Data Warehouse Service

FAQs

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Contents

1 Top FAQ

Recently, we have collected FAQ about GaussDB(DWS) through **Intelligent chatbot**. You may find answers to your questions on this page.

Syntax Usage

Table 1-1 Syntax Usage

Ranking	FAQ	Page URL
1	• How do I query the number of bits in a query string? • How do I truncate a substring? • How do I replace some strings in the returned result? • How do I return the first several characters of a string? • How do I filter out the header and tail of a string? • How do I get the number of bytes of a specified string?	**Character Processing Functions and Operators**
2	• How do I create a partition table? • What are the supported table partition types?	**CREATE TABLE PARTITION**
3	• How do I view all schemas? • How do I view all tables in a schema?	**Schema**

Ranking	FAQ	Page URL
4	• How do I add a table column? • How do I change a data type? • How do I add a NOT NULL constraint to a column? • How do I set the primary key? • How do I alter table attributes?	**ALTER TABLE**
5	• How do I use date functions? • How do I use pg_sleep()? • How do I perform month subtraction? • How do I use functions to change date types?	**Time and Date Processing Functions and Operators**
6	• How do I change distribution columns? • How do I change the distribution column to another column? • Why does the data in the distribution column cannot be updated, and the message "Distributed key column can't be updated in current version" is displayed?	**How Do I Change Distribution Columns**
7	• How do I manage partitions? • How do I add or delete a partition? • How do I rename a partition? • How do I query data in a partition?	**Creating and Managing Partitioned Tables**
8	• How do I query the number of rows in a partition? • How do I merge two partitions?	**ALTER TABLE PARTITION**
9	How do I call the stored procedure?	**CALL**
10	• How do I create a table? • create table like	**CREATE TABLE**

Ranking	FAQ	Page URL
11	• What is the command for authorization? • How do I use the grant syntax? • How do I grant the rights of a user to other users? • How do I grant table permissions to a user? • How do I grant database permissions to a user? • What are the foreign table permissions?	GRANT
12	• How do I use the REPLACE function? • How do I use to_timestamp? • How do I covert a timestamp to a specified format? • How do I use current_timestamp? • How do I use to_number?	Type Conversion Functions

Database Management

Table 1-2 Database management

Ranking	FAQ	Page URL
1	• How do I view table definitions? • How do I view the DDL? • How do I view the structure of views? • How do I querying the size of a database or a table?	Querying the Table and Database Size
2	• How do I clearing tablespaces? • How do I use the VACUUM FULL syntax? • How do I improve the query performance after a large number of adding, deleting, and modifying operations?	VACUUM

Ranking	FAQ	Page URL
3	• How do I check whether a user has permissions on the current table? • How do I check whether a user has a certain permission on a table?	**How Do I View the Table Permissions of a GaussDB(DWS) User?**
4	• How do I query and terminate blocked statements? • How do I query active statements? • How do I terminate a session? • What should I do when lock waiting times out?	**Analyzing SQL Statements That Are Being Executed**
5	• Is there a detailed description for SQL execution plans? • How do I view the execution plan? • What are the differences between Nested Loop, Hash Join, and Merge Join?	**SQL Execution Plan**
6	• How do I remove the read-only status? • What should I do when the database enters the read-only state?	**A GaussDB(DWS) Cluster Becomes Read-Only and Is Locked and Data Cannot Be Written**
7	• How do I collect statistics?	**ANALYZE | ANALYSE**
8	• How do I configure the optimizer? • How do I enable or disable nestloop? • How do I enable or disable mergejoin? • What are the parameters that affect the execution plan?	**Optimizer Method Configuration**
9	• How do I changing the database time zone? • How do I change the time zone?	**How to Change a Database's Default Time Zone When the Database Time Is Different from the System Time?**

Ranking	FAQ	Page URL
10	• How do I query function definitions? • How do I use the access privilege inquiry functions? • How do I query view definitions?	System Information Functions
11	• What are the technical specifications? • What are the supported partition table sizes? • What is the maximum data volume in a single table? • What is the maximum number of columns supported by a table?	Technical Specifications
12	• What are the developer operations? • How do I specify whether to enable the optimizer's use of a distributed framework?	Developer Options

Cluster Management

Table 1-3 Cluster management

Ranking	FAQ	Page URL
1	• What should I do when disk usage is too high? • What should I do if the disk is full? • What should I do if the cluster becomes read-only? • What should I do if a disk alarm is generated? • How do I set the disk threshold? • How do I enable disk alarm subscription?	A GaussDB(DWS) Cluster Becomes Read-Only and Is Locked and Data Cannot Be Written

Ranking	FAQ	Page URL
2	• How do I view basic cluster information? • How do I viewing the EIP of a cluster? • How do I viewing the database connection address? • What are the cluster flavors? • What is the basic disk information?	**Viewing Cluster Details**
3	How do I purchase a cluster?	**Creating a Cluster**
4	• What should I do if the cluster is unbalanced? • How do I perform primary/standby cluster switchover?	**Performing a Primary/Standby Switchback**

2 Product Consulting

2.1 Why Do I Need to Use GaussDB(DWS)?

Background

Large amounts of data (orders, inventories, materials, and payments) are being generated in enterprises' business operation systems and transactional databases everyday.

Decision makers need to effectively harness and analyze this data to extract valuable insights that inform strategic decision-making and drive business success.

Challenges

A data classification and analysis task usually involves simultaneous access to data in multiple database tables, which means multiple tables that are possibly being updated by different transactions need to be locked at the same time. This can be quite difficult for a busy database system.

- Locking multiple tables increases the latency of a complex query.
- Blocking transactions that are updating the database tables causes increased latencies or even interruptions for these transactions.

Solutions

Data warehouses excel in data aggregation and association, facilitating large-scale data mining for better decision-making support. Data mining requires complex queries that involve multiple tables.

The ETL process copies data from dedicated business databases to a data warehouse for centralized analysis and computing. Data of multiple systems can be aggregated to one data warehouse for the extraction of more valuable data insights.

Data warehouses are designed differently from standard transaction-oriented databases, such as Oracle, SQL Server, and MySQL. Data warehouses are optimized in terms of data aggregation and association, but certain features of

standard databases, such as transactional properties and data manipulation operations (add, delete, modify) may be compromised or become unavailable. This is why data warehouses and databases are usually used for different purposes. Transactional databases focus on online transaction processing, while data warehouses are better at complex queries and analysis. They perform their own duties and do not interfere with each other. You could also say databases are for data updates whereas data warehouses are for data analysis.

Cloud Data Warehouse Solution

Conventional data warehouses are not a feasible option for smaller enterprises due to high cost, time-consuming selection and procurement of hardware, and complex capacity expansion.

GaussDB(DWS) offers a better choice:

- This cloud-based, distributed MPP data warehousing service is open, efficient, compatible, scalable, and easy to maintain.
- Built on the GaussDB data warehouse kernel, it provides a seamless experience for enterprises across both on-cloud and on-premises environments.

  GaussDB(DWS) is a next-generation distributed data warehousing system with independent intellectual property rights and better guarantee of business continuity. Currently, it is widely used in government, finance, and carriers. FusionInsight LibrA is compatible with mainstream open-source Postgres databases, especially in Oracle and Teradata SQL statements. GaussDB(DWS) engineers have designed a kernel of hybrid row-column stores not only for faster analysis but also for data processing, such as adding, deleting, modifying data. FusionInsight LibrA features the cost optimizer and warehouse technologies, including machine code vector computing and inter/intra-parallelism for operators and nodes. It uses LLVM to optimize the local code in compilation query plans. More powerful data query and analysis addresses service pain points and improves user experience.
- GaussDB(DWS) can be used out of the box.

  Enabling GaussDB(DWS) on the cloud platform takes only a few minutes, freeing you from the time consuming process of searching for and purchasing data warehouses. This not only simplifies the procurement, but also lowers the cost and requirements for using data warehouses. Small and medium-sized enterprises with access to GaussDB(DWS) can seamlessly mine large amounts of data for actionable insights.

2.2 Should I Choose Public Cloud GaussDB(DWS) or RDS?

Both allow you to run traditional relational databases on the cloud and offload database management tasks. RDS databases are useful for OLTP, reporting, and analysis, but are less capable of handling read operations of a large amount of data (complex read-only queries). GaussDB(DWS) uses multiple nodes and optimization methods like column-based storage, vectorized executors, and distributed frameworks to handle OLAP tasks. This reduces the analysis and

reporting workload for large data sets by a significant amount compared to traditional databases.

You can scale out a GaussDB(DWS) cluster to address complex data and queries, or to handle overwhelming analysis and report workloads that affect OLTP performance.

The following table compares OLTP with OLAP.

Table 2-1 Comparison between OLTP and OLAP

Feature	OLTP	OLAP
Users	Operation personnel and junior managers	Decision-making personnel and senior managers
Functionality	Daily operations	Analysis and decision-making
Design	Application-oriented	Subject-oriented
Data	Latest, detailed, two-dimensional, and separated	Historical, integrated, multidimensional, unified
Access	Reads/Writes dozens of records.	Reads millions of records.
Scope of Work	Simple read/write operations	Complex queries
Database size	Hundreds of GB	TB to PB

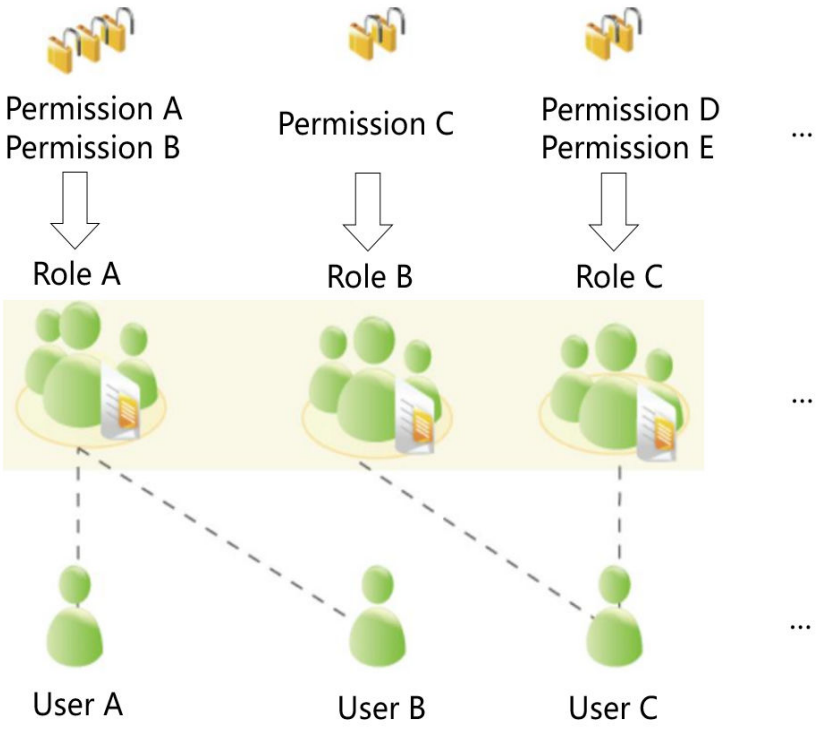
2.3 What Are the Differences Between GaussDB(DWS) Users and Roles?

Users and roles are shared within the entire cluster, but their data is not shared. That is, a user can connect to any database, but after the connection is successful, any user can access only the database declared in the connection request.

- A role is a set of permissions. Generally, roles are used to sort permissions. Users are used to manage permissions and perform operations.
- A role can inherit permissions from other roles. All users in a user group automatically inherit the operation permissions of the role of the group.
- In a database, the permissions of users come from roles.
- A user group is a group of users who have the same permission.
- A user can be regarded as a role with the login permission.
- A role can be regarded as a user without the login permission.

The permissions provided by GaussDB(DWS) include the O&M permissions for components on the management plane. You can grant permissions to users as needed. The management plane uses roles for better permissions management. You can select specified permissions and assign them to roles in a unified manner. In this way, permissions can be viewed and managed in a centralized manner.

The following figure shows the relationships between permissions, roles, and users in unified permissions management.



GaussDB(DWS) provides various permissions. Select and assign permissions to different users based on service scenarios. A role can be assigned one or more permissions.

After a role is granted to a user through **GRANT**, the user will have all the permissions of the role. It is recommended that roles be used to efficiently grant permissions. A user has permissions only for their own tables, but does not have permissions for other users' tables in their schemas.

- Role A is assigned operation permissions A and B. After role A is allocated to user A and user B, user A and user B can obtain operation permissions A and B.
- Role B is assigned operation permission C. After role B is allocated to user C, user C can obtain operation permissions C.
- Role C is assigned operation permissions D and E. After role C is allocated to user C, user C can obtain operation permissions D and F.

2.4 How Do I Check the Creation Time of a GaussDB(DWS) Database User?

Method 1:

When you create a GaussDB(DWS) database user, if the time when the user takes effect (**VALID BEGIN**) is the same as the creation time of the user, and the time when the user takes effect has not been changed, you can check the **valbegin** column in the **PG_USER** view to check the user creation time.

The following is an example:

Create user **jerry** and set its validity start time to its current creation time.

```
CREATE USER jerry PASSWORD 'password' VALID BEGIN '2022-05-19 10:31:56';
```

View users in the **PG_USER** view. The **valbegin** column indicates the time when **jerry** took effect, that is, the time when jerry was created.

```
SELECT * FROM PG_USER;
 usename | usesysid | usecreatedb | usesuper | usecatupd | userepl |  passwd  |        valbegin         | valuntil |
respool    | parent | spacelimit | useconfig | nodegroup | tempspacelimit |
 spillspacelimit
---------+----------+-------------+----------+-----------+---------+----------+-------------------------+----------
+--------------+--------+------------+-----------+-----------+----------------+
-----------------
 Ruby    |       10 | t           | t        | t         | t       | ******** |                         |          | default_pool |      0
|           |          |          |              |

 dbadmin |    16393 | f           | f        | f         | f       | ******** |                         |          | default_pool |      0
|           |          |          |              |

 jack    |   451897 | f           | f        | f         | f       | ******** |                         |          | default_pool |      0
|           |          |          |              |

 emma    |   451910 | f           | f        | f         | f       | ******** |                         |          | default_pool |      0
|           |          |          |              |

 jerry   |   457386 | f           | f        | f         | f       | ******** | 2022-05-19 10:31:56+08 |          | default_pool
|      0 |          |          |              |
(5 rows)
```

Method 2:

Check the **passwordtime** column in the **PG_AUTH_HISTORY** system catalog. This column indicates the time when the user's initial password was created. Only users with system administrator permissions can access the catalog.

```
SELECT roloid, min(passwordtime) as create_time FROM pg_auth_history group by roloid order by roloid;
```

The following is an example:

Query the **PG_USER** view to obtain the OID of user **jerry**, which is **457386**. Query the **passwordtime** column to obtain the creation time of user **jerry**, which is **2022-05-19 10:31:56**.

```
SELECT roloid, min(passwordtime) as create_time FROM pg_auth_history group by roloid order by roloid;
 roloid |          create_time
--------+-------------------------------
     10 | 2022-02-25 09:53:38.711785+08
  16393 | 2022-02-25 09:55:17.992932+08
 451897 | 2022-05-18 09:42:26.897855+08
 451910 | 2022-05-18 09:46:33.152354+08
 457386 | 2022-05-19 10:31:56.037706+08
(5 rows)
```

2.5 How Do I Select a GaussDB(DWS) Region and AZ?

Concepts

A region and availability zone (AZ) identify the location of a data center. You can create resources in regions and AZs.

