-------------
 pool_1       |          20 |                20 | rule_1
(1 row)
```

It is confirmed that the exception rule **rule_1** is bound to **pool_1**.

Step 4 View the rule type and threshold of the exception rule for the current user.

```
SELECT * FROM pg_except_rule WHERE name = 'rule_1';
```



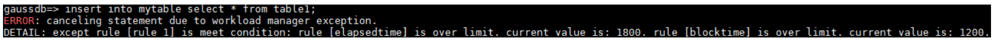
```
gaussdb=> select * from pg_except_rule where name = 'rule_1';
  name  |     rule      | value
--------+---------------+-------
 rule_1 | action        | abort
 rule_1 | blocktime     | 1200
 rule_1 | elapsedtime   | 1800
(3 rows)
```

The return shows that rule_1 has 1200 seconds of block time and 1800 seconds of running duration.

NOTICE

- **PG_EXCEPT_RULE** records information about exception rules and is supported only in cluster 8.2.0 or later.
- The relationship between parameters in the same exception rule is AND.

Step 5 When the block time of a job exceeds 1200s and the running duration exceeds 1800s, an error message is displayed, indicating that the exception rule is triggered and the job is canceled.



```
gaussdb=> insert into mytable select * from table1;
ERROR: canceling statement due to workload manager exception.
DETAIL: except rule [rule_1] is meet condition: rule [elapsedtime] is over limit. current value is: 1800. rule [blocktime] is over limit. current value is: 1200.
```

If error information similar to "ERROR: canceling statement due to workload manager exception." is displayed during job execution, the job is terminated because it exceeds the threshold of the exception rule. If the rules do not need to be modified, you need to optimize the service statements to reduce the execution time.

For details about exception rules, see section **Exception Rules**.

----End

5.2 Excellent Practices for SQL Queries

Based on a large number of SQL execution mechanisms and practices, we can optimize SQL statements following certain rules to more quickly execute SQL statements and obtain correct results.

- Replacing **UNION** with **UNION ALL**

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

- **Adding NOT NULL to the join column**

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

- Converting **NOT IN** to **NOT EXISTS**

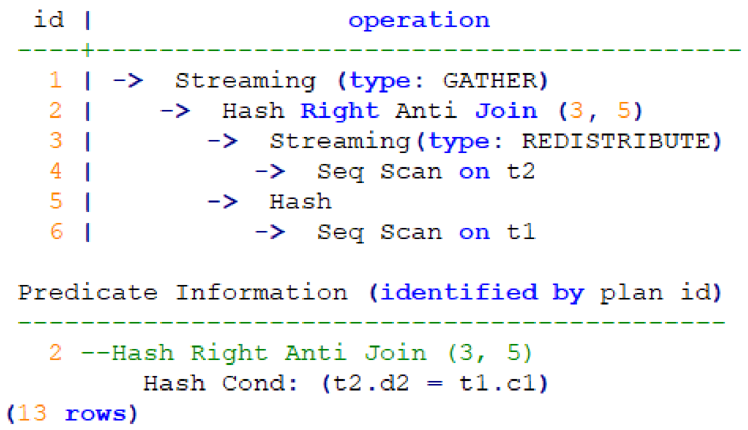
  nestloop anti join must be used to implement **NOT IN**, and **Hash anti join** is required for **NOT EXISTS**. If no **NULL** value exists in the **JOIN** column, **NOT IN** is equivalent to **NOT EXISTS**. Therefore, if you are sure that no **NULL** value exists, you can convert **NOT IN** to **NOT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

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

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

  The generated execution plan is as follows:

Figure 5-1 NOT EXISTS execution plan



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

 Predicate Information (identified by plan id)
 ---------------------------------------------
   2 --Hash Right Anti Join (3, 5)
         Hash Cond: (t2.d2 = t1.c1)
(13 rows)
```

- Use **hashagg**.

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

- Replace functions with **CASE** statements

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

- **Do not use functions or expressions for indexes.**

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

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

- **Split complex SQL statements.**

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

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

For details about SQL tuning, see **Typical SQL Optimization Methods**.

5.3 Analyzing SQL Statements that Are Being Executed

During development, developers often encounter problems such as excessive SQL connections, long SQL query time, and SQL query blocking. You can use the **PG_STAT_ACTIVITY** and **PGXC_THREAD_WAIT_STATUS** views to analyze and locate SQL problems. This section describes some common locating methods.

Table 5-1 Some PG_STAT_ACTIVITY fields

Name	Type	Description
usename	name	Name of the user logging in to the backend
client_addr	inet	IP address of the client connected to the backend **null** 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.

Name	Type	Description
application_name	text	Name of the application connected to the backend
state	text	Overall state of the backend. The values are: - **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 the session status of their own accounts. That is, the state information of other accounts is empty.
waiting	boolean	If the back end is currently waiting for a lock, the value is **t**. Otherwise, the value is **f**. - **t** stands for true. - **f** stands for false.

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

Name	Type	Description
		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.
pid	bigint	ID of the backend thread.

Viewing Connection Information

- Set **track_activities** to **on**.

```
SET track_activities = on;
```

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

- You can run the following SQL statements to check the current connection user, connection address, connection application, status, whether to wait for a lock, queuing status, and thread ID.

```
SELECT usename,client_addr,application_name,state,waiting,enqueue,pid FROM PG_STAT_ACTIVITY
WHERE DATNAME='database name';
```

  The following command output is displayed:

```
 usename |  client_addr  | application_name | state  | waiting | enqueue |       pid
---------+---------------+------------------+--------+---------+---------+-----------------
 leo     | 192.168.0.133 | gsql             | idle   | f       |         | 139666091022080
 dbadmin | 192.168.0.133 | gsql             | active | f       |         | 139666212681472
 joe     | 192.168.0.133 |                  | idle   | f       |         | 139665671489280
(3 rows)
```

- End a session (only the system administrator has the permission).

```
SELECT PG_TERMINATE_BACKEND(pid);
```

Viewing SQL Running Information

- Run the following command to obtain all SQL information that the current user has permission to view (if the current user has administrator or preset role permission, all user query information can be displayed):

```
SELECT usename,state,query FROM PG_STAT_ACTIVITY WHERE DATNAME='database name';
```

  If the value of state is active, the query column indicates the SQL statement that is being executed. In other cases, the query column indicates the previous query statement. If the value of state is idle, the connection is idle and waits for the user to enter a command. The following command output is displayed:

```
 usename | state  |                                   query
---------+--------+--------------------------------------------------------------------------
 leo     | idle   | select * from joe.mytable;
 dbadmin | active | SELECT usename,state,query FROM PG_STAT_ACTIVITY WHERE 
DATNAME='gaussdb';
 joe     | idle   | GRANT SELECT ON TABLE mytable to leo;
(3 rows)
```

- Run the following command to view the information about the SQL statements that are not in the idle state:

```
SELECT datname,usename,query FROM PG_STAT_ACTIVITY WHERE state != 'idle' ;
```

Viewing Time-Consuming Statements

- Check the SQL statements that take a long time to execute.

```
SELECT current_timestamp - query_start as runtime, datname, usename, query FROM 
PG_STAT_ACTIVITY WHERE state != 'idle' order by 1 desc;
```

  Query statements are returned and sorted by execution time length in descending order. The first record is the query statement that takes the longest time to execute.

```
     runtime      | datname  | usename |                                          
query
-----------------+----------+---------
+-------------------------------------------------------------------------------------------------------------------------
--------------------
 00:04:47.054958 | gaussdb  | leo     | insert into mytable1 select generate_series(1, 10000000);
 00:00:01.72789  | gaussdb  | dbadmin | SELECT current_timestamp - query_start as runtime, datname, 
usename, query FROM PG_STAT_ACTIVITY WHERE state != 'idle' order by 1 desc;
(2 rows)
```

- Alternatively, you can set **current_timestamp - query_start** to be greater than a threshold to identify query statements that are executed for a duration longer than this threshold.

```
SELECT query from PG_STAT_ACTIVITY WHERE current_timestamp - query_start > interval '2 days';
```

Querying Blocked Statements

- Run the following command to view blocked query statements:

```
SELECT pid, datname, usename, state, query FROM PG_STAT_ACTIVITY WHERE state <> 'idle' and 
waiting=true;
```

  Run the following statement to end the blocked SQL session:

```
SELECT PG_TERMINATE_BACKEND(pid);
```

  NOTE

  - In most cases, blocking is caused by internal locks and **waiting=true** is displayed. You can view the blocking in the **pg_stat_activity** view.
  - The blocked statements about file write and event schedulers cannot be viewed in the **pg_stat_activity** view.

- View information about the blocked query statements, tables, and schemas.

```
SELECT w.query as waiting_query,
w.pid as w_pid,
w.usename as w_user,
l.query as locking_query,
l.pid as l_pid,
l.usename as l_user,
t.schemaname || '.' || t.relname as tablename
from pg_stat_activity w join pg_locks l1 on w.pid = l1.pid
and not l1.granted join pg_locks l2 on l1.relation = l2.relation
and l2.granted join pg_stat_activity l on l2.pid = l.pid join pg_stat_user_tables t on l1.relation = t.relid
where w.waiting;
```

The command output includes a session ID, user information, query status, and table or schema that caused the block.

After finding the blocked table or schema information, end the faulty session.

```
SELECT PG_TERMINATE_BACKEND(pid);
```

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

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

If information similar to the following is displayed, the user is attempting to terminate the session, but the session will be reconnected rather than terminated.

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

NOTE

If the **PG_TERMINATE_BACKEND** function is used by the gsql client to terminate the background threads of the session, the client will be reconnected automatically rather than be terminated.

5.4 Excellent Practices for Data Skew Queries

5.4.1 Real-Time Detection of Storage Skew During Data Import

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

NOTE

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

Usage

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

Value of **table_skewness_warning_rows** x Number of DNs involving in the import.

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

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

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

5.4.2 Quickly Locating the Tables That Cause Data Skew

Currently, the following skew query APIs are provided: **table_distribution(schemaname text, tablename text)**, **table_distribution()**, and **PGXC_GET_TABLE_SKEWNESS**. You can select one based on service requirements.

Scenario 1: Data Skew Caused by a Full Disk

First, use the **pg_stat_get_last_data_changed_time(oid)** function to query the tables whose data is changed recently. The last change time of a table is recorded only on the CN where **INSERT**, **UPDATE**, and **DELETE** operations are performed. Therefore, you need to query tables that are changed within the last day (the period can be changed in the function).

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

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

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

Scenario 2: Routine Data Skew Inspection

- If the number of tables in the database is less than 10,000, use the **PGXC_GET_TABLE_SKEWNESS** view to query data skew of all tables in the database.

  ```
  SELECT * FROM pgxc_get_table_skewness ORDER BY totalsize DESC;
  ```

- If the number of tables in the database is no less than 10,000, you are advised to use the **table_distribution()** function instead of the **PGXC_GET_TABLE_SKEWNESS** view because the view takes a longer time (hours) due to the query of the entire database for skew columns. When you use the **table_distribution()** function, you can define the output based on **PGXC_GET_TABLE_SKEWNESS**, optimizing the calculation and reducing the output columns. For example:

  ```
  SELECT schemaname,tablename,max(dnsize) AS maxsize, min(dnsize) AS minsize
  FROM pg_catalog.pg_class c
  INNER JOIN pg_catalog.pg_namespace n ON n.oid = c.relnamespace
  INNER JOIN pg_catalog.table_distribution() s ON s.schemaname = n.nspname AND s.tablename =
  c.relname
  INNER JOIN pg_catalog.pgxc_class x ON c.oid = x.pcrelid AND x.pclocatortype = 'H'
  GROUP BY schemaname,tablename;
  ```

Scenario 3: Querying Data Skew of a Table

Run the following SQL statement to query the data skew of a table. Replace **table_name** with the actual table name.

```
SELECT a.count,b.node_name FROM (SELECT count(*) AS count,xc_node_id FROM table_name GROUP BY
xc_node_id) a, pgxc_node b WHERE a.xc_node_id=b.node_id ORDER BY a.count desc;
```

The following is an example of the information returned. If the data distribution deviation on each DN is less than 10%, data is evenly distributed. If it is greater than 10%, data skew occurs.

```
gaussdb=>SELECT a.count,b.node_name FROM (select count(*) as count,xc_node_id FROM staffs GROUP BY
xc_node_id) a, pgxc_node b WHERE a.xc_node_id=b.node_id ORDER BY a.count desc;
count | node_name
------+-----------
11010 | datanode4
10000 | datanode3
12001 | datanode2
 8995 | datanode1
10000 | datanode5
 7999 | datanode6
 9995 | datanode7
10000 | datanode8
(8 rows)
```

5.5 Best Practices for User Management

A GaussDB(DWS) cluster mainly consists of system administrators and common users. This section describes the permissions of system administrators and common users and describes how to create users and query user information.

System Administrator

The user **dbadmin** created when you start a GaussDB(DWS) cluster is a system administrator. It has the highest system permission and can perform all operations, including operations on tablespaces, tables, indexes, schemas, functions, and custom views, as well as query for system catalogs and views.

To create a database administrator, connect to the database as an administrator and run the **CREATE USER** or **ALTER USER** statement with **SYSADMIN** specified.

Examples:

Create user **Jim** as a system administrator.

```
CREATE USER Jim WITH SYSADMIN password '{Password}';
```

Change user **Tom** to a system administrator. **ALTER USER** can be used only for existing users.

```
ALTER USER Tom SYSADMIN;
```

Common User

You can run the **CREATE USER** SQL statement to create a common user. A common user cannot create, modify, delete, or assign tablespaces, and needs to be assigned the permission for accessing tablespaces. A common user has all permissions for its own tables, schemas, functions, and custom views, creates indexes on its own tables, and queries only some system catalogs and views.

The database cluster has one or more named databases. Users are shared within the entire cluster, but their data is not shared.

Common user operations are as follows. Replace **password** with the actual password.

1. Creating a user
   ```
   CREATE USER Tom PASSWORD '{Password}';
   ```
2. Changing a user password

   Change the login password of user **Tom** from **password** to **newpassword**.
   ```
   ALTER USER Tom IDENTIFIED BY 'newpassword' REPLACE '{Password}';
   ```
3. Assigning permissions to a user
   - Add **CREATEDB** when you create a user that has the permission for creating a database.
   ```
   CREATE USER Tom CREATEDB PASSWORD '{Password}';
   ```
   - Add the **CREATEROLE** permission for a user.
   ```
   ALTER USER Tom CREATEROLE;
   ```
4. Revoking user permissions
   ```
   REVOKE ALL PRIVILEGES FROM Tom;
   ```
5. Locking or unlocking a user
   - Lock user **Tom**.
   ```
   ALTER USER Tom ACCOUNT LOCK;
   ```
   - Unlock user **Tom**.
   ```
   ALTER USER Tom ACCOUNT UNLOCK;
   ```
6. Deleting a user
   ```
   DROP USER Tom CASCADE;
   ```

User Information Query

System views related to users, roles, and permissions include **ALL_USERS**, **PG_USER**, and **PG_ROLES**, and system catalogs include **PG_AUTHID** and **PG_AUTH_MEMBERS**.

- **ALL_USERS** displays all users in the database but does not show the details of them.
- **PG_USER** displays user information, including user IDs, the permission to create databases, and resource pools.
- **PG_ROLES** displays information about database roles.
- **PG_AUTHID** records information about database authentication identifiers (roles), including role permissions to log in or create databases.
- **PG_AUTH_MEMBERS** stores information of roles contained in a role group.

1. You can run **PG_USER** to query all users in the database. User ID (**USESYSID**) and permissions can also be queried.

```
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 |
|          |           |               |
 kim     |    21661 | f           | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |           |               |
 u3      |    22662 | f           | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |           |               |
 u1      |    22666 | f           | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |           |               |
 dbadmin |    16396 | f           | f        | f         | f       | ******** |          |          | default_pool |      0
|          |           |           |               |
 u5      |    58421 | f           | f        | f         | f       | ******** |          |          | default_pool |      0 |
|          |           |               |
(6 rows)
```

2. **ALL_USERS** displays all users in the database but does not show the details of them.

```
SELECT * FROM all_users;
 username | user_id
----------+---------
 Ruby     |      10
 manager  |   21649
 kim      |   21661
 u3       |   22662
 u1       |   22666
 u2       |   22802
 dbadmin  |   16396
 u5       |   58421
(8 rows)
```

3. **PG_ROLES** stores information about roles that have accessed the database.

```
SELECT * FROM pg_roles;
 rolname | rolsuper | rolinherit | rolcreaterole | rolcreatedb | rolcatupdate | rolcanlogin | rolreplication |
rolauditadmin | rolsystemadmin | rolconnlimit | rolpassword | rolvalidbegin | rolv
aliduntil |  rolrespool  | rolparentid | roltabspace | rolconfig |  oid  | roluseft | rolkind | nodegroup |
roltempspace | rolspillspace
---------+----------+------------+---------------+-------------+--------------+-------------+----------------
+---------------+----------------+--------------+-------------+---------------+-----
----------+--------------+-------------+-------------+-----------+-------+----------+---------+-----------
+--------------+---------------
 Ruby    | t        | t          | t             | t           | t            | t           | t              | t
|          -1 | ********    |               |
         | default_pool |           0 |             |           |    10 | t        | n       |           |              |
 manager | f        | t          | f             | f           | f            | f           | f              | f
|          -1 | ********    |               |
         | default_pool |           0 |             |           | 21649 | f        | n       |           |              |
 kim     | f        | t          | f             | f           | f            | t           | f              | f
|          -1 | ********    |               |
         | default_pool |           0 |             |           | 21661 | f        | n       |           |              |
 u3      | f       | t        | f          | f         | f          | t         | f            | f           | f
|          -1 | ********     |              |
        | default_pool |          0 |           |         | 22662 | f      | n      |         |           |
 u1      | f       | t        | f          | f         | f          | t         | f            | f           | f
|          -1 | ********     |              |
        | default_pool |          0 |           |         | 22666 | f      | n      |         |           |
 u2      | f       | t        | f          | f         | f          | f         | f            | f           | f
|          -1 | ********     |              |
        | default_pool |          0 |           |         | 22802 | f      | n      |         |           |
 dbadmin | f       | t        | f          | f         | f          | t         | f            | f           | t
|          -1 | ********     |              |
        | default_pool |          0 |           |         | 16396 | f      | n      |         |           |
 u5      | f       | t        | f          | f         | f          | t         | f            | f           | f
|          -1 | ********     |              |
        | default_pool |          0 |           |         | 58421 | f      | n      |         |           |
(8 rows)
```

4. To view user properties, query the system catalog **PG_AUTHID**, which stores information about database authorization identifiers (roles). Each cluster, not each database, has only one **PG_AUTHID** system catalog. Only users with system administrator permissions can access the catalog.

```
SELECT * FROM pg_authid;
rolname  | rolsuper | rolinherit | rolcreaterole | rolcreatedb | rolcatupdate | rolcanlogin | rolreplication |
rolauditadmin | rolsystemadmin | rolconnlimit
|

rolpassword
                                              | rolvalidbegin | rolvaliduntil |  rolrespool  | roluseft | rolparentid |
roltabspace | rolkind | rolnodegroup | roltempspace | rolspillspace | rolexcpdata | rolauthinfo
----------+----------+------------+---------------+-------------+--------------+-------------+----------------
+---------------+----------------+--------------
+-------------------------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------------------------
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-------------------+---------------+---------------+--------------+----------+-------------+-------------+---------
+--------------+--------------+---------------+-------------+-------------
 Ruby     | t        | t          | t             | t           | t            | t           | t              | t             | t
|          -1 |
sha256366f1e665be208e6015bc3c5795d13e4dc297a148dca6c60346018c80e5c04c9ba170384ce44609b
31baa741f09a3ea5bedc7dadb906286ca994067c3fbf672dc08c981929e326ca08c005d8df942994e146ed
3302af47000b36e9852b50e39dmd585de11aafebd90ec620b201fc36f07a5ecdficefade3a1456ec0aca9a0
ee01e3bf2971d1dbafd604e596149e2e2928be4060dec2bd8688776588b4cd8c64fd38f1b0beab1603129f
a396556ba8aa4c7d6e137a04623 |               |               | default_pool | t        |           0 |             |
n       |            0 |              |               |            |
 sysadmin | f        | t          | f             | f           | f            | t           | f              | f             | t
|          -1 |
sha256ecaa7f0ca4436143af43074f16cdd825783ad1a5d659fd94f5e2fa5124e7da44045ecf40bda1a9797
5fcf5920dca0c8be375be5c71b51cb1eeeba0851fb3648cfa49f55989f83fd9baf1a9d5853ce19125f4fc29a7
c709c095ed02d00638410dmd556d6e2dcc41594dc7ad8ee909ef81637ecdficefadefd7d9704ee06affef958
1cd6a50a546607f88891198e96a5e84e7e83dccf56c5cd20a500bbc5248e8ea51f0bca70c5a8dcf00953f8b
62c7a181368153abce760 |               |               | default_pool | f        |           0 |             | n
|             |              |               |            |
 Tom      | f        | t          | f             | t           | f            | t           | f              | f             | f
|          -1 |
sha256f43c4f52ac51e297bc4dbdbc751fcf05319c15681dbf5a9c5777d2edce45cb592a948b25457a728e9
9a3e0608592f33b0a4312eba6124936522304ba298caa2002a04578860fecb0286d7c7baec09365eafd049
b2b99f74f21a08864dd7d3f2amd515ee49f0b18ef8e7d0cd27d91ce2fa9decdficefade16bab5f05b6d7c86a
19ae6406cc59c437506c3f6187bfdf3eefc7a7c7033afa076361b255cc8b6ccb6e19d4767effaec654b3308cc
72cebb891d00a4a10362da |               |               | default_pool | f        |           0 |             | n
|             |              |               |            |
(3 rows)
```

User Resource Query

1. Querying the resource quota and usage of all users

```
SELECT * FROM PG_TOTAL_USER_RESOURCE_INFO;
```

Example of the resource usage of all users:

```
 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
----------+-------------+--------------+----------+-----------+------------+-------------+-----------------
+------------------+------------------+-------------------+-------------+--------------+-------------+--------------
+------------+-------------
perfadm   |           0 |        17250 |        0 |         0 |          0 |          -1 |               0 |              -1
|               0 |               -1 |            0 |            0 |           0 |            0 |          0 |           0
usern     |           0 |        17250 |        0 |        48 |          0 |          -1 |               0 |              -1
|               0 |               -1 |            0 |            0 |           0 |            0 |          0 |           0
userg     |          34 |        15525 |    23.53 |        48 |          0 |          -1 |               0 |              -1 |
814955731 |               -1 |      6111952 |      1145864 |      763994 |       143233 |      42678 |        8001
userg1    |          34 |        13972 |    23.53 |        48 |          0 |          -1 |               0 |              -1 |
814972419 |               -1 |      6111952 |      1145864 |      763994 |       143233 |      42710 |        8007
(4 rows)
```

2. Querying the resource quota and usage of a specified user

   ```
   SELECT * FROM GS_WLM_USER_RESOURCE_INFO('username');
   ```

   Example of the resource usage of user **Tom**:

   ```
   SELECT * FROM GS_WLM_USER_RESOURCE_INFO('Tom');
   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
   -------+-------------+--------------+----------+-----------+------------+-------------+-----------------
   +------------------+------------------+-------------------+-------------+--------------+-------------+--------------
   +------------+-------------
    16523 |          18 |         2831 |        0 |        19 |          0 |          -1 |               0 |              -1
   |               0 |              -1 |            0 |            0 |           0 |            0 |          0 |           0
   (1 row)
   ```

3. Querying the I/O usage of a specified user

   ```
   SELECT * FROM pg_user_iostat('username');
   ```

   Example of the I/O usage of user **Tom**:

   ```
   SELECT * FROM pg_user_iostat('Tom');
   userid | min_curr_iops | max_curr_iops | min_peak_iops | max_peak_iops | io_limits | io_priority
   -------+---------------+---------------+---------------+---------------+-----------+-------------
    16523 |             0 |             0 |             0 |             0 |         0 | None
   (1 row)
   ```

5.6 Viewing Table and Database Information

Querying Table Information

- Querying information about all tables in a database using the **pg_tables** system catalog

  ```
  SELECT * FROM pg_tables;
  ```

- Querying the table structure using **\d+** command of the **gsql** tool.

  Example: Create a table **customer_t1** and insert data into the table.

  ```
  CREATE TABLE customer_t1
  (
      c_customer_sk             integer,
      c_customer_id             char(5),
      c_first_name              char(6),
      c_last_name               char(8)
  )
  with (orientation = column,compression=middle)
  distribute by hash (c_last_name);
  INSERT INTO customer_t1 (c_customer_sk, c_customer_id, c_first_name) VALUES
      (6885, 'map', 'Peter'),
      (4321, 'river', 'Lily'),
      (9527, 'world', 'James');
  ```

  Query the table structure. If no schema is specified when you create a table, the schema of the table defaults to **public**.

```
\d+ customer_t1;
                          Table "public.customer_t1"
    Column     |     Type     | Modifiers | Storage  | Stats target | Description
---------------+--------------+-----------+----------+--------------+-------------
 c_customer_sk | integer      |           | plain    |              |
 c_customer_id | character(5) |           | extended |              |
 c_first_name  | character(6) |           | extended |              |
 c_last_name   | character(8) |           | extended |              |
Has OIDs: no
Distribute By: HASH(c_last_name)
Location Nodes: ALL DATANODES
Options: orientation=column, compression=middle, colversion=2.0, enable_delta=false
```

NOTE

The options may vary in different versions but the difference does not affect services. The options here are for reference only. The actual options are subject to the version.

- Use **pg_get_tabledef** to query the table definition.

```
SELECT * FROM PG_GET_TABLEDEF('customer_t1');
                                  pg_get_tabledef
----------------------------------------------------------------------------------
 SET search_path = tpchobs;                                                      +
 CREATE  TABLE customer_t1 (                                                     +
         c_customer_sk integer,                                                  +
         c_customer_id character(5),                                             +
         c_first_name character(6),                                              +
         c_last_name character(8)                                                +
 )                                                                               +
 WITH (orientation=column, compression=middle, colversion=2.0, enable_delta=false)+
 DISTRIBUTE BY HASH(c_last_name)                                                 +
 TO GROUP group_version1;
(1 row)
```

- Querying all data in **customer_t1**

```
SELECT * FROM customer_t1;
 c_customer_sk | c_customer_id | c_first_name | c_last_name
---------------+---------------+--------------+-------------
          6885 | map           | Peter        |
          4321 | river         | Lily         |
          9527 | world         | James        |
(3 rows)
```

- Querying all data of a column in **customer_t1** using **SELECT**

```
SELECT c_customer_sk FROM customer_t1;
 c_customer_sk
---------------
          6885
          4321
          9527
(3 rows)
```

- Check whether a table has been analyzed. The time when the table was analyzed will be returned. If nothing is returned, it indicates that the table has not been analyzed.

```
SELECT pg_stat_get_last_analyze_time(oid),relname FROM pg_class where relkind='r';
```

  Query the time when the **public** table was analyzed.

```
SELECT pg_stat_get_last_analyze_time(c.oid),c.relname FROM pg_class c LEFT JOIN pg_namespace n
ON c.relnamespace = n.oid WHERE c.relkind='r' AND n.nspname='public';
 pg_stat_get_last_analyze_time |       relname
-------------------------------+----------------------
 2022-05-17 07:48:26.923782+00 | warehouse_t19
 2022-05-17 07:48:26.964512+00 | emp
 2022-05-17 07:48:27.016709+00 | test_trigger_src_tbl
 2022-05-17 07:48:27.045385+00 | customer
 2022-05-17 07:48:27.062486+00 | warehouse_t1
 2022-05-17 07:48:27.114884+00 | customer_t1
 2022-05-17 07:48:27.172256+00 | product_info_input
 2022-05-17 07:48:27.197014+00 | tt1
 2022-05-17 07:48:27.212906+00 | timezone_test
(9 rows)
```

- Quickly query the column information of a table. If a view in **information_schema** has a large number of objects in the database, it takes a long time to return the result. You can run the following SQL statement to quickly query the column information of one or more tables:

```
SELECT /*+ nestloop(a c)*/ c.column_name, c.data_type, c.ordinal_position, pgd.description, pp.partkey,
c.is_nullable, c.column_default, c.character_maximum_length, c.numeric_precision,  c.numeric_scale,
c.datetime_precision, c.interval_type, c.udt_name from information_schema.columns as c left join
pg_namespace sp on sp.nspname = c.table_schema left join pg_class cla on cla.relname =
c.table_name and cla.relnamespace = sp.oid left join pg_catalog.pg_partition pp on (pp.parentid =
cla.oid and pp.parttype = 'r') left join pg_catalog.pg_description pgd on (pgd.objoid=cla.oid and
pgd.objsubid = c.ordinal_position)where c.table_name in ('tablename') and c.table_schema = 'public';
```

For example, to quickly query the column information of the **customer_t1** table, run the following command:

```
SELECT /*+ nestloop(a c)*/ c.column_name, c.data_type, c.ordinal_position, pgd.description, pp.partkey,
c.is_nullable, c.column_default, c.character_maximum_length, c.numeric_precision, c.numeric_scale,
c.datetime_precision, c.interval_type, c.udt_name from information_schema.columns as c left join
pg_namespace sp on sp.nspname = c.table_schema left join pg_class cla on cla.relname =
c.table_name and cla.relnamespace = sp.oid left join pg_catalog.pg_partition pp on (pp.parentid =
cla.oid and pp.parttype = 'r') left join pg_catalog.pg_description pgd on (pgd.objoid=cla.oid and
pgd.objsubid = c.ordinal_position) where c.table_name in ('customer_t1') and c.table_schema = 'public';
  column_name  | data_type | ordinal_position | description | partkey | is_nullable | column_default |
character_maximum_length | numeric_precision | numeric_scale | datetime_precision | interval_type |
udt_name
---------------+-----------+------------------+-------------+---------+-------------+----------------
+--------------------------+-------------------+-------------
--+--------------------+---------------+----------
 c_last_name   | character |                4 |             |         | YES         |                |                        8
|                 |
  |                    |               | bpchar
 c_first_name  | character |                3 |             |         | YES         |                |                        6
|                 |
  |                    |               | bpchar
 c_customer_id | character |                2 |             |         | YES         |                |                        5
|                 |
  |                    |               | bpchar
 c_customer_sk | integer   |                1 |             |         | YES         |                |
|              32 |
0 |                    |               | int4
(4 rows)
```

- Obtain the table definition by querying audit logs.