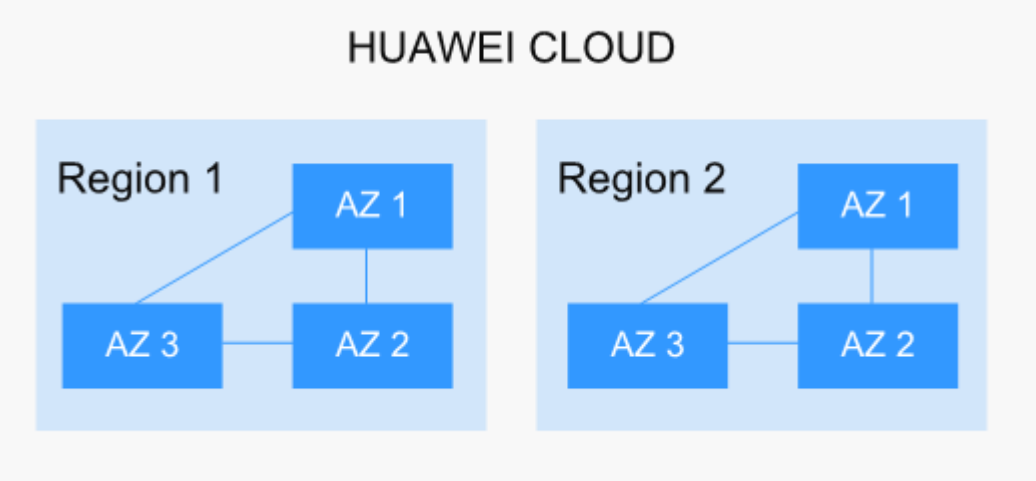
- **Regions** are defined in terms of geographical location and network latency. Each region has its own shared public services (ECS, EVS, OBS, VPC, EIP, and

IMS). Regions are either common or dedicated. A common region provides common cloud services available to all tenants. A dedicated region provides services of a specific type or only for specific tenants.

- An **AZ** contains one or more physical data centers. Each AZ has its own independent power source, network, and cooling. The computing, network, storage, and other resources in an AZ can be logically divided into multiple clusters. AZs in a region are interconnected through high-speed optic fiber, so systems deployed across AZs can achieve higher availability.

Figure 2-1 shows the relationship between regions and AZs.

Figure 2-1 Regions and AZs



Huawei Cloud provides services in many regions around the world. You can select a region and AZ as needed. For more information, see **Global Products and Services**.

How Do I Select a Region?

When selecting a region, consider the following:

- Location

  Select a region close to you or your target users for lower network latency and faster access. All regions in the Chinese mainland provide the same infrastructure, BGP network quality, and operations and configurations on resources. Therefore, if your target users are in the Chinese mainland, you do not need to consider network latency differences when selecting a region.

  The countries and regions outside the Chinese mainland, such as Bangkok and Hong Kong (China), provide services for users outside the Chinese mainland. If you or your target users are in the Chinese mainland, do not select these regions, as doing so will lead to high latency.

  - If you or your target users are in the Asia Pacific region (excluding the Chinese mainland), select the **AP-Bangkok** or **AP-Singapore** region.
  - If you or your target users are in Africa, select the **AF-Johannesburg** region.
  - If you or your target users are in Europe, select the **EU-Paris** region.

- Resource pricing

  This varies by region. For details, see the **pricing details**.

How Do I Select an AZ?

Consider your requirements for DR and network latency when selecting an AZ:

- Deploy resources in different AZs in the same region to improve DR.
- For an application that requires an extremely low latency, deploy all its resources in the same AZ.

Regions and Endpoints

When you use resources with API calls, you must specify the regional endpoint. For details about Huawei Cloud regions and endpoints, see **Regions and Endpoints**.

2.6 Is Data Secure in GaussDB(DWS)?

Yes. In the big data era, data has become a core asset. The public cloud will adhere to the commitment made over the years that we do not touch your applications or data, helping you protect your core assets. This is our commitment to users and the society, laying the foundation for the business success of the public cloud and their partners.

GaussDB(DWS) is a data warehousing system with telecom-class security to safeguard your data and privacy. Moreover, the public cloud GaussDB(DWS) delivers carrier-class quality, which can satisfy data security and privacy requirements of governments, financial organizations, and carriers. Therefore, it is widely used by various industries. GaussDB(DWS) of the public cloud won the following security authentication:

- Internal Cyber Security Lab (ICSL) in compliance with cyber security standards issued by the UK authorities.
- Privacy and Security Assessment (PSA) to meet EU requirements of data security and privacy.

Service Data Security

GaussDB(DWS) is built on public cloud software infrastructure, including ECS and OBS. Both ECS and OBS won the Trusted Cloud Certification issued by the China Data Center Alliance in 2017.

Service data of GaussDB(DWS) users is stored in the ECSs in the cluster. Neither users nor public cloud O&M administrators can log in to these ECSs.

ECSs have their operating systems hardened through various measures such as kernel hardening, patch updates, access controls, port management, and protocol and port attack defense.

GaussDB(DWS) provides comprehensive security measures, such as password policies, authentication, session management, user permissions management, and database auditing.

Snapshot Data Security

GaussDB(DWS) stores its backup data in OBS as snapshots. OBS has passed the China Data Center Alliance trusted cloud security authentication. OBS supports access permission control, key access, and data encryption features. GaussDB(DWS) snapshots can be used for data backup and restoration only and cannot be accessed by any user. The GaussDB(DWS) system administrator can view the OBS storage space occupied by snapshots on the GaussDB(DWS) console and through public cloud bills.

Network Access Security

The L2 and L3 networks of GaussDB(DWS) can be fully isolated to meet the security requirements of government and financial customers.

- GaussDB(DWS) is deployed in a dedicated ECS environment, which is not shared with any other tenant. This eliminates the possibility of data leakage caused by computing resource sharing.
- ECSs in a GaussDB(DWS) cluster are isolated through VPCs, preventing the ECSs from being discovered and accessed by other tenants.
- The network is divided into the service plane and management plane. The two planes are physically isolated, ensuring network security.
- The tenants can flexibly customize the security group and access rules.
- External application software access GaussDB(DWS) over SSL.
- Data imported from OBS is encrypted.

2.7 Can I Modify the Security Group of a GaussDB(DWS) Cluster?

After a GaussDB(DWS) cluster is created, you can change its security group or you can add, delete, or modify rules in its current security group.

Change the security group to another one:

1. Log in to the **GaussDB(DWS) console**.
2. Choose **Dedicated Clusters** > **Clusters** in the navigation pane.
3. In the cluster list, find the target cluster and click the cluster name. The **Basic Information** page is displayed.
4. On the cluster details page, locate the Security Group parameter, click Modify on the right of the security group name, and select the name of the security group to be changed.
5. Click **OK**. The security group is modified.

Modify an existing security group rule:

1. Log in to the **GaussDB(DWS) console**.
2. Choose **Dedicated Clusters** > **Clusters** in the navigation pane.
3. In the cluster list, find the target cluster and click the cluster name. The **Basic Information** page is displayed.

4. Locate the **Security Group** parameter and click the security group name to switch to the **Security Groups** page on the VPC console, on which you can set the security group.

NOTE

- To configure a security group, contact the organization security administrator.
- Changing the security group of a cluster may cause brief service disruption. Exercise caution when performing this operation. For better network performance, do not select more than five security groups.

2.8 What Is a Database/Data Warehouse/Data Lake/ Lakehouse?

The evolving Internet and IoT produce massive volumes of data. This data needs to be managed, using concepts like database, data warehouse, data lake, and lakehouse. What are these concepts? What are their relationships? What are the specific products and solutions? This document helps you understand them through comparison.

Database

A database is where data is organized, stored, and managed by data structure.

Databases have been used in computers since the 1960s, with the two prevailing data models (hierarchical and network), and data and applications were very interdependent. This limited database applications.

A database usually refers to a relational database. A relational database organizes data with a relational model, that is, data is stored in rows and columns. Therefore, database data is well-structured and independent with low redundancy. In 1970, relational databases were born to completely separate data from applications for software and have become an indispensable part of mainstream computer systems. Relational databases are the foundation of database products from all vendors, with relational API support even if a database is non-relational.

Relational databases process basic and routine transactions using OLTP, such as bank transactions.

Data Warehouse

There has been an explosive growth of data since the start of the digital age. This rapid pace of growth has also fueled the rapid advances of data processing systems, such as databases and data warehouses. To extract valuable insights from large amounts of data, OLAP techniques and methods are being used for data mining. However, it is difficult to share data between different databases, and data integration and analysis also face great challenges.

To overcome these challenges for enterprises, Bill Inmon, proposed the idea of data warehousing in 1990. The data warehouse runs on a unique storage architecture to perform OLAP on a large amount of the OLTP data accumulated over the years. In this way, enterprises can obtain valuable information from massive data quickly and effectively to make informed decisions. Thanks to data

warehouses, the information industry has evolved from operational systems based on relational databases to decision support systems.

Unlike a database, a data warehouse has the following features:

- A data warehouse uses themes. It is built to support various services, with data coming from scattered operational data. Therefore, the required data needs to be extracted from multiple heterogeneous data sources, processed and integrated, and reorganized by theme.
- A data warehouse mainly supports enterprise decision analysis and the operations involved are focused on data query. Therefore, it improves the query speed and cuts the total cost of ownership (TCO) by optimizing table structures and storage modes.

Table 2-2 Comparison between data warehouses and databases

Dimension	Data Warehouse	Database
Application scenario	OLAP	OLTP
Data source	Multiple	Single
Data normalization	Denormalized schemas	Highly normalized static schemas
Data access	Optimized read operations	Optimized write operations

Data Lake

Data is an important asset for enterprises. Production and operations data are saved and distilled into effective management policies.

The data lake does that. It is a large data warehouse that centrally stores structured and unstructured data. It can store raw data of multiple data sources and types, meaning that data can be accessed, processed, analyzed, and transmitted without being structured first. The data lake helps enterprises quickly complete federated analysis of heterogeneous data sources and explore data value.

A data lake is in essence a solution that consists of a data storage architecture and data processing tools.

- The **storage architecture** must be scalable and reliable enough to store massive data of any type (structured, semi-structured, unstructured data).
- The two types of **processing tools** have separate functions:
  - The first type: migrates data into the lake, including defining sources, formulating synchronization policies, moving data, and compiling catalogs.
  - The second type then uses that data, including analyzing, mining, and using it. The data lake must be equipped with wide-ranging capabilities, such as comprehensive data and data lifecycle management, diversified data analytics, and secure data acquisition and release. These data

governance tools help guarantee data quality, which can be compromised by a lack of metadata and turn the data lake into a data swamp.

Now with big data and AI, lake data is even more valuable and plays new roles. It represents more enterprise capabilities. For example, the data lake can centralize data management, helping enterprises build more optimized operation models. It also provides other enterprise capabilities such as prediction analysis and recommendation models. These models can stimulate further growth.

Just like any other warehouse and lake, one stores goods, or data, from one source while the other stores water, or data, from many sources.

Table 2-3 Comparison between data lakes and data warehouses

Dimension	Data Lake	Data Warehouse
Use cases	Exploratory analytics (machine learning, data discovery, profiling, prediction)	Data analytics (based on historical structured data)
Cost	Low upfront cost, higher cost later	High upfront cost, lower cost later
Data quality	Massive amounts of raw data to be cleaned and normalized before use	High-quality data that can be used to support decision-making
Target user	Mostly data scientists and data developers	Mostly business analysts

Lakehouse

Although the application scenarios and architectures of a data warehouse and a data lake are different, they can cooperate to resolve problems. A data warehouse stores structured data and is ideal for quick BI and decision-making support, while a data lake stores data in any format and can generate larger value by mining data. Therefore, their convergence can bring more benefits to enterprises in some scenarios.

A lakehouse, the convergence of a data warehouse and a data lake, aims to enable data mobility and streamline construction. The key of the lakehouse architecture is to enable the free flow of data/metadata between the data warehouse and the data lake. The explicit-value data in the lake can flow to or even be directly used by the warehouse. The implicit-value data in the warehouse can also flow to the lake for long-term storage at a low cost and for future data mining.

Intelligent Data Solution

DataArts Studio is a data enablement platform that helps large government agencies and companies customize intelligent data resource management solutions. This solution can import all-domain data into the data lake, eliminating

data silos, unleashing the value of data, and empowering data-driven digital transformation.

DataArts Studio features the FusionInsight intelligent data lake as its core. Around it are computing engines such as the database, data warehouse, data lake, and data platform. It provides comprehensive data enablement, covering data collection, aggregation, computing, asset management, and data openness.

Lake, warehouse, and database engines enable agile data lake construction, fast migration of GaussDB databases, and real-time analysis of the data warehouse. For more information, go to:

- Database
  - Relational databases: **Relational Database Service**, **TaurusDB**, **GaussDB**, **RDS for PostgreSQL**, and more.
  - Non-relational databases: **Document Database Service (DDS)** and **RDS for GeminiDB**
- Data warehouse: **GaussDB(DWS)**
- Data lake/lakehouse: **MRS** and **DLI**
- Data governance center: **DataArts Studio**

2.9 How Are Dirty Pages Generated in GaussDB(DWS)?

Causes

GaussDB(DWS) employs the multi-version concurrency control (MVCC) mechanism to guarantee consistency and concurrency when multiple transactions access the database. Its advantages include unblocked read-write operations, while its disadvantages include disk bloating issues. The MVCC mechanism is the primary cause of dirty pages.