  Use the **pgxc_query_audit** function to query audit logs of all CNs. The syntax is as follows:

```
pgxc_query_audit(timestamptz startime,timestamptz endtime)
```

Query the audit records of multiple objects.

```
SET audit_object_name_format TO 'all';
SELECT object_name,result,operation_type,command_text FROM pgxc_query_audit('2022-08-26
8:00:00','2022-08-26 22:55:00') where command_text like '%student%';
```

Querying the Table Size

- Querying the total size of a table (indexes and data included)

```
SELECT pg_size_pretty(pg_total_relation_size('<schemaname>.<tablename>'));
```

Example:

First, create an index on **customer_t1**.

```
CREATE INDEX index1 ON customer_t1 USING btree(c_customer_sk);
```

Then, query the size of table **customer_t1** of **public**.

```
SELECT pg_size_pretty(pg_total_relation_size('public.customer_t1'));
 pg_size_pretty
```

```
----------------
 264 kB
(1 row)
```

- Querying the size of a table (indexes excluded)

  ```
  SELECT pg_size_pretty(pg_relation_size('<schemaname>.<tablename>'));
  ```

  Example: Query the size of table **customer_t1** of **public**.

  ```
  SELECT pg_size_pretty(pg_relation_size('public.customer_t1'));
   pg_size_pretty
  ----------------
   208 kB
  (1 row)
  ```

- Query all the tables, ranked by their occupied space.

  ```
  SELECT table_schema || '.' || table_name AS table_full_name, pg_size_pretty(pg_total_relation_size('"' ||
  table_schema || '"."' || table_name || '"')) AS size FROM information_schema.tables
  ORDER BY
  pg_total_relation_size('"' || table_schema || '"."' || table_name || '"') DESC limit xx;
  ```

  Example 1: Query the 15 tables that occupy the most space.

  ```
  SELECT table_schema || '.' || table_name AS table_full_name, pg_size_pretty(pg_total_relation_size('"' ||
  table_schema || '"."' || table_name || '"')) AS size FROM information_schema.tables
  ORDER BY
  pg_total_relation_size('"' || table_schema || '"."' || table_name || '"') DESC limit 15;
        table_full_name       |  size
  ---------------------------+---------
   pg_catalog.pg_attribute   | 2048 KB
   pg_catalog.pg_rewrite     | 1888 KB
   pg_catalog.pg_depend      | 1464 KB
   pg_catalog.pg_proc        | 1464 KB
   pg_catalog.pg_class       | 512 KB
   pg_catalog.pg_description | 504 KB
   pg_catalog.pg_collation   | 360 KB
   pg_catalog.pg_statistic   | 352 KB
   pg_catalog.pg_type        | 344 KB
   pg_catalog.pg_operator    | 224 KB
   pg_catalog.pg_amop        | 208 KB
   public.tt1                | 160 KB
   pg_catalog.pg_amproc      | 120 KB
   pg_catalog.pg_index       | 120 KB
   pg_catalog.pg_constraint  | 112 KB
  (15 rows)
  ```

  Example 2: Query the top 20 tables with the largest space usage in the **public** schema.

  ```
  SELECT table_schema || '.' || table_name AS table_full_name, pg_size_pretty(pg_total_relation_size('"' ||
  table_schema || '"."' || table_name || '"')) AS size FROM information_schema.tables where
  table_schema='public'
  ORDER BY
  pg_total_relation_size('"' || table_schema || '"."' || table_name || '"') DESC limit 20;
         table_full_name        |  size
  -----------------------------+---------
   public.tt1                  | 160 KB
   public.product_info_input   | 112 KB
   public.customer_t1          | 96 KB
   public.warehouse_t19        | 48 KB
   public.emp                  | 32 KB
   public.customer             | 0 bytes
   public.test_trigger_src_tbl | 0 bytes
   public.warehouse_t1         | 0 bytes
  (8 rows)
  ```

Quickly Querying the Space Occupied by All Tables in the Database

In a large cluster with a large amount of data (more than 1000 tables), you are advised to use the pgxc_wlm_table_distribution_skewness view to query all tables in the database. This view can be used to query the tablespace usage and data skew distribution in the database. The unit of total_size and avg_size is byte.

```
SELECT *, pg_size_pretty(total_size) as tableSize FROM pgxc_wlm_table_distribution_skewness ORDER BY 
total_size desc;
    schema_name     |                    table_name                    | total_size | avg_size  | max_percent | 
min_percent | skew_percent | tablesize
--------------------+--------------------------------------------------+------------+-----------+-------------
+-------------+--------------+-----------
 public             | history_tbs_test_row_1                           |  804347904 | 134057984 |       18.02 |       15.63 
|         7.53 | 767 MB
 public             | history_tbs_test_row_3                           |  402096128 |  67016021 |       18.30 |       15.60 
|         8.90 | 383 MB
 public             | history_tbs_test_row_2                           |  401743872 |  66957312 |       18.01 |       15.01 
|         7.47 | 383 MB
 public             | i_history_tbs_test_1                             |  325263360 |  54210560 |       17.90 |       15.50 
|         6.90 | 310 MB
```

The query result shows that the history_tbs_test_row_1 table occupies the largest space and data skew occurs.

CAUTION

1. The pgxc_wlm_table_distribution_skewness view can be queried only when the GUC parameters use_workload_manager and enable_perm_space are enabled. In earlier versions, you are advised to use the table_distribution() function to query the entire database. If only the size of a table is queried, the table_distribution(schemaname text, tablename text) function is recommended.
2. In 8.2.1 and later cluster versions, GaussDB (DWS) supports the pgxc_wlm_table_distribution_skewness view, which can be directly queried.
3. In the 8.1.3 cluster version, you can use the following definition to create a view and then query the view:

```
CREATE OR REPLACE VIEW
pgxc_wlm_table_distribution_skewness AS
WITH skew AS
(
SELECT
schemaname,
tablename,
pg_catalog.sum(dnsize)
AS totalsize,
pg_catalog.avg(dnsize)
AS avgsize,
pg_catalog.max(dnsize)
AS maxsize,
pg_catalog.min(dnsize)
AS minsize,
(maxsize
- avgsize) * 100 AS skewsize
FROM
pg_catalog.gs_table_distribution()
GROUP
BY schemaname, tablename
)
SELECT
    schemaname AS schema_name,
    tablename AS table_name,
    totalsize AS total_size,
    avgsize::numeric(1000) AS avg_size,
    (
        CASE
            WHEN totalsize = 0 THEN 0.00
            ELSE (maxsize * 100 /
totalsize)::numeric(5, 2)
        END
    ) AS max_percent,
    (
        CASE
            WHEN totalsize = 0 THEN 0.00
            ELSE (minsize * 100 /
totalsize)::numeric(5, 2)
        END
    ) AS min_percent,
    (
        CASE
            WHEN totalsize = 0 THEN 0.00
            ELSE (skewsize /
maxsize)::numeric(5, 2)
        END
    ) AS skew_percent
FROM skew;
```

Querying Database Information

- Querying the database list using the **\l** meta-command of the **gsql** tool.

```
\l
                          List of databases
   Name    | Owner | Encoding  | Collate | Ctype | Access privileges
-----------+-------+-----------+---------+-------+-------------------
 gaussdb   | Ruby  | SQL_ASCII | C       | C     |
 template0 | Ruby  | SQL_ASCII | C       | C     | =c/Ruby          +
           |       |           |         |       | Ruby=CTc/Ruby
 template1 | Ruby  | SQL_ASCII | C       | C     | =c/Ruby          +
           |       |           |         |       | Ruby=CTc/Ruby
(3 rows)
```

NOTE

- If the parameters **LC_COLLATE** and **LC_CTYPE** are not specified during database installation, the default values of them are **C**.
- If **LC_COLLATE** and **LC_CTYPE** are not specified during database creation, the sorting order and character classification of the template database are used by default.

  For details, see **CREATE DATABASE**.

- Querying the database list using the **pg_database** system catalog

```
SELECT datname FROM pg_database;
  datname
-----------
 template1
 template0
 gaussdb
(3 rows)
```

Querying the Database Size

Querying the size of databases

```
select datname,pg_size_pretty(pg_database_size(datname)) from pg_database;
```

Example:

```
select datname,pg_size_pretty(pg_database_size(datname)) from pg_database;
  datname  | pg_size_pretty
-----------+----------------
 template1 | 61 MB
 template0 | 61 MB
 postgres  | 320 MB
(3 rows)
```

Querying the Size of a Table and the Size of the Corresponding Index in a Specified Schema

```
SELECT
    t.tablename,
    indexname,
    c.reltuples AS num_rows,
    pg_size_pretty(pg_relation_size(quote_ident(t.tablename)::text)) AS table_size,
    pg_size_pretty(pg_relation_size(quote_ident(indexrelname)::text)) AS index_size,
    CASE WHEN indisunique THEN 'Y'
       ELSE 'N'
    END AS UNIQUE,
    idx_scan AS number_of_scans,
    idx_tup_read AS tuples_read,
    idx_tup_fetch AS tuples_fetched
FROM pg_tables t
LEFT OUTER JOIN pg_class c ON t.tablename=c.relname
LEFT OUTER JOIN
    ( SELECT c.relname AS ctablename, ipg.relname AS indexname, x.indnatts AS number_of_columns,
idx_scan, idx_tup_read, idx_tup_fetch, indexrelname, indisunique FROM pg_index x
          JOIN pg_class c ON c.oid = x.indrelid
          JOIN pg_class ipg ON ipg.oid = x.indexrelid
          JOIN pg_stat_all_indexes psai ON x.indexrelid = psai.indexrelid )
    AS foo
    ON t.tablename = foo.ctablename
WHERE t.schemaname='public'
ORDER BY 1,2;
```

5.7 Best Practices of Database SEQUENCE

A sequence, also called a sequence, is a database object used to generate a unique integer. The value of a sequence increases or decreases automatically based on certain rules. Generally, a sequence is used as a primary key. In GaussDB (DWS), when a sequence is created, a metadata table with the same name is created to record sequence information. For example:

```
CREATE SEQUENCE seq_test;
CREATE SEQUENCE

SELECT * FROM seq_test;
 sequence_name | last_value | start_value | increment_by |      max_value      | min_value | cache_value |
log_cnt | is_cycled | is_called |  uuid
---------------+------------+-------------+--------------+---------------------+-----------+-------------+---------
+-----------+-----------+---------
 seq_test      |         -1 |           1 |            1 | 9223372036854775807 |         1 |           1 |       0 | f         |
f         | 1400050
(1 row)
```

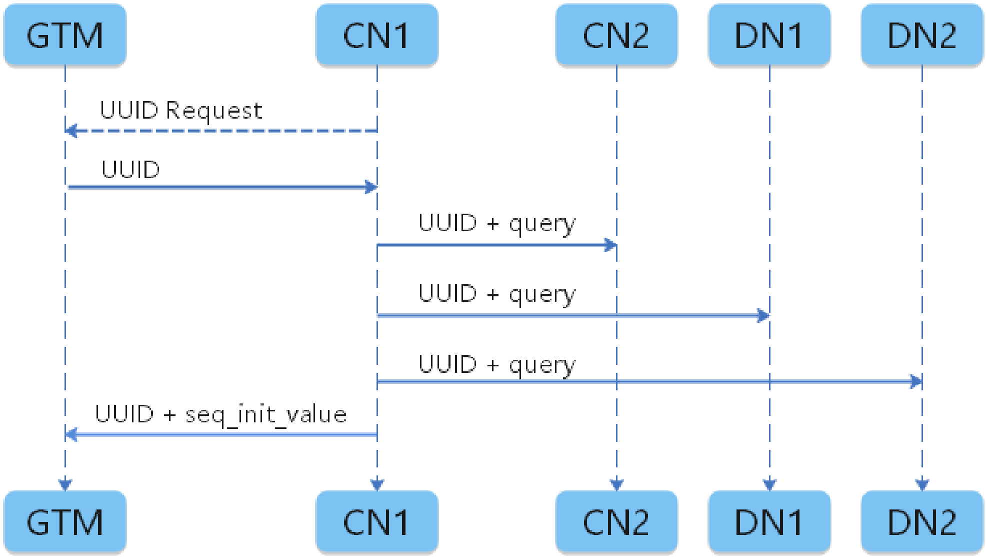
In the preceding command:

- sequence_name indicates the name of a sequence.
- last_value is meaningless.
- start_value indicates the initial value of the sequence.
- increment_by indicates the step of the sequence.
- max_value indicates the maximum value of a sequence.
- min_value indicates the minimum sequence value.
- cache_value indicates the number of sequence values that are pre-stored to quickly obtain the next sequence value. (After the cache is defined, the continuity of sequence values cannot be ensured, holes are generated, and sequence number segments are wasted.)
- log_cnt indicates the number of sequence values recorded in WAL logs. In GaussDB (DWS), sequence values are obtained and managed from GTM. Therefore, log_cnt is meaningless.
- is_cycled indicates whether to continue the loop after the sequence reaches the minimum or maximum value.
- is_called indicates whether the sequence has been invoked. (It only indicates whether the sequence has been invoked on the current instance. For example, after the sequence is invoked on cn1, the value of the original data table on cn1 changes to t, and the value of the field on cn2 is still f.)
- uuid indicates the unique ID of the sequence.

Process of Creating a Sequence

In GaussDB (DWS), the Global Transaction Manager (GTM) generates and maintains globally unique information, such as global transaction IDs, transaction snapshots, and sequences. The following figure shows the process of creating a sequence in GaussDB (DWS).

Figure 5-2 Process of Creating a Sequence



The specific process is as follows:

1. The CN that accepts the SQL command applies for a UUID from the GTM.
2. The GTM returns a UUID.
3. The CN binds the obtained UUID to the sequenceName created by the user.
4. The CN delivers the binding relationship to other nodes, and other nodes create the sequence metadata table synchronously.
5. The CN sends the UUID and startID of the sequence to the GTM for permanent storage.

Therefore, sequence maintenance and application are actually completed on the GTM. When applying for nextval, each instance that invokes nextval applies for a sequence value from the GTM based on the UUID of the sequence. The sequence value range applied for each time is related to the cache. The instance applies for a sequence value from the GTM only after the cache is used up. Therefore, increasing the cache of the sequence helps reduce the number of times that the CN/DN communicates with the GTM.

Two Methods of Creating a Sequence

Method 1: Run the CREATE SEQUENCE statement to create a sequence and use nextval to invoke the sequence in the new table.

```
CREATE SEQUENCE seq_test increment by 1 minvalue 1 no maxvalue start with 1;
CREATE SEQUENCE

CREATE TABLE table_1(id int not null default nextval('seq_test'), name text);
CREATE TABLE
```

Method 2: If the serial type is used during table creation, a sequence is automatically created and the default value of the column is set to nextval.

```
CREATE TABLE mytable(a int, b serial) distribute by hash(a);
NOTICE:  CREATE TABLE will create implicit sequence "mytable_b_seq" for serial column "mytable.b"
CREATE TABLE

 \d+ mytable
                                        Table "dbadmin.mytable"
 Column |  Type   |                      Modifiers                       | Storage | Stats target | Description
--------+---------+------------------------------------------------------+---------+--------------+-------------
 a      | integer |                                                      | plain   |              |
 b      | integer | not null default nextval('mytable_b_seq'::regclass) | plain   |              |
Has OIDs: no
Distribute By: HASH(a)
Location Nodes: ALL DATANODES
Options: orientation=row, compression=no
```

In this example, a sequence named mytable_b_seq is automatically created. Strictly speaking, the serial type is not a real type. It is only a concept for setting a unique identifier in a table. When a serial type is created, a sequence is created and associated with the column.