The scenarios are as follows:

- When the DELETE operation is performed on a table, data is logically deleted but not physically deleted from the disk.
- When an UPDATE operation is performed on a table, GaussDB(DWS) logically marks the original data to be updated for deletion while inserting new data.

For the DELETE and UPDATE operations in a table, the data marked as deleted is called discarded tuples. The proportion of discarded tuples in the entire table is the dirty page rate. Therefore, when the dirty page rate of a table is high, the proportion of data marked as deleted in the table is high.

Solution:

With GaussDB(DWS), you can easily query the dirty page rate through a system view. For details, see **PGXC_STAT_TABLE_DIRTY**.

GaussDB(DWS) offers the **VACUUM** function to address disk space bloat resulting from high dirty page rates. This function clears data marked for deletion. For details, see **VACUUM**.

VACUUM does not release the allocated space. To completely reclaim the cleared space, run **VACUUM FULL**.

NOTE

- **VACUUM FULL** clears and releases the space of deleted data, improving database performance and efficiency. However, running **VACUUM FULL** consumes more time and resources, and may cause some tables to be locked. Therefore, run **VACUUM FULL** only when the database load is light.
- To reduce the impact of disk bloat on database performance, you are advised to do **VACUUM FULL** on non-system catalogs whose dirty page rate exceeds 80%. You can determine whether to do **VACUUM FULL** based on service scenarios.

2.10 How Do I Use VPC Sharing to Process GaussDB(DWS) Resources?

Context

With VPC sharing, multiple accounts can create cloud resources such as GaussDB(DWS) clusters, ELBs, and ECSs within a single, centrally managed VPC. It empowers the VPC owner to distribute access to subnets within the VPC across various accounts. Through VPC sharing, you can easily configure and manage multiple accounts' resources at low costs. For more information, see **VPC Sharing**.

Constraints and Limitations

- The subnets of the owner and those of the principals are in the same VPC, so resources in these subnets can communicate with each other by default. The owner and principals can create resources in a shared subnet. If the resources are associated with different security groups, they are isolated from each other. If you want the resources to communicate with each other, you need to add security group rules. For details, see **Adding a Security Group Rule**.

  For example, to allow mutual access between accounts A and B's GaussDB(DWS) security groups, add inbound rules to each group with the other group specified as the source.
- A principal can receive a maximum of 100 subnet shares.
- A subnet can be shared with a maximum of 100 principals.

Operation Permissions of the Owner and Principles in a Shared VPC

The owner and principals of a shared subnet have different operation permissions on the subnet and associated resources. For details, see **Table 2-4**.

Table 2-4 Operation Permissions of the owner and principles in a shared VPC

Role	When a Share Is Accepted	When a Share Is Stopped	When the Principals Leave a Share
Owner	• The owner cannot modify or delete resources created by principals, such as GaussDB(DWS) clusters, ECSs, and ELBs. • The owner can view information such as the IP address and ID of the resource created by principals on the **IP Addresses** tab of the shared subnet.	• The owner can use, delete, and manage all resources in the VPC. • If principals have resources in the subnet, the owner cannot delete the shared subnet or the VPC where the shared subnet belongs after the share is stopped.	• The owner can use, delete, and manage all resources in the VPC. • If principals have resources in the subnet, the owner cannot delete the shared subnet or the VPC where the shared subnet belongs after the principals leave the share.
Principal	• Principals can create resources, such as ECSs, load balancers, and RDS instances, in the shared VPC. • Principals can view information such as the IP address and ID of the resource created by themselves on the **IP Addresses** tab of the shared subnet.	Principals can use the existing resources created by themselves, but cannot create resources in the shared subnet.	Principals can use the existing resources created by themselves, but cannot create resources in the shared subnet.

Using GaussDB(DWS) Resources in a Shared VPC

1. Share a subnet on the **RAM console** or **VPC console**. For details, see **Table 2-5**.
2. When creating a GaussDB(DWS) cluster, select shared VPC resources on the **Configure Network** > **VPC** page after the share is created.

Table 2-5 Process for sharing a subnet

Method	Description	Operation
Method A	1. On the RAM console, the owner creates a resource share. a. Select a subnet to be shared. b. Select permissions to grant to principals on the shared subnet. c. Specify principals that can use the shared subnet. 2. On the RAM console, principals accept or reject the resource share. • If principals accept the resource share, they can use the shared subnet. If principals do not want to use the shared subnet, they can leave the resource share. • If principals reject the resource share, they cannot use the subnet.	1. "Creating a Share" 2. **Responding to a Resource Sharing Invitation** **Leaving a Resource Share**
Method B	1. On the RAM console, the owner creates a resource share. a. Select a subnet to be shared. b. Select permissions to grant to principals on the shared subnet. c. Specify principals that can use the shared subnet. 2. On the VPC console, the owner shares a subnet and adds it to the resource share created in **1**. 3. On the RAM console, principals accept or reject the resource share. • If principals accept the resource share, they can use the shared subnet. If principals do not want to use the shared subnet, they can leave the resource share. • If principals reject the resource share, they cannot use the subnet.	1. "Creating a Share" 2. **Sharing a Subnet with Other Accounts** 3. **Responding to a Resource Sharing Invitation** **Leaving a Resource Share**

3 Database Connections

3.1 How Applications Communicate with GaussDB(DWS)?

For applications to communicate with GaussDB(DWS), make sure the networks between them are connected. The following table lists common connection scenarios.

Table 3-1 Communication between applications and GaussDB(DWS)

Scenario		Description	Supported Connection Type
Cloud	**Service Application and GaussDB(DWS) Are in the Same VPC in the Same Region**	Two private IP addresses in the same VPC can directly communicate with each other.	• gsql • Data Studio • JDBC/ODBC For more connection modes, see **Methods of Connecting to a Cluster**.
	Service Applications and GaussDB(DWS) Are in Different VPCs in the Same Region	After a **VPC peering** connection is created between two VPCs, the two private IP addresses can directly communicate with each other.	
	Service Applications and GaussDB(DWS) Are in Different Regions	After a **cloud connection** (CC) is established between two regions, the two regions communicate with each other through private IP addresses.	

Scenario		Description	Supported Connection Type
On-premises and on-cloud	Service applications are deployed in on-premise data centers and need to communicate with GaussDB(DWS).	• Use the **public IP address/public domain name** of GaussDB(DWS) for communication. • Use **Direct Connect** (DC) is for communication.	

Service Application and GaussDB(DWS) Are in the Same VPC in the Same Region

To ensure low service latency, you are advised to deploy service applications and GaussDB(DWS) in the same region. For example, if a service application is deployed on an ECS, you are advised to deploy the data warehouse cluster in the same VPC as the ECS. In this way, the application can directly communicate with GaussDB(DWS) through an intranet IP address. In this case, deploy the data warehouse cluster in the same region and VPC where the ECS resides.

For example, if the ECS is deployed in **CN-Hong Kong**, select **CN-Hong Kong** for the GaussDB(DWS) cluster and ensure that the GaussDB(DWS) cluster and the ECS are both in **VPC1**. The private IP address of the ECS is **192.168.120.1**, the private IP address of GaussDB(DWS) is **192.168.120.2**. Therefore, they can communicate with each other through private IP addresses.

The key points in communication check are the ECS outbound rule and GaussDB(DWS) inbound rule. The check procedure is as follows:

Step 1 Check the ECS outbound rules:

Ensure that the outbound rule of the ECS security group allows access. If access is not allowed, see **Configuring Security Group Rules**.

Action	Protocol & Port	Type	Destination
Allow	All	IPv4	0.0.0.0/0

Step 2 Check the GaussDB(DWS) inbound rules:

If no security group is configured when GaussDB(DWS) is created, the default inbound rule allows TCP access from all IPv4 addresses and port 8000. To ensure security, you can also allow only one IP address. For details, see **How Do I Configure a Whitelist to Protect Clusters Available Through a Public IP Address?**

Allow	TCP : 8000	IPv4	0.0.0.0/0

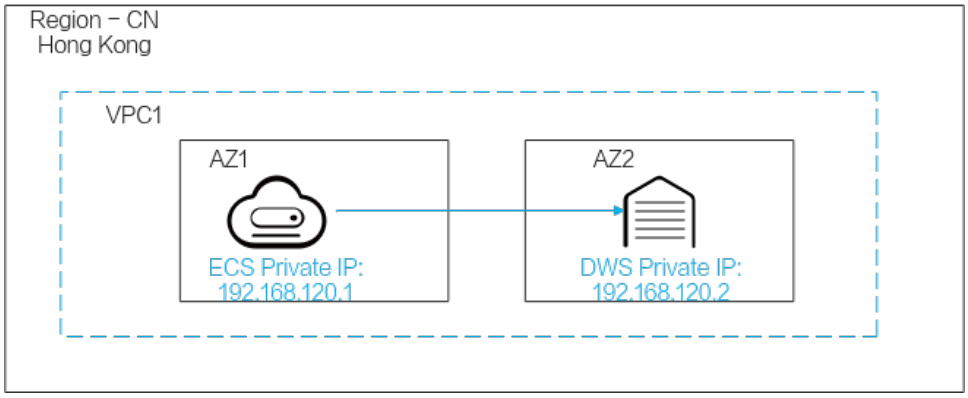
Step 3 Log in to the ECS. If the internal IP address of GaussDB(DWS) can be pinged, the network connection is normal. If the IP address cannot be pinged, check the preceding configuration. If the ECS has a firewall, check the firewall configuration.

----End

Example of using gsql for connection:

gsql -d gaussdb -h *192.168.120.2* **-p 8000 -U dbadmin -W** *password* **-r**

Figure 3-1 Access via Private IP addresses



Service Applications and GaussDB(DWS) Are in Different VPCs in the Same Region

To ensure low service latency, you are advised to deploy service applications and GaussDB(DWS) in the same region. For example, if service applications are deployed on an ECS, you are advised to deploy the data warehouse cluster in the same VPC as the ECS. If a different VPC is selected for the data warehouse cluster, the ECS cannot directly connect to GaussDB(DWS).

For example, both ECS and GaussDB(DWS) are deployed in **CN-Hong Kong**, but ECS is in VPC 1 and GaussDB(DWS) is in VPC 2. In this case, you need to create a **VPC peering connection** between VPC 1 and VPC 2 so that ECS can access GaussDB(DWS) using the private IP address of GaussDB(DWS).

The key points for checking the communication are the ECS outbound rules, GaussDB(DWS) inbound rules, and VPC peering connection. The check procedure is as follows:

Step 1 **Check the ECS outbound rules:**

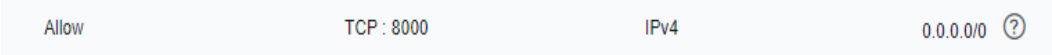
Ensure that the outbound rule of the ECS security group allows access. If access is not allowed, see **Configuring Security Group Rules**.

Action	Protocol & Port	Type	Destination
Allow	All	IPv4	0.0.0.0/0

Step 2 **Check the GaussDB(DWS) inbound rules:**

If no security group is configured when GaussDB(DWS) is created, the default inbound rule allows TCP access from all IPv4 addresses and port 8000. To ensure

security, you can also allow only one IP address. For details, see **How Do I Configure a Whitelist to Protect Clusters Available Through a Public IP Address?**



Step 3 Create a **VPC peering connection** between VPC 1 where the ECS is and VPC 2 where GaussDB(DWS) is.

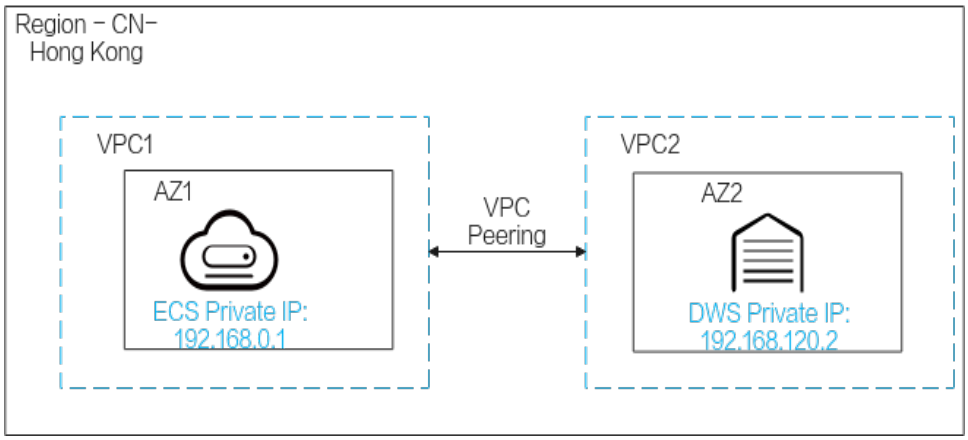
Step 4 Log in to the ECS. If the internal IP address of GaussDB(DWS) can be pinged, the network connection is normal. If the IP address cannot be pinged, check the preceding configuration. If the ECS has a firewall, check the firewall configuration.

----End

Example of using gsql for connection:

gsql -d gaussdb -h *192.168.120.2* **-p 8000 -U dbadmin -W** *password* **-r**

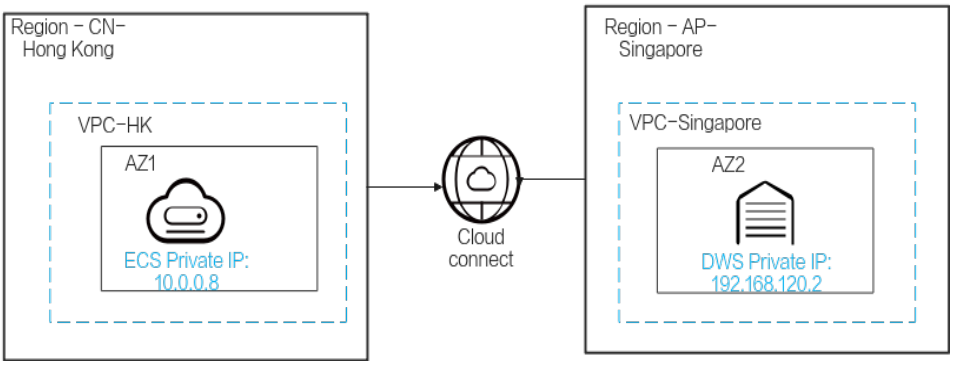
Figure 3-2 Access via VPC peering



Service Applications and GaussDB(DWS) Are in Different Regions

If the service application and GaussDB(DWS) are in different regions, for example, ECS is in **CN-Hong Kong** and GaussDB(DWS) is in **AP-Singapore**, you need to establish a **Cloud Connect** between the two regions for communication.