It is equivalent to the following statement:

```
CREATE TABLE mytable01(a int, b int) distribute by hash(a);
CREATE TABLE

CREATE SEQUENCE mytable01_b_seq owned by mytable.b;
CREATE SEQUENCE

ALTER SEQUENCE mytable01_b_seq owner to u1; --u1 is the owner of the mytable01 table. If the current
user is the owner, you do not need to run this statement.
ALTER SEQUENCE

ALTER TABLE mytable01 alter b set default nextval('mytable01_b_seq'), alter b set not null;
ALTER TABLE

\d+ mytable01
                                        Table "dbadmin.mytable01"
 Column |  Type   |                       Modifiers                        | Storage | Stats target | Description
--------+---------+--------------------------------------------------------+---------+--------------+-------------
 a      | integer |                                                        | plain   |              |
 b      | integer | not null default nextval('mytable01_b_seq'::regclass) | plain   |              |
Has OIDs: no
Distribute By: HASH(a)
Location Nodes: ALL DATANODES
Options: orientation=row, compression=no
```

Common Usage of Sequences in Services

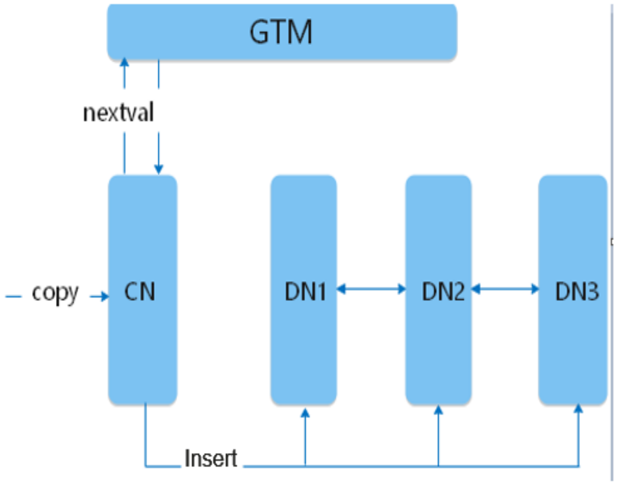
Sequences are often used to generate primary keys or unique columns during data import in data migration scenarios. Different migration tools or service import scenarios use different import methods. Common import methods are classified into **copy** and **insert**. For seqeunce, the processing in the two scenarios is slightly different.

- **Scenario 1: Insert Pushdown**

```
CREATE TABLE test1(a int, b serial) distribute by hash(a);
NOTICE:  CREATE TABLE will create implicit sequence "test1_b_seq" for serial column "test1.b"
CREATE TABLE

CREATE TABLE test2(a int) distribute by hash(a);
CREATE TABLE

EXPLAIN VERBOSE INSERT INTO test1(a) SELECT a FROM test2;
                                        QUERY PLAN
---------------------------------------------------------------------------------------------
  id |              operation              | E-rows | E-distinct | E-memory | E-width | E-costs
```

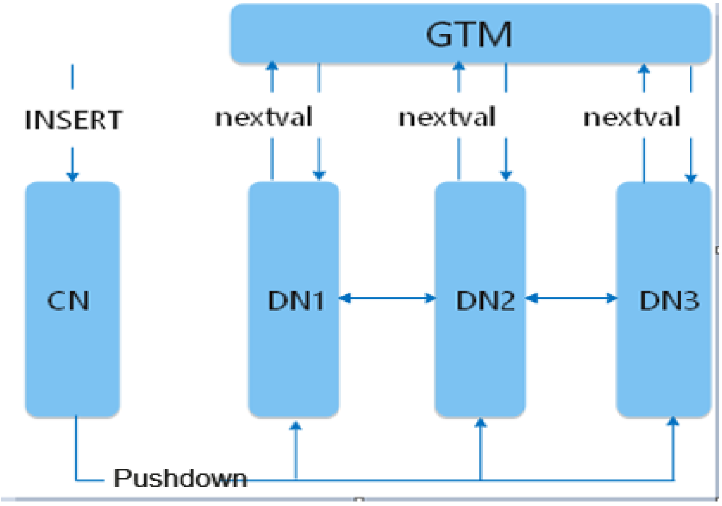
```
----+-------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)        |      1 |            |          |       4 | 16.34
  2 |    ->  Insert on dbadmin.test1      |     30 |            |          |       4 | 16.22
  3 |       ->  Seq Scan on dbadmin.test2 |     30 |            | 1MB      |       4 | 14.21

            RunTime Analyze Information
----------------------------------------------------
        "dbadmin.test2" runtime: 9.586ms, sync stats

     Targetlist Information (identified by plan id)
---------------------------------------------------------
  1 --Streaming (type: GATHER)
        Node/s: All datanodes
  3 --Seq Scan on dbadmin.test2
        Output: test2.a, nextval('test1_b_seq'::regclass)
        Distribute Key: test2.a

  ====== Query Summary =====
------------------------------
 System available mem: 1351680KB
 Query Max mem: 1351680KB
 Query estimated mem: 1024KB
 Parser runtime: 0.076 ms
 Planner runtime: 12.666 ms
 Unique SQL Id: 831364267
(26 rows)
```

In the INSERT scenario, nextval can be pushed down to DNs for execution. Therefore, nextval is pushed down to DNs for execution regardless of whether nextval with the default value is used or nextval is explicitly invoked. The execution plan in the preceding example also shows that nextval is pushed down to DNs for execution, the invoking of nextval is at the sequence layer, indicating that nextval is executed on DNs. In this case, DNs directly apply for sequence values from the GTM, and DNs execute the application concurrently. Therefore, the efficiency is relatively high.



- **Scenario 2: Copy Scenario**

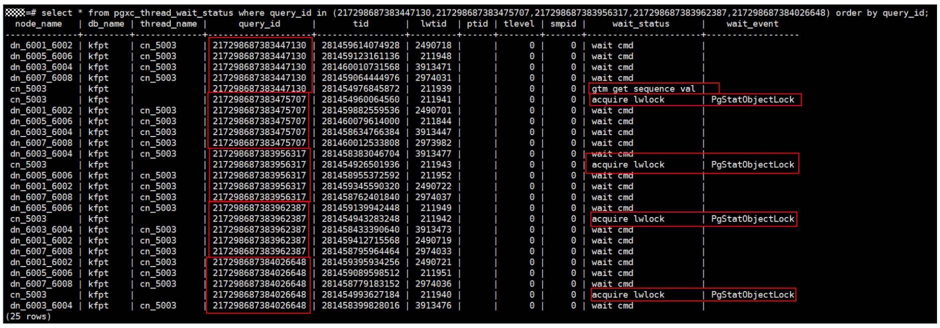
  During service development, in addition to INSERT, COPY can be used to import data to the database. This method is used to copy file content to the database or use the CopyManager interface to import file content to the database. In addition, the CDM data synchronization tool imports data to the database in batches by copying data. If the target table to be copied uses the default value nextval, the process is as follows:



In the copy scenario, the CN applies for sequence values from the GTM. Therefore, when the cache value of sequence is small, the CN frequently establishes connections with the GTM and applies for nextval, causing a performance bottleneck. The **Typical Optimization Scenarios Related to Sequences** describes the service performance in this scenario and provides optimization methods.

Typical Optimization Scenarios Related to Sequences

Service scenario: In a service scenario, the CDM data synchronization tool is used to migrate data and import data from the source end to the target GaussDB (DWS). The import rate differs greatly from the empirical value. After the CDM concurrency is changed from 1 to 5, the synchronization rate still cannot be improved. Check the statement execution status. Except COPY, other services are executed properly without performance bottlenecks or resource bottlenecks. Therefore, it is preliminarily determined that the service has a bottleneck. Check the job waiting view related to COPY.



```
[redacted]=# select * from pgxc_thread_wait_status where query_id in (217298687383447130,217298687383475707,217298687383956317,217298687383962387,217298687384026648) order by query_id;
  node_name    | db_name | thread_name |      query_id      |       tid       |  lwtid  | ptid | tlevel | smpid |     wait_status      |    wait_event
---------------+---------+-------------+--------------------+-----------------+---------+------+--------+-------+----------------------+------------------
 dn_6001_6002  | kfpt    | cn_5003     | 217298687383447130 | 281459614074928 | 2490718 |      |      0 |     0 | wait cmd             |
 dn_6005_6006  | kfpt    | cn_5003     | 217298687383447130 | 281459123161136 |  211948 |      |      0 |     0 | wait cmd             |
 dn_6003_6004  | kfpt    | cn_5003     | 217298687383447130 | 281460010731568 | 3913471 |      |      0 |     0 | wait cmd             |
 dn_6007_6008  | kfpt    | cn_5003     | 217298687383447130 | 281459064444976 | 2974031 |      |      0 |     0 | wait cmd             |
 cn_5003       | kfpt    |             | 217298687383447130 | 281454976845872 |  211939 |      |      0 |     0 | gtm get sequence val |
 cn_5003       | kfpt    |             | 217298687383475707 | 281454960064560 |  211941 |      |      0 |     0 | acquire lwlock       | PgStatObjectLock
 dn_6001_6002  | kfpt    | cn_5003     | 217298687383475707 | 281459882559536 | 2490701 |      |      0 |     0 | wait cmd             |
 dn_6005_6006  | kfpt    | cn_5003     | 217298687383475707 | 281460079614000 |  211844 |      |      0 |     0 | wait cmd             |
 dn_6003_6004  | kfpt    | cn_5003     | 217298687383475707 | 281458634766384 | 3913447 |      |      0 |     0 | wait cmd             |
 dn_6007_6008  | kfpt    | cn_5003     | 217298687383475707 | 281460012533808 | 2973982 |      |      0 |     0 | wait cmd             |
 dn_6003_6004  | kfpt    | cn_5003     | 217298687383956317 | 281458383046704 | 3913477 |      |      0 |     0 | wait cmd             |
 cn_5003       | kfpt    |             | 217298687383956317 | 281454926501936 |  211943 |      |      0 |     0 | acquire lwlock       | PgStatObjectLock
 dn_6005_6006  | kfpt    | cn_5003     | 217298687383956317 | 281458955372592 |  211952 |      |      0 |     0 | wait cmd             |
 dn_6001_6002  | kfpt    | cn_5003     | 217298687383956317 | 281459345590320 | 2490722 |      |      0 |     0 | wait cmd             |
 dn_6007_6008  | kfpt    | cn_5003     | 217298687383956317 | 281458762401840 | 2974037 |      |      0 |     0 | wait cmd             |
 dn_6005_6006  | kfpt    | cn_5003     | 217298687383962387 | 281459139942448 |  211949 |      |      0 |     0 | wait cmd             |
 cn_5003       | kfpt    |             | 217298687383962387 | 281454943283248 |  211942 |      |      0 |     0 | acquire lwlock       | PgStatObjectLock
 dn_6003_6004  | kfpt    | cn_5003     | 217298687383962387 | 281458433390640 | 3913473 |      |      0 |     0 | wait cmd             |
 dn_6001_6002  | kfpt    | cn_5003     | 217298687383962387 | 281459412715568 | 2490719 |      |      0 |     0 | wait cmd             |
 dn_6007_6008  | kfpt    | cn_5003     | 217298687383962387 | 281458795964464 | 2974033 |      |      0 |     0 | wait cmd             |
 dn_6001_6002  | kfpt    | cn_5003     | 217298687384026648 | 281459395934256 | 2490721 |      |      0 |     0 | wait cmd             |
 dn_6005_6006  | kfpt    | cn_5003     | 217298687384026648 | 281459089598512 |  211951 |      |      0 |     0 | wait cmd             |
 dn_6007_6008  | kfpt    | cn_5003     | 217298687384026648 | 281458779183152 | 2974036 |      |      0 |     0 | wait cmd             |
 cn_5003       | kfpt    |             | 217298687384026648 | 281454993627184 |  211940 |      |      0 |     0 | acquire lwlock       | PgStatObjectLock
 dn_6003_6004  | kfpt    | cn_5003     | 217298687384026648 | 281458399828016 | 3913476 |      |      0 |     0 | wait cmd             |
(25 rows)
```

As shown in the preceding figure, five CDM jobs are executed concurrently. Therefore, you can see five COPY statements in the active view. Check the waiting view based on query_id corresponding to the five COPY statements. Among the five copies, only one copy is applying for a sequence value from the GTM at the same time, and other copies are waiting for a lightweight lock. Therefore, even if five concurrent jobs are enabled, the actual effect is not significantly improved compared with that of one concurrent job.

Cause: The serial type is used when the target table is created. By default, the cache of the created sequence is 1. As a result, when data is concurrently copied to the database, the CN frequently establishes connections with the GTM, and lightweight lock contention exists between multiple concurrent tasks, resulting in low data synchronization efficiency.

Solution: In this scenario, increase the cache value of the sequence to prevent bottlenecks caused by frequent GTM connection establishment. In this service scenario example, about 100,000 data records are synchronized each time. Based on service evaluation, change the cache value to 10000. (In practice, set a proper cache value based on services to ensure quick access and avoid sequence number waste.)

In cluster versions 8.2.1.100 and later, you can use ALTER SEQUENCE to change the cache value.

In clusters of 8.2.1 and earlier versions, the cache value of GaussDB (DWS) cannot be changed using ALTER SEQUENCE. You can change the cache value of an existing sequence as follows (the mytable table is used as an example):

Step 1 Remove the association between the current sequence and the target table.

```
ALTER SEQUENCE mytable_b_seq owned by none;
ALTER TABLE mytable alter b drop default;
```

Step 2 Record the current sequence number as the start value of the new sequence.

```
SELECT nextval('mytable_b_seq');
```

Delete a sequence.

```
DROP SEQUENCE mytable_b_seq;
```

Step 3 Create seqeunce and bind it to the target table. Replace xxx with the value of nextval obtained in the previous step.

```
CREATE SEQUENCE mytable_b_seq START with xxx cache 10000 owned by mytable.b;
ALTER SEQUENCE mytable_b_seq owner to u1;--u1 is the owner of the mytable table. If the current user is the owner, you do not need to run this statement.
ALTER TABLE mytable alter b set default nextval('mytable_b_seq');
```

----End

6 Sample Data Analysis

6.1 Checkpoint Vehicle Analysis

This practice shows you how to analyze passing vehicles at checkpoints. In this practice, 890 million data records from checkpoints are loaded to a single database table on GaussDB(DWS) for accurate and fuzzy query, demonstrating the ability of GaussDB(DWS) to perform high-performance query for historical data.

NOTE

The sample data has been uploaded to the **traffic-data** folder in an OBS bucket, and all Huawei Cloud accounts have been granted the read-only permission for accessing the OBS bucket.

General Procedure

This practice takes about 40 minutes. The basic process is as follows:

1. **Making Preparations**
2. **Step 1: Creating a Cluster**
3. **Step 2: Using Data Studio to Connect to a Cluster**
4. **Step 3: Importing Sample Data**
5. **Step 4: Performing Vehicle Analysis**

Supported Regions

Table 6-1 Regions and OBS bucket names

Region	OBS Bucket
EU-Dublin	dws-demo-eu-west-101

Making Preparations

- You have registered a GaussDB(DWS) account and checked the account status before using GaussDB(DWS). The account cannot be in arrears or frozen.
- You have obtained the AK and SK of the account.

Step 1: Creating a Cluster

Step 1 Log in to the management console.

Step 2 Click **Service List** and choose **Analytics** > **GaussDB(DWS)**.

Step 3 In the navigation pane on the left, choose **Clusters**. On the displayed page, click **Create Cluster** in the upper right corner.

Step 4 Configure the parameters according to **Table 6-2**.

Table 6-2 Basic configurations

Parameter	Configuration
Region	Select **CN North-Beijing4** or **CN-Hong KongEU-Dublin**. **NOTE** **EU-Dublin** is used as an example. You can select other regions as required. Ensure that all operations are performed in the same region.
AZ	AZ2
Resource	Standard Warehouse
Compute Resource	ECS
Storage type	Cloud SSD
CPU Architecture	X86
Node Flavor	dws2.m6.4xlarge.8 (16 vCPUs | 128 GB | 2000 GB SSD) **NOTE** If this flavor is sold out, select other AZs or flavors.
Hot Storage	100 GB/node
Nodes	3

Step 5 Verify that the information is correct and click **Next: Configure Network**. Configure the network by referring to **Table 6-3**.

Table 6-3 Configuring the network

Parameter	Configuration
VPC	vpc-default
Subnet	subnet-default(192.168.0.0/24)
Security Group	Automatic creation
EIP	Buy now
Bandwidth	1Mbit/s
ELB	Do not use

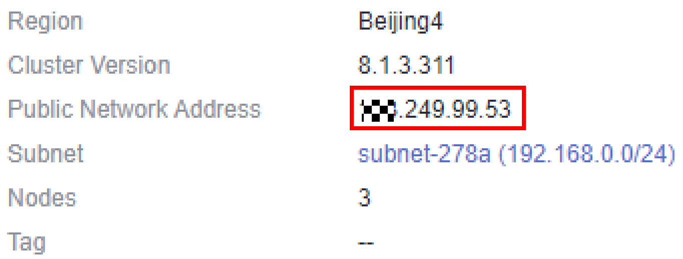
Step 6 Verify that the information is correct and click **Next: Configure Advanced Settings**. Configure the network by referring to **Table 6-4**.

Table 6-4 Configuring advanced settings

Parameter	Configuration
Cluster Name	dws-demo
Cluster Version	Use the recommended version, for example, 8.1.3.311.
Administrator Account	dbadmin
Administrator Password	-
Confirm Password	-
Database Port	8000
Enterprise Project	default
Advanced Settings	Default

Step 7 Click **Next: Confirm**, confirm the configuration, and click **Next**.

Step 8 Wait about 6 minutes. After the cluster is created, click ⌄ next to the cluster name. On the displayed cluster information page, record the value of **Public Network Address**.



Region	Beijing4
Cluster Version	8.1.3.311
Public Network Address	[redacted].249.99.53
Subnet	subnet-278a (192.168.0.0/24)
Nodes	3
Tag	--

----End

Step 2: Using Data Studio to Connect to a Cluster

Step 1 Ensure that JDK 1.8.0 or later has been installed on the client host. Choose **PC > Properties > Advanced System Settings > Environment Variables** and set **JAVA_HOME** (for example, **C:\Program Files\Java\jdk1.8.0_191**).
Add **;%JAVA_HOME%\bin** to the variable **path**.

Step 2 On the **Connections** page of the GaussDB(DWS) console, download the Data Studio GUI client.

Step 3 Decompress the downloaded Data Studio software package, go to the decompressed directory, and double-click **Data Studio.exe** to start the client.

Step 4 On the Data Studio main menu, choose **File > New Connection**. In the dialog box that is displayed, configure the connection based on **Table 6-5**.

Table 6-5 Data Studio software configuration

Parameter	Configuration
Database Type	GaussDB(DWS)
Connection Name	dws-demo
Host	dws-demov.dws.huaweicloud.com The value of this parameter must be the same as the value of **Public Network Address** queried in **Step 1: Creating a Cluster**.
Host Port	8000
Database Name	gaussdb
User Name	dbadmin
Password	-
Enable SSL	Disable

Step 5 Click **OK**.

----End

Step 3: Importing Sample Data

After connecting to the cluster using the SQL client tool, perform the following operations on the SQL client tool to import the sample data from traffic checkpoints and perform data queries.

Step 1 Execute the following statement to create the **traffic** database:

```
CREATE DATABASE traffic encoding 'utf8' template template0;
```

Step 2 Perform the following steps to switch to the new database:

1. In the **Object Browser** window of the Data Studio client, right-click the database connection and choose **Refresh** from the shortcut menu. Then, the new database is displayed.
2. Right-click the name of the new database **traffic** and choose **Connect to DB** from the shortcut menu.
3. Right-click the name of the new database **traffic** and choose **Open Terminal** from the shortcut menu. The SQL command window for connecting to the specified database is displayed. Perform the following steps in the window.

Step 3 Execute the following statements to create a database table for storing vehicle information from traffic checkpoints:

```
CREATE SCHEMA traffic_data;
SET current_schema= traffic_data;
DROP TABLE if exists GCJL;
CREATE TABLE GCJL
(
        kkbh   VARCHAR(20),
        hphm   VARCHAR(20),
        gcsj   DATE ,
        cplx   VARCHAR(8),
        cllx   VARCHAR(8),
        csys   VARCHAR(8)
)
with (orientation = column, COMPRESSION=MIDDLE)
distribute by hash(hphm);
```

Step 4 Create a foreign table, which is used to identify and associate the source data on OBS.

NOTICE

- *<obs_bucket_name>* indicates the OBS bucket name. Only some regions are supported. For details about the supported regions and OBS bucket names, see **Supported Regions**. GaussDB(DWS) clusters do not support cross-region access to OBS bucket data.
- , and replace *<Access_Key_Id>* and *<Secret_Access_Key>* with the value obtained in **Making Preparations**.
- // Hard-coded or plaintext AK and SK are risky. For security purposes, encrypt your AK and SK and store them in the configuration file or environment variables.
- If the message "ERROR: schema "*xxx*" does not exist Position" is displayed when you create a foreign table, the schema does not exist. Perform the previous step to create a schema.

```
CREATE SCHEMA tpchobs;
SET current_schema = 'tpchobs';
DROP FOREIGN table if exists GCJL_OBS;
CREATE FOREIGN TABLE GCJL_OBS
(
        like traffic_data.GCJL
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/traffic-data/gcxx',
        format 'text',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);
```

Step 5 Execute the following statement to import data from the foreign table to the database table:

```
INSERT INTO traffic_data.GCJL SELECT * FROM tpchobs.GCJL_OBS;
```

It takes some time to import data.

----End

Step 4: Performing Vehicle Analysis

1. **Performing ANALYZE**

   This statement collects statistics related to ordinary tables in databases. The statistics are saved to the system catalog **PG_STATISTIC**. When you run the planner, the statistics help you develop an efficient query execution plan.

   Execute the following statement to generate the table statistics:

   ```
   ANALYZE;
   ```

2. **Querying the data volume of the data table**

   Execute the following statement to query the number of loaded data records:

   ```
   SET current_schema= traffic_data;
   SELECT count(*) FROM traffic_data.gcjl;
   ```

3. **Accurate vehicle query**

Run the following statements to query the driving route of a vehicle by the license plate number and time segment. GaussDB(DWS) responds to the request in seconds.

```
SET current_schema= traffic_data;
SELECT hphm, kkbh, gcsj
FROM traffic_data.gcjl
where hphm =  'YD38641'
and gcsj between '2016-01-06' and '2016-01-07'
order by gcsj desc;
```

4. **Fuzzy vehicle query**

   Run the following statements to query the driving route of a vehicle by the license plate number and time segment. GaussDB(DWS) responds to the request in seconds.

```
SET current_schema= traffic_data;
SELECT hphm, kkbh, gcsj
FROM traffic_data.gcjl
where hphm like  'YA23F%'
and kkbh in('508', '1125', '2120')
and gcsj between '2016-01-01' and '2016-01-07'
order by hphm,gcsj desc;
```

6.2 Supply Chain Requirement Analysis of a Company

This practice describes how to load the sample data set from OBS to a data warehouse cluster and perform data queries. This example comprises multi-table analysis and theme analysis in the data analysis scenario.

NOTE

In this example, a standard TPC-H-1x data set of 1 GB size has been generated on GaussDB(DWS), and has been uploaded to the **tpch** folder of an OBS bucket. All accounts have been granted the read-only permission to access the OBS bucket. Users can easily import the data set using their accounts.

General Procedure

This practice takes about 60 minutes. The process is as follows:

1. **Making Preparations**
2. **Step 1: Importing Sample Data**
3. **Step 2: Performing Multi-Table Analysis and Theme Analysis**

Supported Regions

Table 6-6 Regions and OBS bucket names

Region	OBS Bucket
EU-Dublin	dws-demo-eu-west-101

Scenario Description

Understand the basic functions of GaussDB(DWS) and how to import data. Analyze the order data of a company and its suppliers as follows:

1. Analyze the revenue brought by suppliers in a region to the company. The statistics can be used to determine whether a local allocation center needs to be established in a given region.
2. Analyze the relationship between parts and suppliers to obtain the number of suppliers for parts based on the specified contribution conditions. The information can be used to determine whether suppliers are sufficient for large order quantities when the task is urgent.
3. Analyze the revenue loss of small orders. You can query the average annual revenue loss if there are no small orders. Filter out small orders that are lower than 20% of the average supply volume, and calculate the total amount of those small orders to figure out the average annual revenue loss.

Making Preparations

- You have registered a GaussDB(DWS) account and checked the account status before using GaussDB(DWS). The account cannot be in arrears or frozen.
- You have obtained the AK and SK of the account.
- A cluster has been created and connected using Data Studio. For details, see **Checkpoint Vehicle Analysis**.

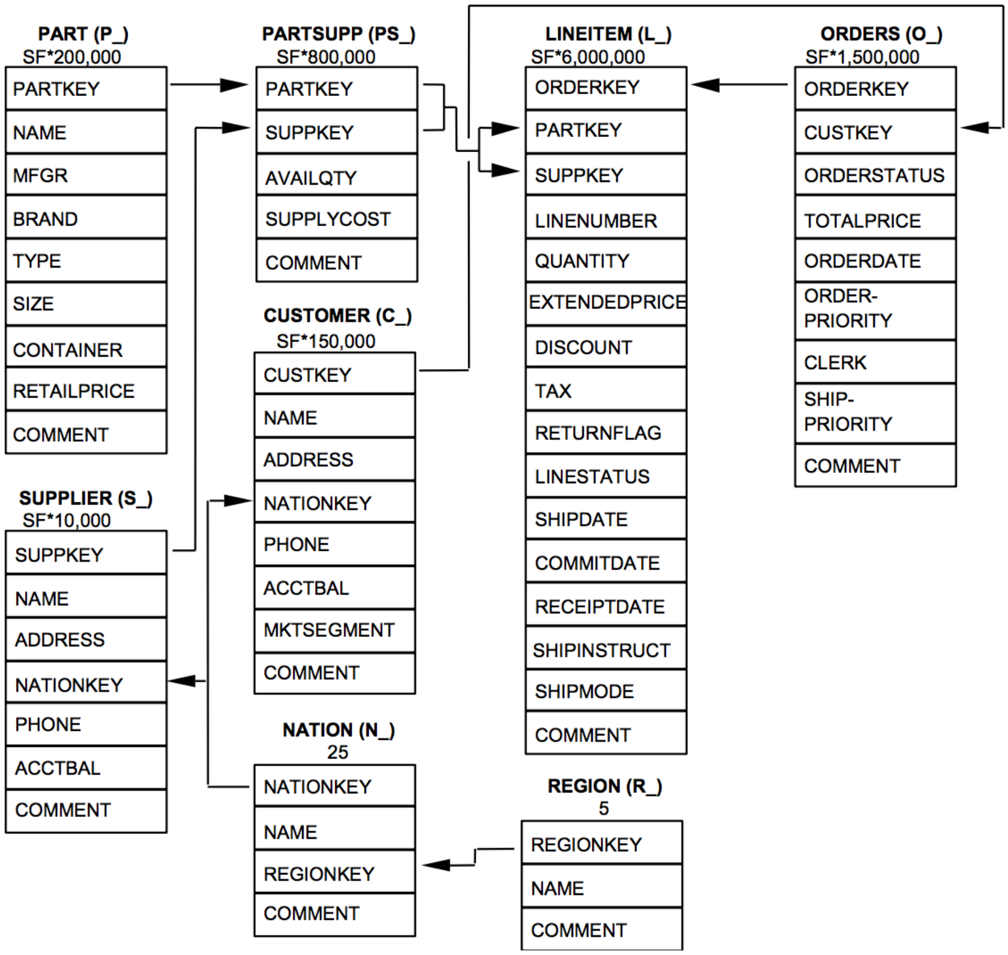
Step 1: Importing Sample Data

After connecting to the cluster using the SQL client tool, perform the following operations in the SQL client tool to import the TPC-H sample data and perform data queries.

Step 1 Create a database table.

The TPC-H sample data consists of eight database tables whose associations are shown in **Figure 6-1**.

Figure 6-1 TPC-H data tables



Execute the following statements to create tables in the **gaussdb** database.

```
CREATE SCHEMA tpch;
SET current_schema = tpch;

DROP TABLE if exists region;
CREATE TABLE REGION
(
        R_REGIONKEY  INT NOT NULL ,
        R_NAME       CHAR(25) NOT NULL ,
        R_COMMENT    VARCHAR(152)
)
with (orientation = column, COMPRESSION=MIDDLE)
distribute by replication;

DROP TABLE if exists nation;
CREATE TABLE NATION
(
        N_NATIONKEY  INT NOT NULL,
        N_NAME       CHAR(25) NOT NULL,
        N_REGIONKEY  INT NOT NULL,
        N_COMMENT    VARCHAR(152)
)
with (orientation = column,COMPRESSION=MIDDLE)
distribute by replication;

DROP TABLE if exists supplier;
CREATE TABLE SUPPLIER
```

```
(
        S_SUPPKEY     BIGINT NOT NULL,
        S_NAME        CHAR(25) NOT NULL,
        S_ADDRESS     VARCHAR(40) NOT NULL,
        S_NATIONKEY   INT NOT NULL,
        S_PHONE       CHAR(15) NOT NULL,
        S_ACCTBAL     DECIMAL(15,2) NOT NULL,
        S_COMMENT     VARCHAR(101) NOT NULL
)
with (orientation = column,COMPRESSION=MIDDLE)
distribute by hash(S_SUPPKEY);

DROP TABLE if exists customer;
CREATE TABLE CUSTOMER
(
        C_CUSTKEY     BIGINT NOT NULL,
        C_NAME        VARCHAR(25) NOT NULL,
        C_ADDRESS     VARCHAR(40) NOT NULL,
        C_NATIONKEY   INT NOT NULL,
        C_PHONE       CHAR(15) NOT NULL,
        C_ACCTBAL     DECIMAL(15,2)   NOT NULL,
        C_MKTSEGMENT  CHAR(10) NOT NULL,
        C_COMMENT     VARCHAR(117) NOT NULL
)
with (orientation = column,COMPRESSION=MIDDLE)
distribute by hash(C_CUSTKEY);

DROP TABLE if exists part;
CREATE TABLE PART
(
        P_PARTKEY     BIGINT NOT NULL,
        P_NAME        VARCHAR(55) NOT NULL,
        P_MFGR        CHAR(25) NOT NULL,
        P_BRAND       CHAR(10) NOT NULL,
        P_TYPE        VARCHAR(25) NOT NULL,
        P_SIZE        BIGINT NOT NULL,
        P_CONTAINER   CHAR(10) NOT NULL,
        P_RETAILPRICE DECIMAL(15,2) NOT NULL,
        P_COMMENT     VARCHAR(23) NOT NULL
)
with (orientation = column,COMPRESSION=MIDDLE)
distribute by hash(P_PARTKEY);

DROP TABLE if exists partsupp;
CREATE TABLE PARTSUPP
(
        PS_PARTKEY     BIGINT NOT NULL,
        PS_SUPPKEY     BIGINT NOT NULL,
        PS_AVAILQTY    BIGINT NOT NULL,
        PS_SUPPLYCOST  DECIMAL(15,2)  NOT NULL,
        PS_COMMENT     VARCHAR(199) NOT NULL
)
with (orientation = column,COMPRESSION=MIDDLE)
distribute by hash(PS_PARTKEY);

DROP TABLE if exists orders;
CREATE TABLE ORDERS
(
        O_ORDERKEY       BIGINT NOT NULL,
        O_CUSTKEY        BIGINT NOT NULL,
        O_ORDERSTATUS    CHAR(1) NOT NULL,
        O_TOTALPRICE     DECIMAL(15,2) NOT NULL,
        O_ORDERDATE      DATE NOT NULL ,
        O_ORDERPRIORITY  CHAR(15) NOT NULL,
        O_CLERK          CHAR(15) NOT NULL ,
        O_SHIPPRIORITY   BIGINT NOT NULL,
        O_COMMENT        VARCHAR(79) NOT NULL
)
with (orientation = column,COMPRESSION=MIDDLE)
```

```
distribute by hash(O_ORDERKEY);

DROP TABLE if exists lineitem;
CREATE TABLE LINEITEM
(
        L_ORDERKEY    BIGINT NOT NULL,
        L_PARTKEY     BIGINT NOT NULL,
        L_SUPPKEY     BIGINT NOT NULL,
        L_LINENUMBER  BIGINT NOT NULL,
        L_QUANTITY    DECIMAL(15,2) NOT NULL,
        L_EXTENDEDPRICE  DECIMAL(15,2) NOT NULL,
        L_DISCOUNT    DECIMAL(15,2) NOT NULL,
        L_TAX         DECIMAL(15,2) NOT NULL,
        L_RETURNFLAG  CHAR(1) NOT NULL,
        L_LINESTATUS  CHAR(1) NOT NULL,
        L_SHIPDATE    DATE NOT NULL,
        L_COMMITDATE  DATE NOT NULL ,
        L_RECEIPTDATE DATE NOT NULL,
        L_SHIPINSTRUCT CHAR(25) NOT NULL,
        L_SHIPMODE     CHAR(10) NOT NULL,
        L_COMMENT      VARCHAR(44) NOT NULL
)
with (orientation = column,COMPRESSION=MIDDLE)
distribute by hash(L_ORDERKEY);
```

Step 2 Create a foreign table, which is used to identify and associate the source data on OBS.