Figure 3-3 Access via cloud connect



Service applications are deployed in on-premise data centers and need to communicate with GaussDB(DWS).

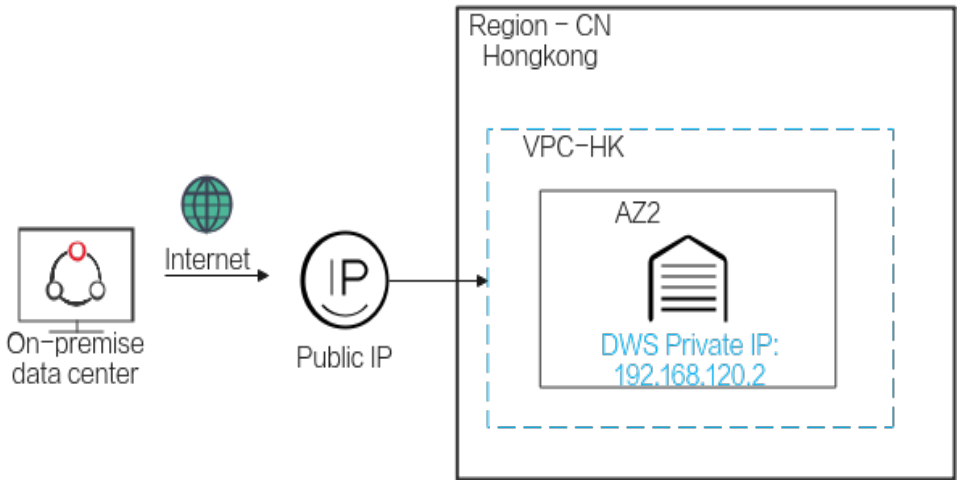
If service applications are not on the cloud but in the local data center, they need to communicate with GaussDB(DWS) on the cloud.

- **Scenario 1**: On-premises service applications communicate with GaussDB(DWS) through GaussDB(DWS) public IP addresses.

  Example of using gsql for connection:

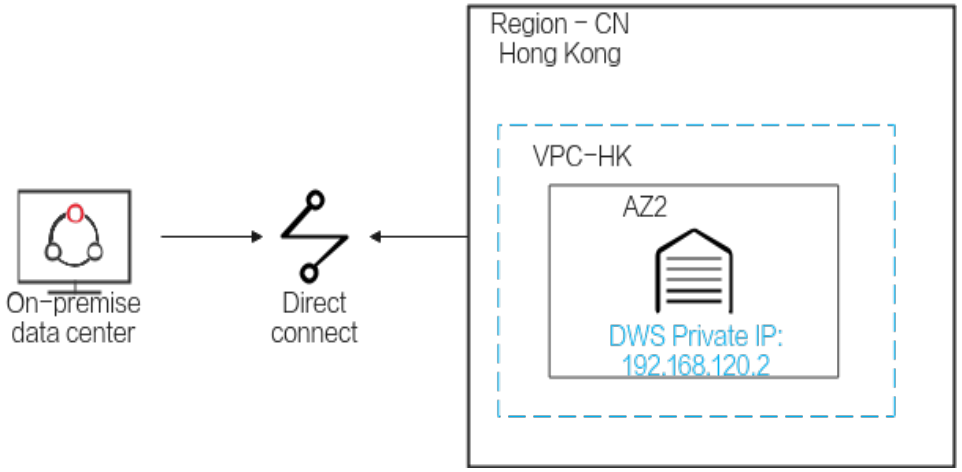
  gsql -d gaussdb -h *public_IP_address* **-p 8000 -U dbadmin -W** *password* **-r**

  Figure 3-4 Access via public IP addresses



- **Scenario 2**: On-premises services cannot access the external network. In this case, use **Direct Connect**.

  Figure 3-5 Access via direct connect



3.2 Does GaussDB(DWS) Support Third-Party Clients and JDBC and ODBC Drivers?

Yes, but GaussDB(DWS) clients and drivers are recommended. Unlike open-source PostgreSQL clients and drivers, GaussDB(DWS) clients and drivers have two key advantages:

- **Security hardening**: PostgreSQL drivers only support MD5 authentication, but GaussDB(DWS) drivers support both SHA256 and MD5.
- **Data type enhancement**: GaussDB(DWS) drivers support new data types smalldatetime and tinyint.

GaussDB(DWS) supports open-source PostgreSQL clients and JDBC and ODBC drivers.

The compatible client and driver versions are:

- PostgreSQL psql 9.2.4 or later
- PostgreSQL JDBC Driver 9.3-1103 or later
- PSQL ODBC 09.01.0200 or later

For how to use JDBC/ODBC to connect to GaussDB(DWS), see **Guide: JDBC- or ODBC-Based Development**.

NOTICE

- You are advised to use the officially recommended method for connecting to the database. For details, see **Methods of Connecting to a Cluster**.
- Compatibility with other clients cannot be guaranteed, so it may be necessary to verify it.
- If an error occurs due to incompatibility with another client and the client cannot be replaced, try replacing the libpq driver on the client. Download and decompress the gsql client package, obtain the **libpg.so** file in the **gsql** directory, and replace the **libpg.so** file in the specified directory on the client. For details, see **Downloading Related Tools**.

3.3 How Do I Do If I Cannot Connect to a GaussDB(DWS) Cluster?

Possible Causes

Check the following:

- Whether the cluster status is normal.
- Whether the connection command, username, password, IP address, and port number are incorrect.

- Whether the operating system type and version of the client are correct.
- Whether the client is incorrectly installed.

If cluster connection failed on the public cloud, check for the following as well:

- The ECSs are not in the same AZ, VPC, subnet, and security group as the cluster.
- Some of the inbound and outbound rules of the security group are incorrect.

If cluster connection failed through the Internet, confirm the following:

- Whether your network is connected to the Internet.
- Whether the firewall blocked the access.
- Whether you need to access the Internet through a proxy.

Contacting Customer Service

If the fault cannot be identified, submit a service ticket to report the problem: Log in to the management console and choose Service Tickets > Create Service Ticket.

3.4 Why Was I Not Notified of Failure After Unbinding the EIP When GaussDB(DWS) Is Connected Over the Internet?

The network is disconnected when the EIP is unbound. However, the TCP layer does not detect a faulty physical connection in time due to keepalive settings. As a result, the gsql, ODBC, and JDBC clients also cannot identify the network fault in time.

The time for the client to wait for the database to return is related to the setting of the **keepalive** parameter, and may be specifically expressed as: **keepalive_time** + **keepalive_probes***__keepalive_intvl__.

Keepalive values affect network communication stability. Adjust them to service pressure and network conditions.

On Linux, run the **sysctl** command to modify the following parameters:

- net.ipv4.tcp_keepalive_time
- net.ipv4.tcp_keeaplive_probes
- net.ipv4.tcp_keepalive_intvl

For example, if you want to change the value of **net.ipv4.tcp_keepalive_time**, run the following command to change it to **120**.

sysctl net.ipv4.tcp_keepalive_time=120

On Windows, modify the following configuration information in registry **HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\Tcpip\Parameters**:

- KeepAliveTime
- KeepAliveInterval

- TcpMaxDataRetransmissions (equivalent to **tcp_keepalive_probes**)

NOTE

If you cannot find the preceding parameters in registry **HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\Tcpip\Parameters**, add these parameters. Open **Registry Editor**, right-click the blank area on the right, and choose **Create** > **DWORD (32-bit) Value** to add these parameters.

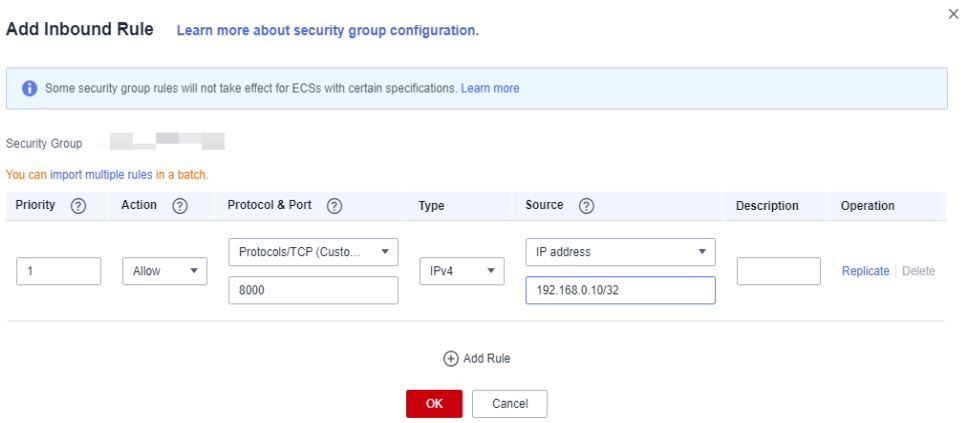
3.5 How Do I Configure a Whitelist If I Want to Connect to a GaussDB(DWS) Cluster Using EIP?

You can log in to the **VPC management console** to manually create a security group. Then, return to the GaussDB(DWS) cluster creation page, click next to the **Security Group** drop-down list to refresh the page, and select the newly created security group.

To enable the GaussDB(DWS) client to connect to the cluster, add an inbound rule to the new security group to allow access to the GaussDB(DWS) cluster's database port.

- **Protocol**: **TCP**
- **Port**: **8000** Use the database port set when creating the GaussDB(DWS) cluster. This port receives client connections to GaussDB(DWS).
- **Source**: Select **IP address** and use the host IP address of the client host, for example, **192.168.0.10/32**.

Figure 3-6 Adding an inbound rule



The whitelist will be added.

4 Data Migration

4.1 What Are the Differences Between Data Formats Supported by OBS and GDS Foreign Tables in GaussDB(DWS)?

The file formats supported by OBS and GDS foreign tables are as follows:

OBS supports ORC, text, JSON, CSV, CarbonData, and Parquet file formats for data import and ORC, CSV, Text, and Parquet file formats for data export. The default format is text.

GDS supports the following file formats: TEXT, CSV, and FIXED. The default format is TEXT.

4.2 How Is Data Stored in GaussDB(DWS)?

GaussDB(DWS) efficiently imports data from various sources through several modes. For details, see **Importing Data**.

- Importing data from the OBS

  Upload data to OBS and then export it to GaussDB(DWS) clusters. Data formats such as CSV and TEXT are supported.

- Inserting data with **INSERT** statements

  Use the gsql client tool provided by GaussDB(DWS) or the JDBC/ODBC driver to write data to GaussDB(DWS) from upper-layer applications. GaussDB(DWS) supports complete database transaction-level CRUD operations. This is the simplest method and is applicable to scenarios with small data volume and low concurrency.

- Importing data from MRS with MRS as the ETL.
- Importing data with the **COPY FROM STDIN** command

  Run the **COPY FROM STDIN** command to write data to a table.

- Importing data from a remote server to GaussDB(DWS) using GDS

Use the GDS data import function provided by GaussDB(DWS) to import data files from a common file system (for example, an ECS).

- Migrating data to GaussDB(DWS) using CDM

4.3 How Much Service Data Can Be Stored in GaussDB(DWS)?

Each node in a GaussDB(DWS) cluster has a default storage capacity of 1.49 TB, 2.98 TB, 4.47 TB, 160 GB, 1.68 TB, or 13.41 TB. A cluster can house 3 to 256 nodes and the total storage capacity of the cluster expands proportionally as the cluster scale grows.

To enhance reliability, each node has a copy, which occupies half of the storage space.

The GaussDB(DWS) system creates backups, indexes, temporary cache files, and run logs that take up storage space. Each node stores data that accounts for approximately half of the total storage capacity.

4.4 How Do I Import and Export Data in GaussDB(DWS) Using \copy?

GaussDB(DWS) is a fully managed cloud service. As a result, users cannot directly access the background to import or export data using **COPY**, which is therefore disabled. You are advised to store data files on OBS and use OBS foreign tables to import data. If you want to use **COPY** to import and export data, perform the following operations:

1. Place the data file on the client.
2. Use gsql to connect to the target cluster.
3. Run the following command to import data. Enter the directory name and file name of the data file on the client and specify the import option in **with**. The command is almost the same as the common **COPY** command. You only need to add a backslash (\) before the command. When the data is successfully imported, no notification will be displayed.
   ```
   \copy tb_name from '/directory_name/file_name' with(...);
   ```
4. Run the following command to export data to a local file. Retain the default settings of parameters.
   ```
   \copy table_name to '/directory_name/file_name';
   ```
5. Specify the **copy_option** parameter to export data to a CSV file.
   ```
   \copy table_name to '/directory_name/file_name' CSV;
   ```
6. Use **with** to specify parameters, exporting data as CSV files that use vertical bars (|) as delimiters.
   ```
   \copy table_name to '/directory_name/file_name' with(format 'csv',delimiter '|') ;
   ```


4.5 How Do I Implement Fault Tolerance Import Between Different GaussDB(DWS) Encoding Libraries

To import data from database A (UTF8) to database B (GBK), there may be a character set mismatch error which causes the data import to fail.