NOTICE

- *<obs_bucket_name>* indicates the OBS bucket name. Only some regions are supported. For details about the supported regions and OBS bucket names, see **Supported Regions**. GaussDB(DWS) clusters do not support cross-region access to OBS bucket data.
- , and replace *<Access_Key_Id>* and *<Secret_Access_Key>* with the value obtained in **Making Preparations**.
- // Hard-coded or plaintext AK and SK are risky. For security purposes, encrypt your AK and SK and store them in the configuration file or environment variables.
- If the message "ERROR: schema "*xxx*" does not exist Position" is displayed when you create a foreign table, the schema does not exist. Perform the previous step to create a schema.

```
CREATE SCHEMA tpchobs;
SET current_schema='tpchobs';
DROP FOREIGN table if exists region;
CREATE FOREIGN TABLE REGION
(
        like tpch.region
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/tpch/region.tbl',
        format 'text',
        delimiter '|',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);
```

```
DROP FOREIGN table if exists nation;
CREATE FOREIGN TABLE NATION
(
        like tpch.nation
)
SERVER gsmpp_server
OPTIONS (
         encoding 'utf8',
         location 'obs://<obs_bucket_name>/tpch/nation.tbl',
         format 'text',
         delimiter '|',
         access_key '<Access_Key_Id>',
         secret_access_key '<Secret_Access_Key>',
         chunksize '64',
         IGNORE_EXTRA_DATA 'on'
);

DROP FOREIGN table if exists supplier;
CREATE FOREIGN TABLE SUPPLIER
(
        like tpch.supplier
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/tpch/supplier.tbl',
        format 'text',
        delimiter '|',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);

DROP FOREIGN table if exists customer;
CREATE FOREIGN TABLE CUSTOMER
(
        like tpch.customer
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/tpch/customer.tbl',
        format 'text',
        delimiter '|',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);
DROP FOREIGN table if exists part;
CREATE FOREIGN TABLE PART
(
        like tpch.part

)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/tpch/part.tbl',
        format 'text',
        delimiter '|',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);
DROP FOREIGN table if exists partsupp;
```

```
CREATE FOREIGN TABLE PARTSUPP
(
        like tpch.partsupp
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/tpch/partsupp.tbl',
        format 'text',
        delimiter '|',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);
DROP FOREIGN table if exists orders;
CREATE FOREIGN TABLE ORDERS
(
        like tpch.orders
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/tpch/orders.tbl',
        format 'text',
        delimiter '|',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);
DROP FOREIGN table if exists lineitem;
CREATE FOREIGN TABLE LINEITEM
(
        like tpch.lineitem
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/tpch/lineitem.tbl',
        format 'text',
        delimiter '|',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on'
);
```

Step 3 Copy and execute the following statements to import the foreign table data to the corresponding database table.

Run the **insert** command to import the data in the OBS foreign table to the GaussDB(DWS) database table. The database kernel concurrently imports the OBS data at a high speed to GaussDB(DWS).

```
INSERT INTO tpch.lineitem SELECT * FROM tpchobs.lineitem;
INSERT INTO tpch.part SELECT * FROM tpchobs.part;
INSERT INTO tpch.partsupp SELECT * FROM tpchobs.partsupp;
INSERT INTO tpch.customer SELECT * FROM tpchobs.customer;
INSERT INTO tpch.supplier SELECT * FROM tpchobs.supplier;
INSERT INTO tpch.nation SELECT * FROM tpchobs.nation;
INSERT INTO tpch.region SELECT * FROM tpchobs.region;
INSERT INTO tpch.orders SELECT * FROM tpchobs.orders;
```

It takes 10 minutes to import data.

----End

Step 2: Performing Multi-Table Analysis and Theme Analysis

The following uses standard TPC-H query as an example to demonstrate how to perform basic data query on GaussDB(DWS).

Before querying data, run the **Analyze** command to generate statistics related to the database table. The statistics data is stored in system table PG_STATISTIC and is useful when you run the planner, which provides you with an efficient query execution plan.

The following are querying examples:

- **Querying revenue of a supplier in a region (TPCH-Q5)**

  By executing the TPCH-Q5 query statement, you can query the revenue statistics of a spare parts supplier in a region. The revenue is calculated based on **sum(l_extendedprice * (1 - l_discount))**. The statistics can be used to determine whether a local allocation center needs to be established in a given region.

  Copy and execute the following TPCH-Q5 statement for query. This statement features multi-table join query with **GROUP BY**, **ORDER BY**, and **AGGREGATE**.

  ```
  SET current_schema='tpch';
  SELECT
  n_name,
  sum(l_extendedprice * (1 - l_discount)) as revenue
  FROM
  customer,
  orders,
  lineitem,
  supplier,
  nation,
  region
  where
  c_custkey = o_custkey
  and l_orderkey = o_orderkey
  and l_suppkey = s_suppkey
  and c_nationkey = s_nationkey
  and s_nationkey = n_nationkey
  and n_regionkey = r_regionkey
  and r_name = 'ASIA'
  and o_orderdate >= '1994-01-01'::date
  and o_orderdate < '1994-01-01'::date + interval '1 year'
  group by
  n_name
  order by
  revenue desc;
  ```

- **Querying relationships between spare parts and suppliers (TPCH-Q16)**

  By executing the TPCH-Q16 query statement, you can obtain the number of suppliers that can supply spare parts with the specified contribution conditions. This information can be used to determine whether there are sufficient suppliers when the order quantity is large and the task is urgent.

  Copy and execute the following TPCH-Q16 statement for query. The statement features multi-table connection operations with group by, sort by, aggregate, deduplicate, and NOT IN subquery.

  ```
  SET current_schema='tpch';
  SELECT
  p_brand,
  p_type,
  p_size,
  count(distinct ps_suppkey) as supplier_cnt
  FROM
  ```

```
partsupp,
part
where
p_partkey = ps_partkey
and p_brand <> 'Brand#45'
and p_type not like 'MEDIUM POLISHED%'
and p_size in (49, 14, 23, 45, 19, 3, 36, 9)
and ps_suppkey not in (
        select
        s_suppkey
        from
        supplier
        where
        s_comment like '%Customer%Complaints%'
)
group by
p_brand,
p_type,
p_size
order by
supplier_cnt desc,
p_brand,
p_type,
p_size
limit 100;
```

- **Querying revenue loss of small orders (TPCH-Q17)**

  You can query the average annual revenue loss if there are no small orders. Filter out small orders that are lower than the 20% of the average supply volume, and calculate the total amount of those small orders to figure out the average annual revenue loss.

  Copy and execute the following TPCH-Q17 statement for query. The statement features multi-table connection operations with aggregate and aggregate subquery.

```
SET current_schema='tpch';
SELECT
sum(l_extendedprice) / 7.0 as avg_yearly
FROM
lineitem,
part
where
p_partkey = l_partkey
and p_brand = 'Brand#23'
and p_container = 'MED BOX'
and l_quantity < (
        select 0.2 * avg(l_quantity)
        from lineitem
        where l_partkey = p_partkey
);
```

6.3 Operations Status Analysis of a Retail Department Store

Background

In this practice, the daily business data of each retail store is loaded from OBS to the corresponding table in the data warehouse cluster for summarizing and querying KPIs. This data includes store turnover, customer flow, monthly sales ranking, monthly customer flow conversion rate, monthly price-rent ratio, and sales per unit area. This example demonstrates the multidimensional query and analysis of GaussDB(DWS) in the retail scenario.

NOTE

The sample data has been uploaded to the **retail-data** folder in an OBS bucket, and all HUAWEI CLOUD accounts have been granted the read-only permission to access the OBS bucket.

General Procedure

This practice takes about 60 minutes. The process is as follows:

1. **Preparations**
2. **Step 1: Importing Sample Data from the Retail Department Store**
3. **Step 2: Performing Operations Status Analysis**

Supported Regions

Table 6-7 Regions and OBS bucket names

Region	OBS Bucket
EU-Dublin	dws-demo-eu-west-101

Preparations

- You have registered a GaussDB(DWS) account, and the account is not in arrears or frozen.
- You have obtained the AK and SK of the account.
- A cluster has been created and connected using Data Studio. For details, see **Step 1: Creating a Cluster** and **Step 2: Using Data Studio to Connect to a Cluster**.

Step 1: Importing Sample Data from the Retail Department Store

After connecting to the cluster using the SQL client tool, perform the following operations in the SQL client tool to import the sample data from retail department stores and perform queries.

Step 1 Execute the following statement to create the **retail** database:

```
CREATE DATABASE retail encoding 'utf8' template template0;
```

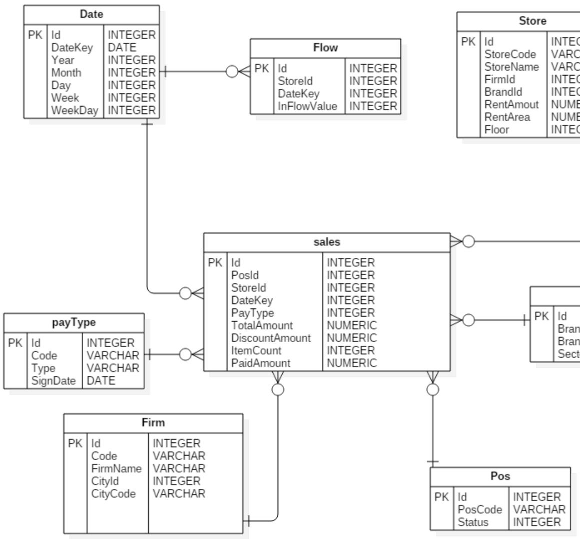
Step 2 Perform the following steps to switch to the new database:

1. In the **Object Browser** window of the Data Studio client, right-click the database connection and choose **Refresh** from the shortcut menu. Then, the new database is displayed.
2. Right-click the name of the new database **retail** and choose **Connect to DB** from the shortcut menu.
3. Right-click the name of the new database **retail** and choose **Open Terminal** from the shortcut menu. The SQL command window for connecting to the specified database is displayed. Perform the following steps in the window.

Step 3 Create a database table.

The sample data consists of 10 database tables whose associations are shown in **Figure 6-2**.

Figure 6-2 Sample data tables of retail department stores



Copy and execute the following statements to switch to create a database table of retail department store information.

```
CREATE SCHEMA retail_data;
SET current_schema='retail_data';

DROP TABLE IF EXISTS STORE;
CREATE TABLE STORE (
        ID INT,
        STORECODE VARCHAR(10),
        STORENAME VARCHAR(100),
        FIRMID INT,
        FLOOR INT,
        BRANDID INT,
        RENTAMOUNT NUMERIC(18,2),
        RENTAREA NUMERIC(18,2)
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY REPLICATION;

DROP TABLE IF EXISTS POS;
CREATE TABLE POS(
        ID INT,
        POSCODE VARCHAR(20),
        STATUS INT,
        MODIFICATIONDATE DATE
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY REPLICATION;

DROP TABLE IF EXISTS BRAND;
CREATE TABLE BRAND (
        ID INT,
        BRANDCODE VARCHAR(10),
        BRANDNAME VARCHAR(100),
        SECTORID INT
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY REPLICATION;

DROP TABLE IF EXISTS SECTOR;
```

```
CREATE TABLE SECTOR(
        ID INT,
        SECTORCODE VARCHAR(10),
        SECTORNAME VARCHAR(20),
        CATEGORYID INT
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY REPLICATION;

DROP TABLE IF EXISTS CATEGORY;
CREATE TABLE CATEGORY(
        ID INT,
        CODE VARCHAR(10),
        NAME VARCHAR(20)
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY REPLICATION;

DROP TABLE IF EXISTS FIRM;
CREATE TABLE FIRM(
        ID INT,
        CODE VARCHAR(4),
        NAME VARCHAR(40),
        CITYID INT,
        CITYNAME VARCHAR(10),
        CITYCODE VARCHAR(20)
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY REPLICATION;

DROP TABLE IF EXISTS DATE;
CREATE TABLE DATE(
        ID INT,
        DATEKEY DATE,
        YEAR INT,
        MONTH INT,
        DAY INT,
        WEEK INT,
        WEEKDAY INT
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY REPLICATION;

DROP TABLE IF EXISTS PAYTYPE;
CREATE TABLE PAYTYPE(
        ID INT,
        CODE VARCHAR(10),
        TYPE VARCHAR(10),
        SIGNDATE DATE
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY REPLICATION;

DROP TABLE IF EXISTS SALES;
CREATE TABLE SALES(
         ID INT,
         POSID INT,
         STOREID INT,
         DATEKEY INT,
         PAYTYPE INT,
         TOTALAMOUNT NUMERIC(18,2),
         DISCOUNTAMOUNT NUMERIC(18,2),
         ITEMCOUNT INT,
         PAIDAMOUNT NUMERIC(18,2)
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY HASH(ID);

DROP TABLE IF EXISTS FLOW;
CREATE TABLE FLOW (
         ID INT,
         STOREID INT,
         DATEKEY INT,
         INFLOWVALUE INT
)
WITH (ORIENTATION = COLUMN, COMPRESSION=MIDDLE) DISTRIBUTE BY HASH(ID);
```

Step 4 Create a foreign table, which is used to identify and associate the source data on OBS.