To import a small amount of data, run the **\COPY** command. The procedure is as follows:

Step 1 Create databases A and B. The encoding format of database A is UTF8, and that of database B is GBK.

```
postgres=> CREATE DATABASE A ENCODING 'UTF8' template = template0;
postgres=> CREATE DATABASE B ENCODING 'GBK' template = template0;
```

Step 2 View the database list. You can view the created databases A and B.

```
postgres=> \l
                              List of databases
   Name    |  Owner  | Encoding  | Collate | Ctype | Access privileges
-----------+---------+-----------+---------+-------+-------------------
 a         | dbadmin | UTF8      | C       | C     |
 b         | dbadmin | GBK       | C       | C     |
 gaussdb   | Ruby    | SQL_ASCII | C       | C     |
 postgres  | 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
 xiaodi    | dbadmin | UTF8      | C       | C     |
(7 rows)
```

Step 3 Switch to database A and enter the user password. Create a table named **test01** and insert data into the table.

```
postgres=> \c a
Password for user dbadmin:
SSL connection (protocol: TLSv1.3, cipher: TLS_AES_128_GCM_SHA256, bits: 128)
You are now connected to database "a" as user "dbadmin".

a=> CREATE TABLE test01
 (
    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);
CREATE TABLE
a=> INSERT INTO test01(c_customer_sk, c_customer_id, c_first_name) VALUES (3769, 'hello', 'Grace');
INSERT 0 1
a=> INSERT INTO test01 VALUES (456, 'good');
INSERT 0 1
```

Step 4 Run the **\COPY** command to export data from the UTF8 library in Unicode format to the **test01.dat** file.

```
\copy test01 to '/opt/test01.dat' with (ENCODING 'Unicode');
```

Step 5 Switch to database B and create a table with the same name **test01**.

```
a=> \c b
Password for user dbadmin:
SSL connection (protocol: TLSv1.3, cipher: TLS_AES_128_GCM_SHA256, bits: 128)
You are now connected to database "b" as user "dbadmin".
```



```
b=> CREATE TABLE test01
 (
    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);
```

Step 6 Run the **\COPY** command to import the **test01.dat** file to database B.

```
\copy test01 from '/opt/test01.dat' with (ENCODING 'Unicode' ,COMPATIBLE_ILLEGAL_CHARS 'true');
```

NOTE

- The error tolerance parameter **COMPATIBLE_ILLEGAL_CHARS** specifies that invalid characters are tolerated during data import. Invalid characters are converted and then imported to the database. No error message is displayed. The import is not interrupted.
- The BINARY format is not supported. When data of such format is imported, error "cannot specify bulkload compatibility options in BINARY mode" will occur.
- The parameter is valid only for data importing using the **COPY FROM** option.

Step 7 View data in the **test01** table in database B.

```
b=> select * from test01;
 c_customer_sk | c_customer_id | c_first_name | c_last_name
---------------+---------------+--------------+-------------
          3769 | hello         | Grace        |
           456 | good          |              |
(2 rows)
```

Step 8 After the preceding operations are performed, data is imported from database A (UTF8) to database B (GBK).

----End

4.6 Which Factors Are Related to GaussDB(DWS) Import Performance?

The GaussDB(DWS) import performance is affected by the following factors:

1. Cluster specifications: disk I/O, network throughput, memory, and CPU specifications
2. Service planning: type of table fields, compress, and row-store or column-store
3. Data storage: local cluster, OBS
4. Data import mode

5 Database Use

5.1 How Do I Adjust GaussDB(DWS) Distribution Columns?

In a data warehouse database, you need to carefully choose distribution columns for large tables, because they can affect your database and query performance. If an improper distribution key is used, data skew may occur after data is imported. As a result, the usage of some disks will be much higher than that of other disks, and the cluster may even become read-only. If the hash distribution policy is used and data skew occurs, the I/O performance of some DNs will be poor, affecting the overall query performance. Proper selection and adjustment of distribution columns are critical to table query performance.

If the hash distribution policy is used, you need to check tables to ensure their data is evenly distributed on each DN. Generally, over 5% difference between the amount of data on different DNs is regarded as data skew. If the difference is over 10%, you have to choose another distribution column.

For tables that are not evenly distributed, adjust their distribution columns to reduce data skew and avoid database performance problems.

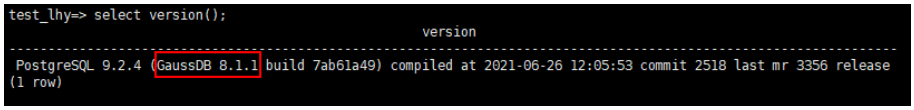
Choosing an Appropriate Distribution Column

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

- 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 card number column as the distribution key.
- Do not select the column where a constant filter exists.
- 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.
- Multiple distribution columns can be selected to evenly distribute data.

Procedure

Run the **select version();** statement to query the current database version. Required performance varies according to the version.



- **For 8.0.x and earlier versions, specify the distribution column when rebuilding a table.**

Step 1 Use Data Studio or gsql in Linux to access the database.

Step 2 Create a table.

NOTE

In the following statements, **table1** is the original table name and **table1_new** is the new table name. **column1** and **column2** are distribution column names.

```
CREATE TABLE IF NOT EXISTS table1_new
( LIKE table1 INCLUDING ALL EXCLUDING DISTRIBUTION)
DISTRIBUTE BY
HASH (column1, column2);
```

Step 3 Migrate data to the new table.

```
START TRANSACTION;
LOCK TABLE table1 IN ACCESS EXCLUSIVE MODE;
INSERT INTO table1_new SELECT * FROM table1;
COMMIT;
```

Step 4 Verify that the table data has been migrated. Delete the original table.

```
SELECT COUNT(*) FROM table1_new;
DROP TABLE table1;
```

Step 5 Replace the original table.

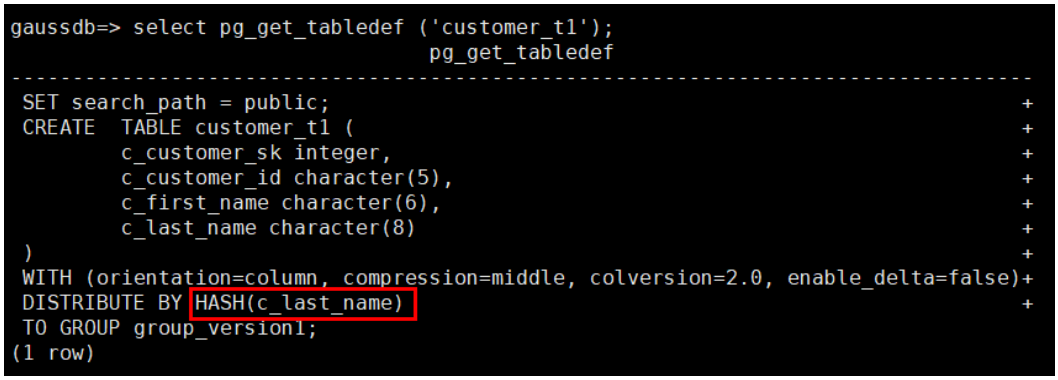
```
ALTER TABLE table1_new RENAME TO table1;
```

----End

- In version 8.1.0 or later, you can use the **ALTER TABLE** syntax. For example:

Step 1 Query the table definition. The command output shows that the distribution column of the table is **c_last_name**.

```
SELECT pg_get_tabledef('customer_t1');
```



Step 2 Check the error reported when data in the distribution column is updated.

```
UPDATE customer_t1 SET c_last_name = 'Jimy' WHERE c_customer_sk = 6885;
```



```
gaussdb=> update customer_t1 set c_last_name = 'Jimy' where c_customer_sk = 6885;
ERROR:  Distributed key column can't be updated in current version
```

Step 3 Change the distribution column of the table to a column that cannot be updated, for example, **c_customer_sk**.

```
ALTER TABLE customer_t1 DISTRIBUTE BY hash (c_customer_sk);
```

```
gaussdb=> alter table customer_t1 DISTRIBUTE BY hash (c_customer_sk);
ALTER TABLE
```

Step 4 Update the data in the old distribution column.

```
UPDATE customer_t1 SET c_last_name = 'Jimy' WHERE c_customer_sk = 6885;
```

```
gaussdb=> update customer_t1 set c_last_name = 'Jimy' where c_customer_sk = 6885;
UPDATE 1
```

----End

5.2 How Do I View and Set the Character Set Encoding Format of a GaussDB(DWS) Database?

Viewing the Database Character Encoding

Use the **server_encoding** parameter to check the character set encoding of the current database. For example, the character encoding of database **music** is UTF8.

```
music=> SHOW server_encoding;
 server_encoding
-----------------
 UTF8
(1 row)
```

Setting the Database Character Encoding

NOTE

GaussDB(DWS) does not support the modification of the character encoding format of a created database.

If you need to specify the character encoding format of a database, use **template0** and the **CREATE DATABASE** syntax to create a database. To make your database compatible with most characters, you are advised to use the UTF8 encoding when creating a database.

CREATE DATABASE syntax

```
CREATE DATABASE database_name
   [ [ WITH ] { [ OWNER [=] user_name ] |
            [ TEMPLATE [=] template ] |
            [ ENCODING [=] encoding ] |
            [ LC_COLLATE [=] lc_collate ] |
            [ LC_CTYPE [=] lc_ctype ] |
            [ DBCOMPATIBILITY [=] compatibility_type ] |
            [ CONNECTION LIMIT [=] connlimit ]}[...] ];
```

- **TEMPLATE [=] template**

Indicates the template name, that is, the name of the template to be used to create the database. GaussDB(DWS) creates a database by copying data from a database template. GaussDB(DWS) initially has two database templates: **template0** and **template1**, as well as a default user database **gaussdb**.

Value range: an existing database name. If this is not specified, the system copies **template1** by default. Its value cannot be **gaussdb**.

NOTICE

Currently, database templates cannot contain sequences. If sequences exist in the template library, database creation will fail.

- **ENCODING [=] encoding**

  Character encoding used by the database. The value can be a character string (for example, **SQL_ASCII'**) or an integer number.

  By default, the encoding format of the template database is used. The encoding of template databases **template0** and **template1** depends on the OS by default. The character encoding of **template1** cannot be changed. To change the encoding, use **template0** to create a database.

  Value range: **GBK**, **UTF8**, and **Latin1**

  NOTICE

  The character set encoding of the new database must be compatible with the local settings (**LC_COLLATE** and **LC_CTYPE**).

Examples

Create database **music** using UTF8 (the local encoding type is also UTF8).

```
CREATE DATABASE music ENCODING 'UTF8' template = template0;
```

5.3 How Do I Do If a Field of the Date Type Is Automatically Converted to a Timestamp Type During Table Creation in GaussDB(DWS)?

When creating a database, you can set the **DBCOMPATIBILITY** parameter to the compatible database type. The value of **DBCOMPATIBILITY** can be **ORA**, **TD**, and **MySQL**, indicating Oracle, Teradata, and MySQL databases, respectively. If this parameter is not specified during database creation, the default value **ORA** is used. In ORA compatibility mode, the date type is automatically converted to timestamp(0). The date type is only supported in the MySQL compatibility mode.

To solve the problem, you need to change the compatibility mode to MySQL. GaussDB(DWS) does not allow you to modify the compatibility mode of an existing database. You can only specify the compatibility mode when creating a database. GaussDB(DWS) supports the MySQL compatibility mode in clusters version 8.1.1 or later. To configure this mode, run the following commands:


```
gaussdb=> CREATE DATABASE mydatabase DBCOMPATIBILITY='mysql';
CREATE DATABASE
gaussdb=> \c mydatabase
Non-SSL connection (SSL connection is recommended when requiring high-security)
You are now connected to database "mydatabase" as user "dbadmin".
mydatabase=> create table t1(c1 int, c2 date);
NOTICE: The 'DISTRIBUTE BY' clause is not specified. Using round-robin as the distribution mode by default.
HINT: Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
CREATE TABLE
```

If the problem cannot be solved by changing the compatibility, you can try to change the column type. For example, insert data of the date type as strings into a table. Example:

```
gaussdb=> CREATE TABLE mytable (a date,b int);
CREATE TABLE
gaussdb=> INSERT INTO mytable VALUES(date '12-08-2023',01);
INSERT 0 1
gaussdb=> SELECT * FROM mytable;
         a          | b
--------------------+---
 2023-12-08 00:00:00 | 1
(1 row)
gaussdb=> ALTER TABLE mytable MODIFY a VARCHAR(20);
ALTER TABLE
gaussdb=> INSERT INTO mytable VALUES('2023-12-10',02);
INSERT 0 1
gaussdb=> SELECT * FROM mytable;
         a          | b
--------------------+---
 2023-12-08 00:00:00 | 1
 2023-12-10          | 2
(2 rows)
```

5.4 Do I Need to Run VACUUM FULL and ANALYZE on Common Tables Periodically in GaussDB(DWS)?

Yes.

For tables that are frequently added, deleted, or modified, you need to periodically perform **VACUUM FULL** and **ANALYZE** to reclaim the disk space occupied by updated or deleted data, preventing performance deterioration caused by data bloat and inaccurate statistics.

- Generally, you are advised to perform **ANALYZE** after a large number of **adding or modification** operations are performed on a table.
- After a table is deleted, you are advised to run **VACUUM** rather than **VACUUM FULL**. However, you can run **VACUUM FULL** in some particular cases, such as when you want to physically narrow a table to decrease the occupied disk space after deleting most rows of the table. For details about the differences between **VACUUM** and **VACUUM FULL**, see **VACUUM and VACUUM FULL**.

Syntax

Perform **ANALYZE** on a table.

```
ANALYZE table_name;
```

Perform **ANALYZE** on all tables (non-foreign tables) in the database.


```
ANALYZE;
```

Perform **VACUUM** on a table.

```
VACUUM table_name;
```

Perform **VACUUM FULL** on a table.

```
VACUUM FULL table_name;
```

For more syntaxes, see **VACUUM** and **ANALYZE | ANALYSE**.

NOTE

- If the physical space usage does not decrease after you run the **VACUUM FULL** command, check whether there were other active transactions (started before you delete data transactions and not ended before you run **VACUUM FULL**). If yes, run this command again when the transactions have finished.
- In version 8.1.3 or later, **VACUUM**/**VACUUM FULL** can be invoked on the management plane. For details, see **Intelligent O&M**.

VACUUM and VACUUM FULL

In GaussDB(DWS), **VACUUM** is essentially a vacuum cleaner used to absorb dust. Here, "dust" means old data. If the data is not cleared in a timely manner, more database space will be used to store such data, causing performance downgrade or even a system breakdown.