NOTICE

- *<obs_bucket_name>* indicates the OBS bucket name. Only some regions are supported. For details about the supported regions and OBS bucket names, see **Supported Regions**. GaussDB(DWS) clusters do not support cross-region access to OBS bucket data.
- , and replace *<Access_Key_Id>* and *<Secret_Access_Key>* with the value obtained in **Preparations**.
- // Hard-coded or plaintext AK and SK are risky. For security purposes, encrypt your AK and SK and store them in the configuration file or environment variables.
- If the message "ERROR: schema "*xxx*" does not exist Position" is displayed when you create a foreign table, the schema does not exist. Perform the previous step to create a schema.

```
CREATE SCHEMA retail_obs_data;
SET current_schema='retail_obs_data';
DROP FOREIGN table if exists SALES_OBS;
CREATE FOREIGN TABLE SALES_OBS
(
        like retail_data.SALES
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/retail-data/sales',
        format 'csv',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on',
        header 'on'
);

DROP FOREIGN table if exists FLOW_OBS;
CREATE FOREIGN TABLE FLOW_OBS
(
        like retail_data.flow
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/retail-data/flow',
        format 'csv',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on',
        header 'on'
);

DROP FOREIGN table if exists BRAND_OBS;
CREATE FOREIGN TABLE BRAND_OBS
```

```
(
        like retail_data.brand
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/retail-data/brand',
        format 'csv',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on',
        header 'on'
);


DROP FOREIGN table if exists CATEGORY_OBS;
CREATE FOREIGN TABLE CATEGORY_OBS
(
       like retail_data.category
)
SERVER gsmpp_server
OPTIONS (
       encoding 'utf8',
       location 'obs://<obs_bucket_name>/retail-data/category',
       format 'csv',
       delimiter ',',
       access_key '<Access_Key_Id>',
       secret_access_key '<Secret_Access_Key>',
       chunksize '64',
       IGNORE_EXTRA_DATA 'on',
       header 'on'
);

DROP FOREIGN table if exists DATE_OBS;
CREATE FOREIGN TABLE DATE_OBS
(
        like retail_data.date
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/retail-data/date',
        format 'csv',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on',
        header 'on'
);

DROP FOREIGN table if exists FIRM_OBS;
CREATE FOREIGN TABLE FIRM_OBS
(
        like retail_data.firm
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/retail-data/firm',
        format 'csv',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on',
        header 'on'
```

```
);


DROP FOREIGN table if exists PAYTYPE_OBS;
CREATE FOREIGN TABLE PAYTYPE_OBS
(
        like retail_data.paytype
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/retail-data/paytype',
        format 'csv',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on',
        header 'on'
);


DROP FOREIGN table if exists POS_OBS;
CREATE FOREIGN TABLE POS_OBS
(
        like retail_data.pos
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/retail-data/pos',
        format 'csv',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on',
        header 'on'
);

DROP FOREIGN table if exists SECTOR_OBS;
CREATE FOREIGN TABLE SECTOR_OBS
(
        like retail_data.sector
)
SERVER gsmpp_server
OPTIONS (
        encoding 'utf8',
        location 'obs://<obs_bucket_name>/retail-data/sector',
        format 'csv',
        delimiter ',',
        access_key '<Access_Key_Id>',
        secret_access_key '<Secret_Access_Key>',
        chunksize '64',
        IGNORE_EXTRA_DATA 'on',
        header 'on'
);


DROP FOREIGN table if exists STORE_OBS;
CREATE FOREIGN TABLE STORE_OBS
(
         like retail_data.store
)
SERVER gsmpp_server
OPTIONS (
         encoding 'utf8',
         location 'obs://<obs_bucket_name>/retail-data/store',
         format 'csv',
         delimiter ',',
         access_key '<Access_Key_Id>',
         secret_access_key '<Secret_Access_Key>',
         chunksize '64',
         IGNORE_EXTRA_DATA 'on',
         header 'on'
);
```

Step 5 Copy and execute the following statements to import the foreign table data to the cluster:

```
INSERT INTO retail_data.store SELECT * FROM retail_obs_data.STORE_OBS;
INSERT INTO retail_data.sector SELECT * FROM retail_obs_data.SECTOR_OBS;
INSERT INTO retail_data.paytype SELECT * FROM retail_obs_data.PAYTYPE_OBS;
INSERT INTO retail_data.firm SELECT * FROM retail_obs_data.FIRM_OBS;
INSERT INTO retail_data.flow SELECT * FROM retail_obs_data.FLOW_OBS;
INSERT INTO retail_data.category SELECT * FROM retail_obs_data.CATEGORY_OBS;
INSERT INTO retail_data.date SELECT * FROM retail_obs_data.DATE_OBS;
INSERT INTO retail_data.pos SELECT * FROM retail_obs_data.POS_OBS;
INSERT INTO retail_data.brand SELECT * FROM retail_obs_data.BRAND_OBS;
INSERT INTO retail_data.sales SELECT * FROM retail_obs_data.SALES_OBS;
```

It takes some time to import data.

Step 6 Copy and execute the following statement to create the **v_sales_flow_details** view:

```
SET current_schema='retail_data';
CREATE VIEW v_sales_flow_details AS
SELECT
FIRM.ID FIRMID, FIRM.NAME FIRNAME, FIRM. CITYCODE,
CATEGORY.ID CATEGORYID, CATEGORY.NAME CATEGORYNAME,
SECTOR.ID SECTORID, SECTOR.SECTORNAME,
BRAND.ID BRANDID, BRAND.BRANDNAME,
STORE.ID STOREID, STORE.STORENAME, STORE.RENTAMOUNT, STORE.RENTAREA,
DATE.DATEKEY, SALES.TOTALAMOUNT, DISCOUNTAMOUNT, ITEMCOUNT, PAIDAMOUNT, INFLOWVALUE
FROM SALES
INNER JOIN STORE ON SALES.STOREID = STORE.ID
INNER JOIN FIRM ON STORE.FIRMID = FIRM.ID
INNER JOIN BRAND ON STORE.BRANDID = BRAND.ID
INNER JOIN SECTOR ON BRAND.SECTORID = SECTOR.ID
INNER JOIN CATEGORY ON SECTOR.CATEGORYID = CATEGORY.ID
INNER JOIN DATE ON SALES.DATEKEY = DATE.ID
INNER JOIN FLOW ON FLOW.DATEKEY = DATE.ID AND FLOW.STOREID = STORE.ID;
```

----End

Step 2: Performing Operations Status Analysis

The following uses standard query of retail information from department stores as an example to demonstrate how to perform basic data query on GaussDB(DWS).

Before querying data, run the **Analyze** command to generate statistics related to the database table. The statistics data is stored in system table PG_STATISTIC and is useful when you run the planner, which provides you with an efficient query execution plan.

The following are querying examples:

- **Querying the monthly sales revenue of each store**

  Copy and execute the following statements to query the total revenue of each store in a certain month:

  ```
  SET current_schema='retail_data';
  SELECT DATE_TRUNC('month',datekey)
  AT TIME ZONE 'UTC' AS __timestamp,
  SUM(paidamount)
  ```

```
AS sum__paidamount
FROM v_sales_flow_details
GROUP BY DATE_TRUNC('month',datekey) AT TIME ZONE 'UTC'
ORDER BY SUM(paidamount) DESC;
```

- **Querying the sales revenue and price-rent ratio of each store**

  Copy and execute the following statement to query the sales revenue and price-rent ratio of each store:

```
SET current_schema='retail_data';
SELECT firname AS firname,
storename AS storename,
SUM(paidamount)
AS sum__paidamount,
AVG(RENTAMOUNT)/SUM(PAIDAMOUNT)
AS rentamount_sales_rate
FROM v_sales_flow_details
GROUP BY firname, storename
ORDER BY SUM(paidamount) DESC;
```

- **Analyzing the sales revenue of each city**

  Copy and execute the following statement to analyze and query the sales revenue of all provinces:

```
SET current_schema='retail_data';
SELECT citycode AS citycode,
SUM(paidamount)
AS sum__paidamount
FROM v_sales_flow_details
GROUP BY citycode
ORDER BY SUM(paidamount) DESC;
```

- **Analyzing and comparing the price-rent ratio and customer flow conversion rate of each store**

```
SET current_schema='retail_data';
SELECT brandname AS brandname,
firname AS firname,
SUM(PAIDAMOUNT)/AVG(RENTAREA) AS sales_rentarea_rate,
SUM(ITEMCOUNT)/SUM(INFLOWVALUE) AS poscount_flow_rate,
AVG(RENTAMOUNT)/SUM(PAIDAMOUNT) AS rentamount_sales_rate
FROM v_sales_flow_details
GROUP BY brandname,  firname
ORDER BY sales_rentarea_rate DESC;
```

- **Analyzing brands in the retail industry**

```
SET current_schema='retail_data';
SELECT categoryname AS categoryname,
brandname AS brandname,
SUM(paidamount) AS sum__paidamount
FROM v_sales_flow_details
GROUP BY categoryname,
brandname
ORDER BY sum__paidamount DESC;
```

- **Querying daily sales information of each brand**

```
SET current_schema='retail_data';
SELECT brandname AS brandname,
DATE_TRUNC('day', datekey) AT TIME ZONE 'UTC' AS __timestamp,
SUM(paidamount) AS sum__paidamount
FROM v_sales_flow_details
WHERE datekey >= '2016-01-01 00:00:00'
AND datekey <= '2016-01-30 00:00:00'
GROUP BY brandname,
DATE_TRUNC('day', datekey) AT TIME ZONE 'UTC'
ORDER BY sum__paidamount ASC
LIMIT 50000;
```

7 Security Management

7.1 Role-based Access Control (RBAC)

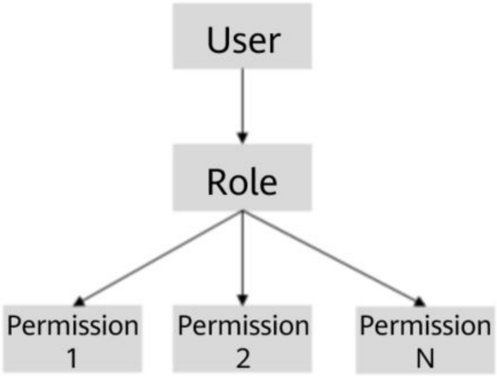
What is RBAC?

- Role-based access control (RBAC) is to grant permissions to roles and let users obtain permissions by associating with roles.
- A role is a set of permissions.
- RBAC greatly simplifies permissions management.

What is the RBAC Model?

Assign appropriate permissions to roles.

Associate users with the roles.



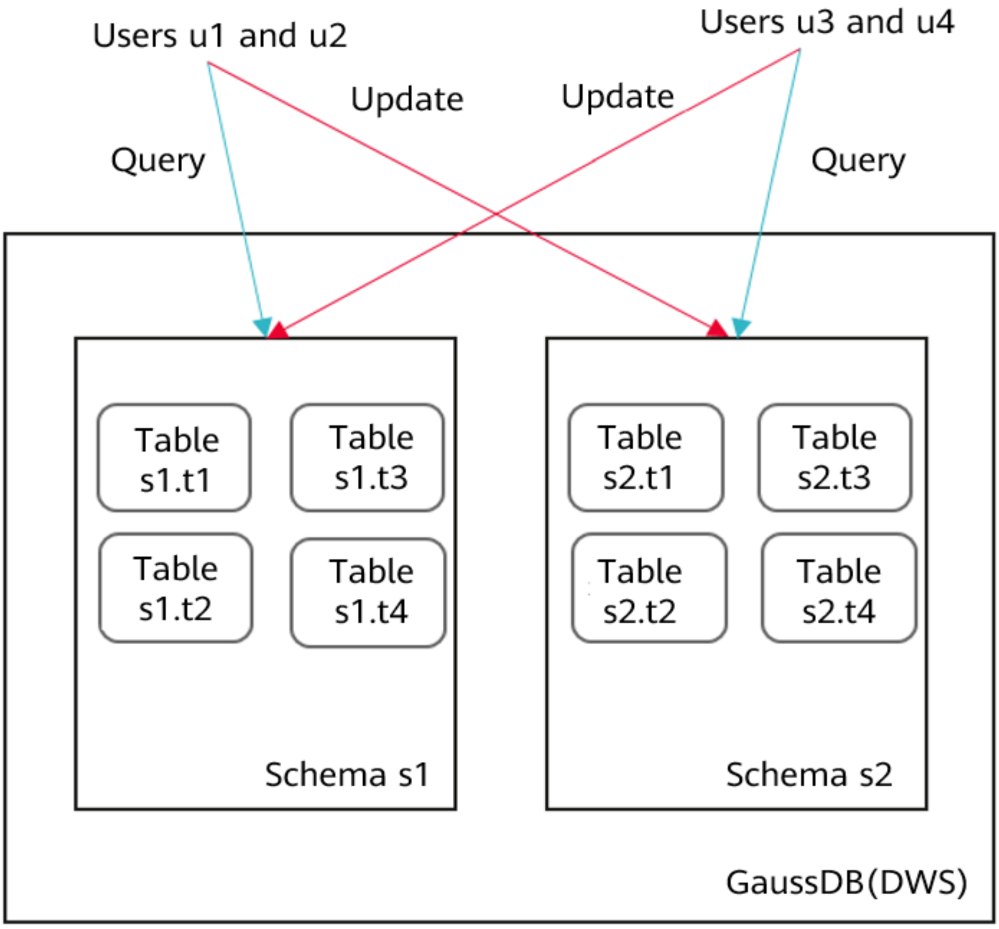
Scenarios

Assume there are two schemas, **s1** and **s2**.

There are two groups of users:

- Users **u1** and **u2** can query all the tables in **s1** and update all the tables in **s2**.

- Users **u3** and **u4** can query all the tables in **s2** and update all the tables in **s1**.



Procedure for Granting Permissions

Step 1 Connect to the DWS database as user **dbadmin**.

Step 2 Run the following statements to create schemas **s1** and **s2** and users **u1** to **u4**:

NOTE

Replace *{password}* with the actual password.

```
CREATE SCHEMA s1;
CREATE SCHEMA s2;
CREATE USER u1 PASSWORD '{password}';
CREATE USER u2 PASSWORD '{password}';
CREATE USER u3 PASSWORD '{password}';
CREATE USER u4 PASSWORD '{password}';
```

Step 3 Copy and run the following statements to create the **s1.t1** and **s2.t1** tables:

```
CREATE TABLE s1.t1 (c1 int, c2 int);
CREATE TABLE s2.t1 (c1 int, c2 int);
```

Step 4 Run the following statement to insert data to the tables:

```
INSERT INTO s1.t1 VALUES (1,2);
INSERT INTO s2.t1 VALUES (1,2);
```

Step 5 Run the following statements to create four roles, each having the query or update permission of table **s1** or **s2**:

```
CREATE ROLE rs1_select PASSWORD disable;  -- Permission to query s1
CREATE ROLE rs1_update PASSWORD disable; -- Permission to update s1
CREATE ROLE rs2_select PASSWORD disable; -- Permission to query s2
CREATE ROLE rs2_update PASSWORD disable; -- Permission to update s2
```

Step 6 Run the following statements to grant the access permissions of schemas **s1** and **s2** to the roles:

```
GRANT USAGE ON SCHEMA s1, s2 TO rs1_select, rs1_update,rs2_select, rs2_update;
```

Step 7 Run the following statements to grant specific permissions to the roles:

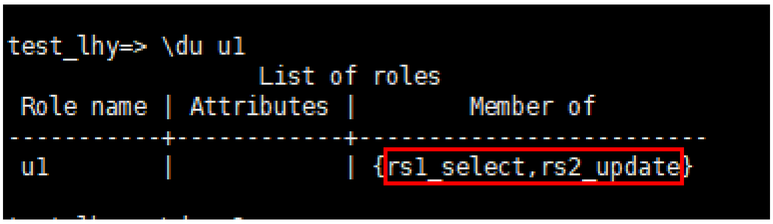
```
GRANT SELECT ON ALL TABLES IN SCHEMA s1 TO rs1_select; -- Grant the query permission on all the tables in s1 to the rs1_select role.
GRANT SELECT,UPDATE ON ALL TABLES IN SCHEMA s1 TO rs1_update;  -- Grant the query and update permissions on all the tables in s1 to the rs1_update role.
GRANT SELECT ON ALL TABLES IN SCHEMA s2 TO rs2_select;  -- Grant the query permission on all the tables in s2 to the rs2_select role.
GRANT SELECT,UPDATE ON ALL TABLES IN SCHEMA s2 TO rs2_update;  -- Grant the query and update permissions on all the tables in s2 to the rs2_update role.
```

Step 8 Run the following statements to grant roles to users:

```
GRANT rs1_select, rs2_update TO u1, u2;  -- Users u1 and u2 have the permissions to query s1 and update s2.
GRANT rs2_select, rs1_update TO u3, u4;  -- Users u3 and u4 have the permissions to query s2 and update s1.
```

Step 9 Run the following statement to view the role bound to a specific user:

```
\du u1;
```



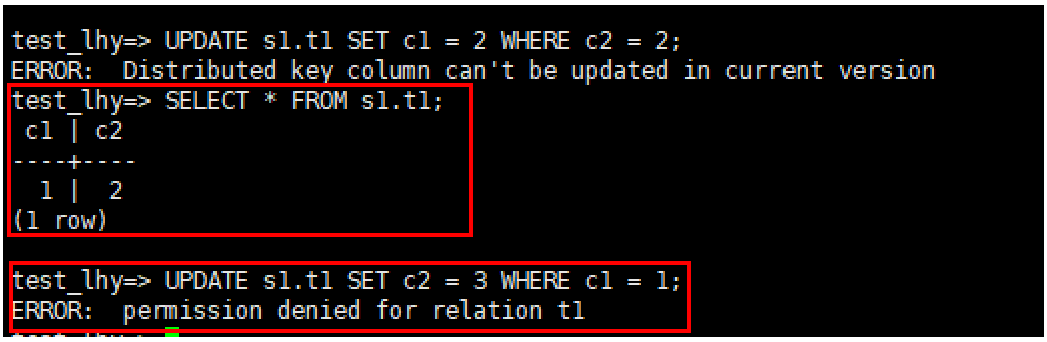
```
test_lhy=> \du u1
                List of roles
 Role name | Attributes |        Member of
-----------+------------+-------------------------
 u1        |            | {rs1_select,rs2_update}
```

Step 10 Start another session. Connect to the database as user **u1**.

```
gsql -d gaussdb -h GaussDB(DWS)_EIP -U u1 -p 8000 -r -W {password};
```

Step 11 Run the following statements in the new session verify that user **u1** can query but cannot update **s1.t1**:

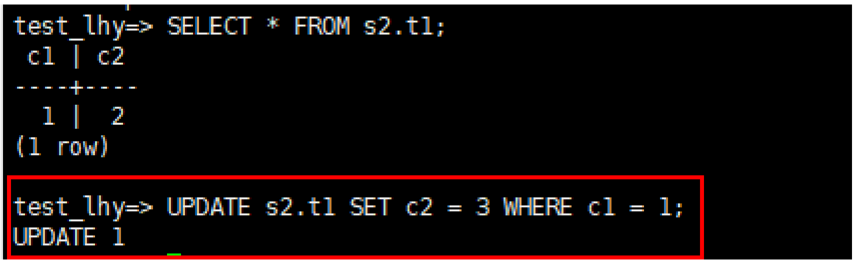
```
SELECT * FROM s1.t1;
UPDATE s1.t1 SET c2 = 3 WHERE c1 = 1;
```



```
test_lhy=> UPDATE s1.t1 SET c1 = 2 WHERE c2 = 2;
ERROR:  Distributed key column can't be updated in current version
test_lhy=> SELECT * FROM s1.t1;
 c1 | c2
----+----
  1 |  2
(1 row)

test_lhy=> UPDATE s1.t1 SET c2 = 3 WHERE c1 = 1;
ERROR:  permission denied for relation t1
```

Step 12 Run the following statements in the new session to verify that user **u1** can update **s2.t1**:

```
SELECT * FROM s2.t1;
UPDATE s2.t1 SET c2 = 3 WHERE c1 = 1;
```



```
test_lhy=> SELECT * FROM s2.t1;
 c1 | c2
----+----
  1 |  2
(1 row)

test_lhy=> UPDATE s2.t1 SET c2 = 3 WHERE c1 = 1;
UPDATE 1
```

----End

7.2 Encrypting and Decrypting Data Columns

Data encryption is widely used in various information systems as a technology to effectively prevent unauthorized access and prevent data leakage. As the core of the information system, the GaussDB(DWS) data warehouse also provides data encryption functions, including transparent encryption and encryption using SQL functions. This section describes SQL function encryption.

NOTE

Currently, GaussDB(DWS) does not support decrypting data encrypted in Oracle, Teradata, and MySQL databases. The encryption and decryption of Oracle, Teradata, and MySQL databases are different from those of GaussDB(DWS). GaussDB(DWS) can only decrypt unencrypted data migrated from Oracle, Teradata, and MySQL databases.

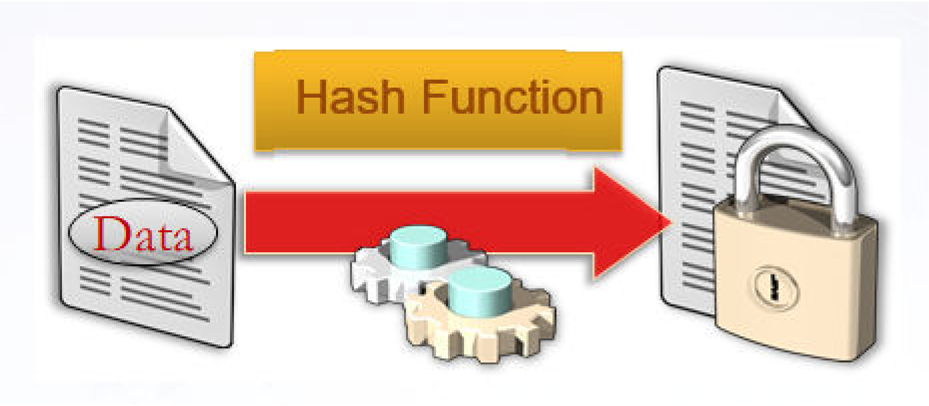
Background

- Hash Functions

  The hash function is also called the digest algorithm. It maps input data of an arbitrary length to an output of fixed length. For example, Hash(data)=result. This process is irreversible. That is, the hash function does not have an inverse function, and data cannot be obtained from the result. In scenarios where plaintext passwords should not be stored (passwords are sensitive) or known by system administrators, hash algorithms should be used to store one-way hash values of passwords.

  In actual use, salt values and iteration are added to prevent same hash values generated by same passwords, hence to prevent rainbow table attacks.

  Figure 7-1 Hash functions

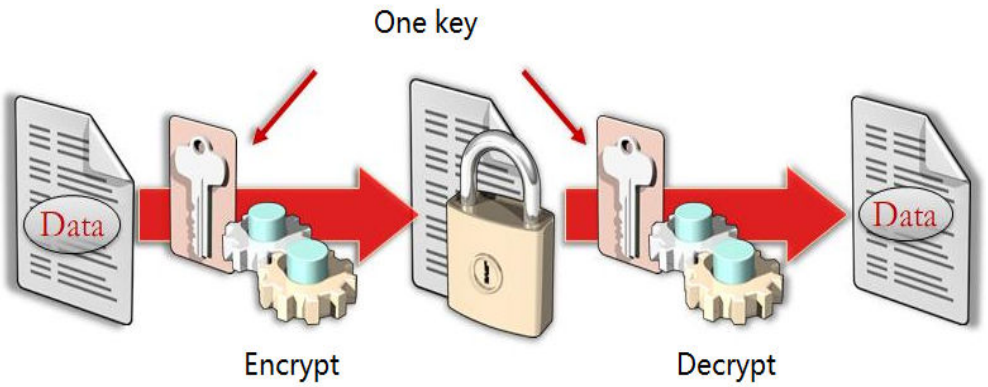
- Symmetric Encryption Algorithms

  Symmetric encryption algorithms use the same key to encrypt and decrypt data. There are two subcategories of symmetric encryption algorithms: block ciphers and stream ciphers.

  Block ciphers break the plaintext into fixed-length groups of bits known as blocks and Each block then gets encrypted as a unit. And if there's not enough data to completely fill a block, "padding" is then used to ensure that the blocks meet the fixed-length requirements. Due to padding, the length of the ciphertext obtained by block ciphers is greater than that of the plaintext.

  In stream ciphers, encryption and decryption parties use same pseudo-random encrypted data stream as keys, and plaintext data is sequentially encrypted by these keys. In practice, data is encrypted one bit at a time using an XOR operation. Stream cyphers do not need to be padded. Therefore the length of the obtained ciphertext is same as the length of the plaintext.

  Figure 7-2 Symmetric encryption algorithms



Technical Details

GaussDB(DWS) provides hash functions and symmetric cryptographic algorithms to encrypt and decrypt data columns. Hash functions support sha256, sha384, sha512, and SM3. Symmetric cryptographic algorithms support AES128, AES192, AES256, and SM4.

- Hash Functions
  - md5(string)

    Use MD5 to encrypt string and return a hexadecimal value. MD5 is insecure and is not recommended.
  - gs_hash(hashstr, hashmethod)

    Obtains the digest string of a **hashstr** string based on the algorithm specified by **hashmethod**. **hashmethod** can be **sha256**, **sha384**, **sha512**, or **sm3**.
- Symmetric Encryption Algorithms
  - gs_encrypt(encryptstr, keystr, cryptotype, cryptomode, hashmethod)

    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.

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

  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.

- gs_encrypt_aes128(encryptstr,keystr)

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

- gs_decrypt_aes128(decryptstr,keystr)

  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.

For more information about functions, see **Using Functions for Encryption and Decryption**.

Examples

Step 1 Connect to the database.

For details, see **Using the gsql CLI Client to Connect to a Cluster**.

Step 2 Create the table **student** with the attributes **id**, **name**, and **score**. Then use hash functions to encrypt and save names, and use symmetric cryptographic algorithms to save scores.

```
CREATE TABLE student (id int, name text, score text, subject text);
INSERT INTO student VALUES (1, gs_hash('alice', 'sha256'), gs_encrypt('95', '12345', 'aes128', 'cbc', 
'sha256'),gs_encrypt_aes128('math', '1234'));
INSERT INTO student VALUES (2, gs_hash('bob', 'sha256'), gs_encrypt('92', '12345', 'aes128', 'cbc', 
'sha256'),gs_encrypt_aes128('english', '1234'));
INSERT INTO student VALUES (3, gs_hash('peter', 'sha256'), gs_encrypt('98', '12345', 'aes128', 'cbc', 
'sha256'),gs_encrypt_aes128('science', '1234'));
```

Step 3 Query the table **student** without using keys. The query result shows that the encrypted data in the name and score columns cannot be viewed even if you have the **SELECT** permission.

```
select * from student;
 id |                              name                              |                                                 
score                                                 |                                                 
                              subject
----+------------------------------------------------------------------
+------------------------------------------------------------------------------------------------------------------------------
+-----------
-------------------------------------------------------------------------------------
  1 | 2bd806c97f0e00af1a1fc3328fa763a9269723c8db8fac4f93af71db186d6e90 | AAAAAAAAAABAuUC3VQ
+MvPCDAaTUySl1e2gGLr4/ATdCUjTEvova3cb/Ba3ZKqIn1yNVGEFBvJnTq/3sLF4//
Gm8qG7AyfNbbqdW3aYErLVpbE/QWFX9Ig== | aFEWQR2gkj
iu6sfsAad+dHzfFDHePZ6xd44zyekh+qVFlh9FODZ0DoaFAJXctwUsiqaiitTxW8cCSEaNjS/E7Ke1ruY=
  2 | 81b637d8fcd2c6da6359e6963113a1170de795e4b725b84d1e0b4cfd9ec58ce9 | AAAAAAAAAABAuUC3VQ
+MvPCDAaTUySl1taXxAoDqE793hgyCJvC0ESdAX5Mtgdq2LXI1f5ZxraQ73WIJVtIBX8oe3gTDxoXGlHbHht4kzM
4U8dOwr5rjgg== | aFEWQR2gkj
iu6sfsAad+dM8tPTDo/Pds6ZmqdmjGiKxf39+Wzx5NoQ6c8FrzihnRzgc0fycWSu5YGWNOKYWhRsE84Ac=
  3 | 026ad9b14a7453b7488daa0c6acbc258b1506f52c441c7c465474c1a564394ff | 
AAAAAAAAAACnyusORPeApqMUgh56ucQu3uso/
Llw5MbPFMkOXuspEzhhnc9vErwOFe6cuGtx8muEyHCX7V5yXs+8FxhNh3n5L3419LDWJJLY2O4merHpSg== | 
zomphRfHV4
H32hTtgkio1PyrobVO8N+hN7kAKwtygKP2E7Aaf1vsjmtLHcL88jyeJNe1lxe0fAvodzPJAxAuV3UJN4M=
(3 rows)
```

Step 4 Query the table **student** using keys. The query result shows that the data is decrypted by the function **gs_decrypt** (corresponding to **gs_encrypt**) and can be viewed.

```
select id, gs_decrypt(score, '12345', 'aes128', 'cbc', 'sha256'),gs_decrypt_aes128(subject, '1234') from student;
 id | gs_decrypt | gs_decrypt_aes128
----+------------+-------------------
  1 | 95         | math
  2 | 92         | english
  3 | 98         | science
(3 rows)
```

----End

7.3 Managing and Controlling Data Permissions Through Views

Use views to grant different users the permission to query different data in the same table, providing data permission management and security.

Scenario

After connecting to the cluster as user dbadmin, create a sample table customer.

```
CREATE TABLE customer (id bigserial NOT NULL, province_id bigint NOT NULL, user_info varchar, primary
key (id)) DISTRIBUTE BY HASH(id);
```

Insert test data into the sample table customer.

```
INSERT INTO customer(province_id,user_info) VALUES (1,'Alice'),(1,'Jack'),(2,'Jack'),(3,'Matu');
INSERT 0 4
```

Query the customer table.

```
SELECT * FROM customer;
 id | province_id | user_info
----+-------------+-----------
  3 |           2 | Jack
  1 |           1 | Alice
  2 |           1 | Jack
  4 |           3 | Matu
(4 rows)
```

Requirement: User u1 can view only the data of province 1 (province_id=1), and user u2 can view only the data of province 2 (province_id=2).

Implementation

You can create a view to meet the requirements in the preceding scenario. The procedure is as follows:

Step 1 After connecting to the cluster as user dbadmin, create views v1 and v2 for provinces 1 and 2 in dbadmin mode.

Run the CREATE VIEW statement to create view v1 for querying the data of province 1.

```
CREATE VIEW v1 AS
    SELECT * FROM customer WHERE province_id=1;
```

Run the CREATE VIEW statement to create view v2 for querying the data of province 2.

```
CREATE VIEW v2 AS
    SELECT * FROM customer WHERE province_id=2;
```

Step 2 Create users u1 and u2.

```
CREATE USER u1 PASSWORD '*********';
CREATE USER u2 PASSWORD '*********';
```

Step 3 Run the GRANT statement to grant the data query permission to the target user.

Grant the permission on the schema view corresponding to u1 and u2.

```
GRANT USAGE ON schema dbadmin TO u1,u2;
```

Grant u1 the permission to query data of province 1 in the v1 view.

```
GRANT SELECT ON v1 TO u1;
```

Grant u2 the permission to query data of province 2 in the V2 view.

```
GRANT SELECT ON v2 TO u2;
```

----End

Verifying the Query Result

- Switch to the u1 account to connect to the cluster.

  ```
  SET ROLE u1 PASSWORD '*********';
  ```

  This interface is used to query the v1 view. u1 can query only the v1 view data.

  ```
  SELECT * FROM dbadmin.v1;
   id | province_id | user_info
  ----+-------------+-----------
    1 |           1 | Alice
    2 |           1 | Jack
  (2 rows)
  ```

  If u1 attempts to query data in view v2, the following error information is displayed:

  ```
  SELECT * FROM dbadmin.v2;
  ERROR:  SELECT permission denied to user "u1" for relation "dbadmin.v2"
  ```

  The result shows that user u1 can view only the data of province 1 (province_id=1).

- Use the u2 account to connect to the cluster.

  ```
  SET ROLE u2 PASSWORD '*********';
  ```

  This interface is used to query the v2 view. u2 can query only the v2 view data.

  ```
  SELECT * FROM dbadmin.v2;
   id | province_id | user_info
  ----+-------------+-----------
    3 |           2 | Jack
  (1 row)
  ```

  If u2 attempts to query data in view v1, the following error information is displayed:

  ```
  SELECT * FROM dbadmin.v1;
  ERROR:  SELECT permission denied to user "u2" for relation "dbadmin.v1"
  ```

  The result shows that user u2 can view only the data of province 2 (province_id=2).