Purposes of VACUUM:

- Solve space bloat: Clear obsolete tuples and corresponding indexes, which include the tuple (and index) of a committed **DELETE** transaction, the old version (and index) of an **UPDATE** transaction, the inserted tuple (and index) of a rolled back **INSERT** transaction, the new version (and index) of an **UPDATE** transaction, and the tuple (and index) of a **COPY** transaction.
- VACUUM FREEZE: Prevents system breakdown caused by transaction ID wraparound. It converts transaction IDs smaller than OldestXmin to freeze xids, update relfrozenxids in a table, and update relfrozenxids and truncate clogs in a database.
- Update statistics: **VACUUM ANALYZE** updates statistics, enabling the optimizer to select a better way to execute SQL statements.

The VACUUM statement includes **VACUUM** and **VACUUM FULL**. Currently, **VACUUM** can only work on row-store tables. **VACUUM FULL** can be used to release space of column-store tables. For details, see the following table.

Table 5-1 VACUUM and VACUUM FULL

Item	VACUUM	VACUUM FULL
Clearing space	If the deleted record is at the end of a table, the space occupied by the deleted record is physically released and returned to the operating system. If the data is not at the end of a table, the space occupied by dead tuples in the table or index is set to be available for reuse.	Despite the position of the deleted data, the space occupied by the data is physically released and returned to the operating system. When data is inserted, a new disk page is allocated.
Lock type	Shared lock. The **VACUUM** operation can be performed in parallel with other operations.	Exclusive lock. All operations based on the table are suspended during execution.
Physical space	Not released	Released
Transaction ID	Not reclaimed	Reclaimed
Execution overhead	The overhead is low and the operation can be executed periodically.	The overhead is high. You are advised to perform it when the disk page space occupied by the database is close to the threshold and the data operations are few.
Effect	It improves the efficiency of operations on the table.	It greatly improves the efficiency of operations on the table.

5.5 How Do I Export a GaussDB(DWS) Table Schema?

Using SQL Editor

You are advised to use SQL Editor to export table data. Log in to a data source, select the corresponding database and schema, enter the SQL statement for querying table data, and click **Export**. The following export methods are supported:

- Local export: Export all SQL query results to an XLSX or CSV file. You can open the file on your local PC. A maximum of 20,000 records can be exported.
- Full export: Export all query SQL results to a specified path in an OBS bucket. By default, the results are exported to a CSV file.

For details, see **Exporting Data**.

Using gs_dump and gs_dumpall

Alternatively, you can use **gs_dump** and **gs_dumpall** to export data.

- Exporting a single database:
  - Database-level export
  - Schema-level export
  - Table-level export
- Exporting all databases:
  - Database-level export
  - global object export of each database

For details, see **gs_dump** and **gs_dumpall**.

5.6 How Do I Delete Table Data Efficiently in GaussDB(DWS)?

Yes. **TRUNCATE** is more efficient than **DELETE** for deleting massive data.

For details, see **TRUNCATE**.

Function

TRUNCATE quickly removes all rows from a table. It has the same effect as an unqualified DELETE but since it does not actually scan the table it is faster. This is most effective on large tables.

Functions

- **TRUNCATE TABLE** works like a **DELETE** statement with no **WHERE** clause, that is, emptying a table.
- **TRUNCATE TABLE** uses less system and transaction log resources.
  - **DELETE** deletes a row each time, and records each deletion in the transaction log.
  - **TRUNCATE TABLE** deletes all rows in a table by releasing the data page, and only records each releasing of the data page in the transaction log.
- **TRUNCATE**, **DELETE**, and **DROP** are different in that:
  - **TRUNCATE TABLE** deletes content, releases space, but does not delete definitions.
  - **DELETE TABLE** deletes content, but does not delete definitions or release space.
  - **DROP TABLE** deletes content and definitions, and releases space.

Examples

- Create a table.

```
CREATE TABLE tpcds.reason_t1 AS TABLE tpcds.reason;
```

  Truncate the table.

```
TRUNCATE TABLE tpcds.reason_t1;
```

  Delete the table.

```
DROP TABLE tpcds.reason_t1;
```


- Create a partitioned table.

```
CREATE TABLE tpcds.reason_p
(
  r_reason_sk integer,
  r_reason_id character(16),
  r_reason_desc character(100)
)PARTITION BY RANGE (r_reason_sk)
(
  partition p_05_before values less than (05),
  partition p_15 values less than (15),
  partition p_25 values less than (25),
  partition p_35 values less than (35),
  partition p_45_after values less than (MAXVALUE)
);
```

Insert data.

```
INSERT INTO tpcds.reason_p SELECT * FROM tpcds.reason;
```

Truncate the **p_05_before** partition.

```
ALTER TABLE tpcds.reason_p TRUNCATE PARTITION p_05_before;
```

Truncate the partition **p_15** where 13 is located.

```
ALTER TABLE tpcds.reason_p TRUNCATE PARTITION for (13);
```

Truncate the partitioned table.

```
TRUNCATE TABLE tpcds.reason_p;
```

Delete the table.

```
DROP TABLE tpcds.reason_p;
```

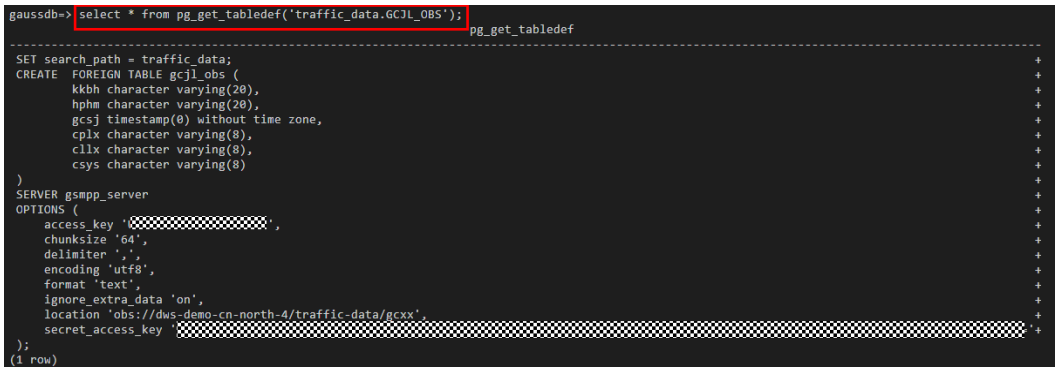
5.7 How Do I View GaussDB(DWS) Foreign Table Information?

To query information about OBS/GDS foreign tables such as OBS paths, run the following statement:

```
SELECT * FROM pg_get_tabledef ('foreign_table_name')
```

The following uses table **traffic_data.GCJL_OBS** as an example:

```
SELECT * FROM pg_get_tabledef('traffic_data.GCJL_OBS');
```



5.8 How Will Data Be Stored in a GaussDB(DWS) Table If No Distribution Column Is Specified During Its Creation?

> **NOTE**
>
> For clusters of 8.1.2 or later, you can use the GUC parameter **default_distribution_mode** to query and set the default table distribution mode.

If no distribution column is specified during table creation, data is stored as follows:

- Scenario 1

  If the primary key or unique constraint is included during table creation, hash distribution is selected. The distribution column is the column corresponding to the primary key or unique constraint.

```
CREATE TABLE warehouse1
(
    W_WAREHOUSE_SK            INTEGER            PRIMARY KEY,
    W_WAREHOUSE_ID            CHAR(16)             NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)
);
NOTICE:  CREATE TABLE / PRIMARY KEY will create implicit index "warehouse1_pkey" for table
"warehouse1"
CREATE TABLE

SELECT getdistributekey('warehouse1');
 getdistributekey
------------------
 w_warehouse_sk
(1 row)
```

- Scenario 2

  If the primary key or unique constraint is not included during table creation but there are columns whose data types can be used as distribution columns, hash distribution is selected. The distribution column is the first column whose data type can be used as a distribution column.

```
CREATE TABLE warehouse2
(
    W_WAREHOUSE_SK            INTEGER                   ,
    W_WAREHOUSE_ID            CHAR(16)             NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)
);
NOTICE:  The 'DISTRIBUTE BY' clause is not specified. Using 'w_warehouse_sk' as the distribution
column by default.
HINT:  Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
CREATE TABLE

SELECT getdistributekey('warehouse2');
 getdistributekey
------------------
 w_warehouse_sk
(1 row)
```

- Scenario 3

  If the primary key or unique constraint is not included during table creation and no column whose data type can be used as a distribution column exists, round-robin distribution is selected.


```
CREATE TABLE warehouse3
(
    W_WAREHOUSE_ID            CHAR(16)              NOT NULL,
    W_WAREHOUSE_NAME          VARCHAR(20)
);
NOTICE:  The 'DISTRIBUTE BY' clause is not specified. Using 'w_warehouse_id' as the distribution column by default.
HINT:  Please use 'DISTRIBUTE BY' clause to specify suitable data distribution column.
CREATE TABLE

SELECT getdistributekey('warehouse3');
 getdistributekey
------------------
 w_warehouse_id
(1 row)
```

5.9 How Do I Replace the Null Results with 0 in a GaussDB(DWS) Join Query?

When OUTER JOIN (LEFT JOIN, RIGHT JOIN, and FULL JOIN) is executed, the match failure in the outer join generates a large number of NULL values. You can replace these null values with 0.

You can use the **COALESCE** function to do that. This function returns the first non-null parameter value in the parameter list. For example:

```
SELECT coalesce(NULL,'hello');
 coalesce
----------
 hello
(1 row)
```

Use left join to join the tables **course1** and **course2**.

```
SELECT * FROM course1;
  stu_id  |  stu_name  |     cour_name
----------+------------+--------------------
 20110103 | ALLEN      | Math
 20110102 | JACK       | Programming Design
 20110101 | MAX        | Science
(3 rows)

SELECT * FROM course2;
 cour_id |     cour_name      | teacher_name
---------+--------------------+--------------
    1002 | Programming Design | Mark
    1001 | Science            | Anne
(2 rows)

SELECT course1.stu_name,course2.cour_id,course2.cour_name,course2.teacher_name FROM course1 LEFT JOIN course2 ON course1.cour_name = course2.cour_name ORDER BY 1;
  stu_name  | cour_id |     cour_name      | teacher_name
------------+---------+--------------------+--------------
 ALLEN      |         |                    |
 JACK       |    1002 | Programming Design | Mark
 MAX        |    1001 | Science            | Anne
(3 rows)
```

Use the **COALESCE** function to replace null values in the query result with 0 or other non-zero values:

```
SELECT course1.stu_name,
 coalesce(course2.cour_id,0) AS cour_id,
 coalesce(course2.cour_name,'NA') AS cour_name,
 coalesce(course2.teacher_name,'NA') AS teacher_name
```



```
 FROM course1
 LEFT JOIN course2 ON course1.cour_name = course2.cour_name
 ORDER BY 1;
  stu_name  | cour_id |     cour_name      | teacher_name
------------+---------+--------------------+--------------
 ALLEN      |       0 | NA                 | NA
 JACK       |    1002 | Programming Design | Mark
 MAX        |    1001 | Science            | Anne
(3 rows)
```

5.10 How Do I Check Whether a GaussDB(DWS) Table Is Row-Stored or Column-Stored?

The storage mode of a table is controlled by the ORIENTATION parameter in the table creation statement. **row** indicates row storage, and **column** indicates column storage.

If **ORIENTATION** is not specified, row storage is used by default.

You can use the table definition function **PG_GET_TABLEDEF** to check whether the created table is row-store or column-store.

For example, **orientation=column** indicates a column-store table.

Currently, you cannot run the **ALTER TABLE** statement to modify the parameter **ORIENTATION**.

```
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)
```

5.11 How Do I Query GaussDB(DWS) Column-Store Table Information?

The following SQL statements are used to query common information about column-store tables:

Create a column-store table named my_table, and insert data into the table.

```
CREATE TABLE my_table
(
    product_id INT,
    product_name VARCHAR2(40),
    product_quantity INT
 )
WITH (ORIENTATION = COLUMN)
PARTITION BY range(product_quantity)
(
partition my_table_p1 values less than(600),
partition my_table_p2 values less than(800),
```



```
partition my_table_p3 values less than(950),
partition my_table_p4 values less than(1000));

INSERT INTO my_table VALUES(1011, 'tents', 720);
INSERT INTO my_table VALUES(1012, 'hammock', 890);
INSERT INTO my_table VALUES(1013, 'compass', 210);
INSERT INTO my_table VALUES(1014, 'telescope', 490);
INSERT INTO my_table VALUES(1015, 'flashlight', 990);
INSERT INTO my_table VALUES(1016, 'ropes', 890);
```

Run the following command to view the created column-store partitioned table:

```
SELECT * FROM my_table;
 product_id | product_name | product_quantity
------------+--------------+------------------
       1013 | compass      |              210
       1014 | telescope    |              490
       1011 | tents        |              720
       1015 | flashlight   |              990
       1012 | hammock      |              890
       1016 | ropes        |              890
(6 rows)
```

Querying the Boundary of a Partition

```
SELECT relname, partstrategy, boundaries FROM pg_partition where parentid=(select parentid from
pg_partition where relname='my_table');
   relname   | partstrategy | boundaries
-------------+--------------+------------
 my_table    | r            |
 my_table_p1 | r            | {600}
 my_table_p2 | r            | {800}
 my_table_p3 | r            | {950}
 my_table_p4 | r            | {1000}
(5 rows)
```

Querying the Number of Columns in a Column-Store Table

```
SELECT count(*) FROM ALL_TAB_COLUMNS where table_name='my_table';
 count
-------
     3
(1 row)
```

Querying Data Distribution on DNs

```
SELECT table_skewness('my_table');
           table_skewness
-----------------------------------
 ("dn_6007_6008         ",3,50.000%)
 ("dn_6009_6010         ",2,33.333%)
 ("dn_6003_6004         ",1,16.667%)
 ("dn_6001_6002         ",0,0.000%)
 ("dn_6005_6006         ",0,0.000%)
 ("dn_6011_6012         ",0,0.000%)
(6 rows)
```

Querying the Names of the Cudesc and Delta Tables in Partition P1 on a DN

```
EXECUTE DIRECT ON (dn_6003_6004) 'select a.relname from pg_class a, pg_partition b where
(a.oid=b.reldeltarelid or a.oid=b.relcudescrelid) and b.relname=''my_table_p1''';
       relname
----------------------
 pg_delta_part_60317
 pg_cudesc_part_60317
(2 rows)
```


5.12 Why Is the Index Invalid During GaussDB(DWS) Query?

Creating indexes for tables can improve database query performance. However, sometimes indexes cannot be used in a query plan. This section describes several common reasons and optimization methods.

Reason 1: The Returned Result Sets Are Large.

The following uses Seq Scan and Index Scan on a row-store table as an example:

- Seq Scan: searches table records in sequence. All records are retrieved during each scan. This is the simplest and most basic table scanning method, and its cost is high.
- Index Scan: searches the index first, find the target location (pointer) in the index, and then retrieve data on the target page.

Index scan is faster than sequence scan in most cases. However, if the obtained result sets account for a large proportion (more than 70%) of all data, Index Scan needs to scan indexes before reading table data. This makes it slower table scan.

Reason 2: ANALYZE Is Not Performed In a Timely Manner.

ANALYZE is used to update table statistics. If **ANALYZE** is not executed on a table or a large amount of data is added to or deleted from a table after **ANALYZE** is executed, the statistics may be inaccurate, which may cause a query to skip the index.

Optimization method: Run the **ANALYZE** statement on the table to update statistics.

Reason 3: Filtering Conditions Contains Functions or Implicit Data Type Conversion

If calculation, function, or implicit data type conversion is contained in filter criteria, indexes may fail to be selected.

For example, when a table is created, indexes are created in columns **a**, **b**, and **c**.

```
CREATE TABLE test(a int, b text, c date);
```

- Perform calculation on the indexed columns.

  The following command output indicates that both **where a = 101** and **where a = 102 - 1** use the index in column a, but **where a + 1 = 102** does not use the index.

```
explain verbose select * from test where a  = 101;
                                      QUERY PLAN
-------------------------------------------------------------------------------------------------------
 id |                  operation                  | E-rows | E-distinct | E-memory | E-width | E-costs
----+---------------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)                |      1 |            |          |      44 | 16.27
  2 |    ->  Index Scan using index_a on public.test |      1 |            | 1MB      |      44 | 8.27

 Predicate Information (identified by plan id)
```



```
-----------------------------------------------
  2 --Index Scan using index_a on public.test
        Index Cond: (test.a = 101)

 Targetlist Information (identified by plan id)
-----------------------------------------------
  1 --Streaming (type: GATHER)
        Output: a, b, c
        Node/s: dn_6005_6006
  2 --Index Scan using index_a on public.test
        Output: a, b, c
        Distribute Key: a

  ====== Query Summary =====
-------------------------------
 System available mem: 3358720KB
 Query Max mem: 3358720KB
 Query estimated mem: 1024KB
(24 rows)
 explain verbose select * from test where a  = 102 - 1;
                                        QUERY PLAN
-----------------------------------------------------------------------------------------------------------------
 id |                  operation                   | E-rows | E-distinct | E-memory | E-width | E-costs
----+----------------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)                 |      1 |            |          |      44 | 16.27
  2 |    ->  Index Scan using index_a on public.test |      1 |            | 1MB      |      44 | 8.27

 Predicate Information (identified by plan id)
-----------------------------------------------
  2 --Index Scan using index_a on public.test
        Index Cond: (test.a = 101)

 Targetlist Information (identified by plan id)
-----------------------------------------------
  1 --Streaming (type: GATHER)
        Output: a, b, c
        Node/s: dn_6005_6006
  2 --Index Scan using index_a on public.test
        Output: a, b, c
        Distribute Key: a

  ====== Query Summary =====
-------------------------------
 System available mem: 3358720KB
 Query Max mem: 3358720KB
 Query estimated mem: 1024KB
(24 rows)
explain verbose select * from test where a + 1 = 102;
                                    QUERY PLAN
-----------------------------------------------------------------------------------------------
 id |          operation           | E-rows | E-distinct | E-memory | E-width | E-costs
----+------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER) |      1 |            |          |      44 | 22.21
  2 |    ->  Seq Scan on public.test |      1 |            | 1MB      |      44 | 14.21

 Predicate Information (identified by plan id)
-----------------------------------------------
  2 --Seq Scan on public.test
        Filter: ((test.a + 1) = 102)

 Targetlist Information (identified by plan id)
-----------------------------------------------
  1 --Streaming (type: GATHER)
        Output: a, b, c
        Node/s: All datanodes
  2 --Seq Scan on public.test
        Output: a, b, c
        Distribute Key: a
```



```
  ====== Query Summary =====
 --------------------------------
 System available mem: 3358720KB
 Query Max mem: 3358720KB
 Query estimated mem: 1024KB
(24 rows)
```

Optimization method: Use constants instead of expressions, or put constant calculation on the right of the equal sign (=).

- Use functions on indexed columns.

  According to the following execution result, if a function is used on an indexed column, the index fails to be selected.

```
explain verbose select * from test where to_char(c, 'yyyyMMdd') =
to_char(CURRENT_DATE,'yyyyMMdd');
                                                 QUERY PLAN
-------------------------------------------------------------------------------------------------------------------------------------
---------------------
 id |           operation            | E-rows | E-distinct | E-memory | E-width | E-costs
 ----+--------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)   |      1 |            |          |      44 | 22.28
  2 |    ->  Seq Scan on public.test |      1 |            | 1MB      |      44 | 14.28

                                        Predicate Information (identified by plan id)

-------------------------------------------------------------------------------------------------------------------------------------
--------------------
  2 --Seq Scan on public.test
        Filter: (to_char(test.c, 'yyyyMMdd'::text) = to_char(('2022-11-30'::pg_catalog.date)::timestamp
with time zone, 'yyyyMMdd'::text))

 Targetlist Information (identified by plan id)
 ------------------------------------------------
  1 --Streaming (type: GATHER)
        Output: a, b, c
        Node/s: All datanodes
  2 --Seq Scan on public.test
        Output: a, b, c
        Distribute Key: a

  ====== Query Summary =====
 --------------------------------
 System available mem: 3358720KB
 Query Max mem: 3358720KB
 Query estimated mem: 1024KB
(24 rows)
explain verbose select * from test where c = current_date;
                                          QUERY PLAN
-----------------------------------------------------------------------------------------------------------------
 id |                  operation                   | E-rows | E-distinct | E-memory | E-width | E-costs
 ----+----------------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)                 |      1 |            |          |      44 | 16.27
  2 |    ->  Index Scan using index_c on public.test |      1 |            | 1MB      |      44 | 8.27

       Predicate Information (identified by plan id)
 -------------------------------------------------------------
  2 --Index Scan using index_c on public.test
        Index Cond: (test.c = '2022-11-30'::pg_catalog.date)

 Targetlist Information (identified by plan id)
 ------------------------------------------------
  1 --Streaming (type: GATHER)
        Output: a, b, c
        Node/s: All datanodes
  2 --Index Scan using index_c on public.test
        Output: a, b, c
        Distribute Key: a

  ====== Query Summary =====
```



```
-------------------------------
System available mem: 3358720KB
Query Max mem: 3358720KB
Query estimated mem: 1024KB
(24 rows)
```

Optimization method: Do not use unnecessary functions on indexed columns.

- Implicit conversion of data types.

  This scenario is common. For example, the type of column **b** is Text, and the filtering condition is **where b = 2**. During plan generation, the Text type is implicitly converted to the Bigint type, and the actual filtering condition changes to **where b::bigint = 2**. As a result, the index in column **b** becomes invalid.

```
explain verbose select * from test where b = 2;
                                QUERY PLAN
-------------------------------------------------------------------------------------------
 id |          operation            | E-rows | E-distinct | E-memory | E-width | E-costs
----+-------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)  |      1 |            |          |      44 | 22.21
  2 |    ->  Seq Scan on public.test |      1 |            | 1MB      |      44 | 14.21

Predicate Information (identified by plan id)
-----------------------------------------------
  2 --Seq Scan on public.test
        Filter: ((test.b)::bigint = 2)

Targetlist Information (identified by plan id)
-----------------------------------------------
  1 --Streaming (type: GATHER)
        Output: a, b, c
        Node/s: All datanodes
  2 --Seq Scan on public.test
        Output: a, b, c
        Distribute Key: a

  ====== Query Summary =====
-------------------------------
System available mem: 3358720KB
Query Max mem: 3358720KB
Query estimated mem: 1024KB
(24 rows)
explain verbose select * from test where b = '2';
                                    QUERY PLAN
-----------------------------------------------------------------------------------------------------------
 id |                  operation                   | E-rows | E-distinct | E-memory | E-width | E-costs
----+----------------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)                 |      1 |            |          |      44 | 16.27
  2 |    ->  Index Scan using index_b on public.test |      1 |            | 1MB      |      44 | 8.27

Predicate Information (identified by plan id)
-----------------------------------------------
  2 --Index Scan using index_b on public.test
        Index Cond: (test.b = '2'::text)

Targetlist Information (identified by plan id)
-----------------------------------------------
  1 --Streaming (type: GATHER)
        Output: a, b, c
        Node/s: All datanodes
  2 --Index Scan using index_b on public.test
        Output: a, b, c
        Distribute Key: a

  ====== Query Summary =====
-------------------------------
System available mem: 3358720KB
Query Max mem: 3358720KB
```



```
 Query estimated mem: 1024KB
(24 rows)
```

Optimization method: Use constants of the same type as the indexed column to avoid implicit type conversion.

Scenario 4: Hashjoin Is Replaced with Nestloop + Indexscan.

When two tables are joined, the number of rows in the result set filtered by the WHERE condition in one table is small, thus the number of rows in the final result set is also small. In this case, the effect of nestloop+indexscan is better than that of hashjoin. The better execution plan is as follows:

You can see that the Index Cond: (t1.b = t2.b) at layer 5 has pushed the join condition down to the base table scanning.

```
explain verbose select t1.a,t1.b from t1,t2 where t1.b=t2.b and t2.a=4;
 id |                    operation                    | E-rows | E-distinct | E-memory | E-width | E-costs
----+-------------------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)                    |     26 |            |          |       8 | 17.97
  2 |    ->  Nested Loop (3,5)                        |     26 |            | 1MB      |       8 | 11.97
  3 |       ->  Streaming(type: BROADCAST)            |      2 |            | 2MB      |       4 | 2.78
  4 |          ->  Seq Scan on public.t2              |      1 |            | 1MB      |       4 | 2.62
  5 |       ->  Index Scan using t1_b_idx on public.t1 |     26 |            | 1MB      |       8 | 9.05
(5 rows)

 Predicate Information (identified by plan id)
-----------------------------------------------
   4 --Seq Scan on public.t2
         Filter: (t2.a = 4)
   5 --Index Scan using t1_b_idx on public.t1
         Index Cond: (t1.b = t2.b)
(4 rows)

 Targetlist Information (identified by plan id)
------------------------------------------------
   1 --Streaming (type: GATHER)
         Output: t1.a, t1.b
         Node/s: All datanodes
   2 --Nested Loop (3,5)
         Output: t1.a, t1.b
   3 --Streaming(type: BROADCAST)
         Output: t2.b
         Spawn on: datanode2
         Consumer Nodes: All datanodes
   4 --Seq Scan on public.t2
         Output: t2.b
         Distribute Key: t2.a
   5 --Index Scan using t1_b_idx on public.t1
         Output: t1.a, t1.b
         Distribute Key: t1.a
(15 rows)

   ====== Query Summary =====
---------------------------------
 System available mem: 9262694KB
 Query Max mem: 9471590KB
 Query estimated mem: 5144KB
(3 rows)
```

If the optimizer does not select such an execution plan, you can optimize it as follows:

```
set enable_index_nestloop = on;
set enable_hashjoin = off;
set enable_seqscan = off;
```


Reason 5: The Scan Method Is Incorrectly Specified by Hints.

GaussDB(DWS) plan hints can specify three scan methods: tablescan, indexscan, and indexonlyscan.

- Table Scan: full table scan, such as Seq Scan of row-store tables and CStore Scan of column-store tables.
- Index Scan: scans indexes and then obtains table records based on the indexes.
- Index-Only Scan: scans indexes, which cover all required results. Compared with the index scan, the index-only scan covers all queried columns. In this way, only indexes are retrieved, and data records do not need to be retrieved.

In Index-Only Scan scenarios, Index Scan specified by a hint will be invalid.

```
explain verbose select/*+ indexscan(test)*/ b from test where b = '1';
WARNING:  unused hint: IndexScan(test)
                                      QUERY PLAN
-------------------------------------------------------------------------------------------------------------------
 id |                    operation                    | E-rows | E-distinct | E-memory | E-width | E-costs
----+-------------------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)                    |      1 |            |          |      32 | 16.27
  2 |    ->  Index Only Scan using index_b on public.test |      1 |            | 1MB      |      32 | 8.27

  Predicate Information (identified by plan id)
-------------------------------------------------
  2 --Index Only Scan using index_b on public.test
        Index Cond: (test.b = '1'::text)

  Targetlist Information (identified by plan id)
-------------------------------------------------
  1 --Streaming (type: GATHER)
        Output: b
        Node/s: All datanodes
  2 --Index Only Scan using index_b on public.test
        Output: b
        Distribute Key: a

  ====== Query Summary =====
-------------------------------
 System available mem: 3358720KB
 Query Max mem: 3358720KB
 Query estimated mem: 1024KB
(24 rows)
explain verbose select/*+ indexonlyscan(test)*/ b from test where b = '1';
                                      QUERY PLAN
-------------------------------------------------------------------------------------------------------------------
 id |                    operation                    | E-rows | E-distinct | E-memory | E-width | E-costs
----+-------------------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)                    |      1 |            |          |      32 | 16.27
  2 |    ->  Index Only Scan using index_b on public.test |      1 |            | 1MB      |      32 | 8.27

  Predicate Information (identified by plan id)
-------------------------------------------------
  2 --Index Only Scan using index_b on public.test
        Index Cond: (test.b = '1'::text)

  Targetlist Information (identified by plan id)
-------------------------------------------------
  1 --Streaming (type: GATHER)
        Output: b
        Node/s: All datanodes
  2 --Index Only Scan using index_b on public.test
        Output: b
        Distribute Key: a
```



```
  ====== Query Summary =====
-------------------------------
System available mem: 3358720KB
Query Max mem: 3358720KB
Query estimated mem: 1024KB
(24 rows)
```

Optimization method: Correctly specify Index scan and Index-Only Scan.

Reason 6: Incorrect Use of GIN Index in Full-Text Retrieval

To accelerate text search, you can create a GIN index for full-text search.

```
CREATE INDEX idxb ON test using gin(to_tsvector('english',b));
```

When creating the GIN index, you must use the 2-argument version of to_tsvector. Only when the query also uses the 2-argument version and the arguments are the same as that in the Gin index, the GIN index can be called.

NOTE

The to_tsvector() function accepts one or two augments. If the one-augment version of the index is used, the system will use the configuration specified by **default_text_search_config** by default. To create an index, the two-augment version must be used, or the index content may be inconsistent.

```
explain verbose select  * from test where to_tsvector(b) @@ to_tsquery('cat') order by 1;
                                  QUERY PLAN
-------------------------------------------------------------------------------------------------
 id |            operation             | E-rows | E-distinct | E-memory | E-width | E-costs
----+----------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)     |      2 |            |          |      44 | 22.23
  2 |    ->  Sort                      |      2 |            | 16MB     |      44 | 14.23
  3 |       ->  Seq Scan on public.test |      1 |            | 1MB      |      44 | 14.21

      Predicate Information (identified by plan id)
-----------------------------------------------------------
  3 --Seq Scan on public.test
       Filter: (to_tsvector(test.b) @@ '''cat'''::tsquery)

 Targetlist Information (identified by plan id)
-------------------------------------------------
  1 --Streaming (type: GATHER)
       Output: a, b, c
       Merge Sort Key: test.a
       Node/s: All datanodes
  2 --Sort
       Output: a, b, c
       Sort Key: test.a
  3 --Seq Scan on public.test
       Output: a, b, c
       Distribute Key: a

  ====== Query Summary =====
-------------------------------
System available mem: 3358720KB
Query Max mem: 3358720KB
Query estimated mem: 1024KB
(29 rows)
explain verbose select  * from test where to_tsvector('english',b) @@ to_tsquery('cat') order by 1;
                                  QUERY PLAN
-------------------------------------------------------------------------------------------------
 id |               operation               | E-rows | E-distinct | E-memory | E-width | E-costs
----+---------------------------------------+--------+------------+----------+---------+---------
  1 | ->  Streaming (type: GATHER)          |      2 |            |          |      44 | 20.03
  2 |    ->  Sort                           |      2 |            | 16MB     |      44 | 12.03
  3 |       ->  Bitmap Heap Scan on public.test |      1 |            | 1MB      |      44 | 12.02
```

```
 4 |         ->  Bitmap Index Scan            |     1 |           | 1MB     |       0 | 8.00

                  Predicate Information (identified by plan id)
-------------------------------------------------------------------------------------------
 3 --Bitmap Heap Scan on public.test
       Recheck Cond: (to_tsvector('english'::regconfig, test.b) @@ "'cat'"::tsquery)
 4 --Bitmap Index Scan
       Index Cond: (to_tsvector('english'::regconfig, test.b) @@ "'cat'"::tsquery)

Targetlist Information (identified by plan id)
------------------------------------------------
 1 --Streaming (type: GATHER)
       Output: a, b, c
       Merge Sort Key: test.a
       Node/s: All datanodes
 2 --Sort
       Output: a, b, c
       Sort Key: test.a
 3 --Bitmap Heap Scan on public.test
       Output: a, b, c
       Distribute Key: a

 ====== Query Summary =====
--------------------------------
System available mem: 3358720KB
Query Max mem: 3358720KB
Query estimated mem: 2048KB
(32 rows)
```

Optimization method: Use the 2-argument version of to_tsvector for the query and ensure that the argument values are the same as those in the index.

5.13 How Do I Use a User-Defined GaussDB(DWS) Function to Rewrite the CRC32() Function?

GaussDB(DWS) currently does not have a built-in **CRC32()** function. However, if you need to implement the **CRC32()** function in MySQL, you can rewrite it using a user-defined GaussDB(DWS) function.

- CRC32(expr)
- Description: Calculates the cyclic redundancy. The input parameter **expr** is a string. If the parameter is NULL, NULL is returned. Otherwise, a 32-bit unsigned value is returned after redundancy calculation.

Example of rewriting the **CRC32()** function using user-defined GaussDB(DWS) function statements:

```
CREATE OR REPLACE FUNCTION crc32(text_string text) RETURNS bigint AS $$
DECLARE
    val bigint;
    i int;
    j int;
    byte_length int;
    binary_string bytea;
BEGIN
    IF text_string is null THEN
        RETURN null;
    ELSIF text_string = '' THEN
        RETURN 0;
    END IF;

    i = 0;
    val = 4294967295;
```



```
    byte_length = bit_length(text_string) / 8;
    binary_string = decode(replace(text_string, E'\\', E'\\\\'), 'escape');
    LOOP
        val = (val # get_byte(binary_string, i))::bigint;
        i = i + 1;
        j = 0;
        LOOP
            val = ((val >> 1) # (3988292384 * (val & 1)))::bigint;
            j = j + 1;
            IF j >= 8 THEN
                EXIT;
            END IF;
        END LOOP;
        IF i >= byte_length THEN
            EXIT;
        END IF;
    END LOOP;
    RETURN (val # 4294967295);
END
$$ IMMUTABLE LANGUAGE plpgsql;
```

Verify the rewriting result.

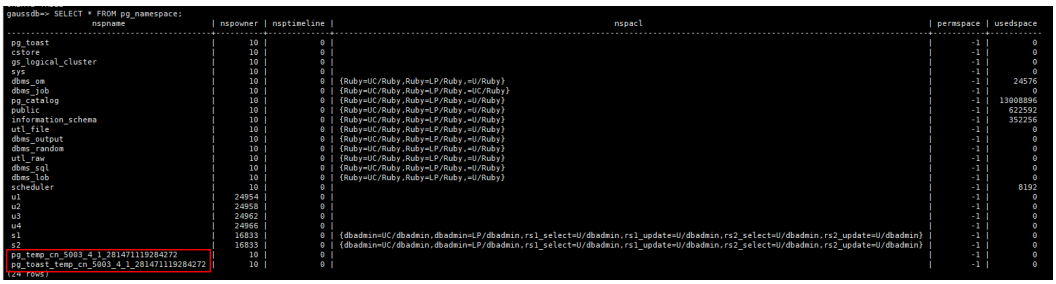
```
select crc32(null),crc32(''),crc32('1');
 crc32 | crc32 |   crc32
-------+-------+------------
       |     0 | 2212294583
(1 row)
```

For how to use user-defined functions, see **CREATE FUNCTION**.

5.14 What Is a GaussDB(DWS) Schema Starting with pg_toast_temp* or pg_temp*?

When you query the schema list, the query result may contain schemas starting with **pg_temp*** or **pg_toast_temp***, as shown in the following figure.

```
SELECT * FROM pg_namespace;
```



These schemas are created when temporary tables are created. Each session has an independent schema starting with **pg_temp** to ensure that the temporary tables are visible only to the current session. Therefore, you are not advised to manually delete schemas starting with **pg_temp** or **pg_toast_temp** during routine operations.

Temporary tables are visible only in the current session and are automatically deleted after the session ends. The corresponding schemas are also deleted.

5.15 Solutions to Inconsistent GaussDB(DWS) Query Results

In GaussDB(DWS), inconsistencies in the returned results of the same query statement when using SQL queries occur. Such issues are primarily due to improper syntax or usage. Proper service usage can prevent these problems. The following are some examples of query results inconsistency along with the solutions.

Window Function Results Are Incompletely Sorted

Scenario:

In the window function **row_number()**, column **c** of table **t3** is queried after sorting. The two query results are different.

```
SELECT * FROM t3 order by 1,2,3;
 a | b | c
---+---+---
 1 | 2 | 1
 1 | 2 | 2
 1 | 2 | 3
(3 rows)

SELECT c,rn FROM (select c,row_number() over(order by a,b) as rn from t3) where rn = 1;
 c | rn
---+----
1  |  1
(1 row)
SELECT c,rn FROM (select c,row_number() over(order by a,b) as rn from t3) where rn = 1;
 c | rn
---+----
 3 |  1
(1 row)
```

Analysis:

As shown above, run **select c,rn from (select c,row_number() over(order by a,b) as rn from t3) where rn = 1;** twice, the results are different. That is because duplicate values **1** and **2** exist in the sorting columns **a** and **b** of the window function while their values in column **c** are different. As a result, when the first record is obtained based on the sorting result in columns **a** and **b**, the obtained data in column **c** is random, as a result, the result sets are inconsistent.

Solution:

The values in column **c** need to be added to the sorting.

```
SELECT c,rn FROM (select c,row_number() over(order by a,b,c) as rn from t3) where rn = 1;
 c | rn
---+----
 1 |  1
(1 row)
```

Using Sorting in Subviews/Subqueries

Scenario

After table **test** and view **v** are created, the query results are inconsistent when sorting is used to query table **test** in a subquery.


```
CREATE TABLE test(a serial ,b int);
INSERT INTO test(b) VALUES(1);
INSERT INTO test(b) SELECT b FROM test;
...
INSERT INTO test(b) SELECT b FROM test;
CREATE VIEW v as SELECT * FROM test ORDER BY a;
```

Problem SQL:

```
SELECT * FROM v limit 1;
 a | b
---+---
 3 | 1
(1 row)

SELECT * FROM (select * from test order by a) limit 10;
 a  | b
----+---
 14 | 1
(1 row)

SELECT * FROM test order by a limit 10;
 a | b
---+---
 1 | 1
(1 row)
```

Analysis:

ORDER BY is invalid for subviews and subqueries.

Solution:

You are not advised to use **ORDER BY** in subviews and subqueries. To ensure that the results are in order, use **ORDER BY** in the outermost query.

LIMIT in Subqueries

Scenario: When **LIMIT** is used in a subquery, the two query results are inconsistent.

```
SELECT * FROM (select a from test limit 1 ) order by 1;
 a
---
 5
(1 row)

SELECT * FROM (select a from test limit 1 ) order by 1;
 a
---
 1
(1 row)
```

Analysis:

The LIMIT in the subquery causes random results to be obtained.

Solution:

To ensure the stability of the final query result, do not use **LIMIT** in subqueries.

Using String_agg

Scenario: When **string_agg** is used to query the table **employee**, the query results are inconsistent.


```
SELECT * FROM employee;
 empno | ename  |   job   | mgr |      hiredate       |  sal  | comm | deptno
-------+--------+---------+-----+---------------------+-------+------+--------
  7654 | MARTIN | SALEMAN | 7698 | 2022-11-08 00:00:00 | 12000 | 1400 |     30
  7566 | JONES  | MANAGER | 7839 | 2022-11-08 00:00:00 | 32000 |    0 |     20
  7499 | ALLEN  | SALEMAN | 7698 | 2022-11-08 00:00:00 | 16000 |  300 |     30
(3 rows)

SELECT count(*) FROM (select deptno, string_agg(ename, ',') from employee group by deptno) t1, (select
deptno, string_agg(ename, ',') from employee group by deptno) t2 where t1.string_agg = t2.string_agg;
 count
-------
     2
(1 row)

SELECT count(*) FROM (select deptno, string_agg(ename, ',') from employee group by deptno) t1, (select
deptno, string_agg(ename, ',') from employee group by deptno) t2 where t1.string_agg = t2.string_agg;
 count
-------
     1
(1 row)
```

Analysis:

The **string_agg** function is used to concatenate data in a group into one row. However, if you use **string_agg(ename, ',')**, the order of concatenated results needs to be specified. For example, in the preceding statement, **select deptno, string_agg(ename, ',') from employee group by deptno;**

can output either of the following:

```
30 | ALLEN,MARTIN
```

Or:

```
30 |MARTIN,ALLEN
```

In the preceding scenario, the result of subquery **t1** may be different from that of subquery **t2** when deptno is **30**.

Solution:

Add **ORDER BY** to **String_agg** to ensure that data is concatenated in sequence.

```
SELECT count(*) FROM (select deptno, string_agg(ename, ',' order by ename desc) from employee group by
deptno) t1 ,(select deptno, string_agg(ename, ',' order by ename desc) from employee group by deptno) t2
where t1.string_agg = t2.string_agg;
```

Database Compatibility Mode

Scenario: The query results of empty strings in the database are inconsistent.

database1 (TD-compatible):

```
td=# select '' is null;
 isnull
--------
 f
(1 row)
```

database2 (ORA compatible):

```
ora=# select '' is null;
 isnull
--------
 t
(1 row)
```


Analysis:

The empty string query results are different because the syntax of the empty string is different from that of the null string in different database compatibility.

GaussDB(DWS) currently supports three database compatibility modes: Oracle, TD, and MySQL. The syntax and behavior vary depending on the compatibility mode. For details about the compatibility differences, see **Syntax Compatibility Differences Among Oracle, Teradata, and MySQL**.

Databases in different compatibility modes have different compatibility issues. You can run **select datname, datcompatibility from pg_database;** to check the database compatibility.

Solution:

The problem is solved when the compatibility modes of the databases in the two environments are set to the same. The **DBCOMPATIBILITY** attribute of a database does not support **ALTER**. You can only specify the same **DBCOMPATIBILITY** attribute when creating a database.

The configuration item behavior_compat_options for database compatibility behaviors is configured inconsistently.

Scenario: The calculation results of the **add_months** function are inconsistent.

database1:

```
SELECT add_months('2018-02-28',3) from dual;
add_months
---------------------
2018-05-28 00:00:00
(1 row)
```

database2:

```
SELECT add_months('2018-02-28',3) from dual;
add_months
---------------------
2018-05-31 00:00:00
(1 row)
```

Analysis:

Some behaviors may vary depending on the settings of the database compatibility configuration item **behavior_compat_options**. For details about the options of this item, see **behavior_compat_options**.

The **end_month_calculate** in **behavior_compat_options** controls the calculation logic of the **add_months** function. If this parameter is specified, and the **Day** of **param1** indicates the last day of a month shorter than **result**, the **Day** in the calculation result will equal that in **result**.

Solution:

The **behavior_compat_options** parameter must be configured consistently. This parameter is of the **USERSET** type and can be set at the session level or modified at the cluster level.

The attributes of the user-defined function are not properly set.

Scenario: When the customized function **get_count()** is invoked, the results are inconsistent.

```
CREATE FUNCTION get_count() returns int
SHIPPABLE
as $$
declare
    result int;
begin
result = (select count(*) from test); --test table is a hash table.
    return result;
end;
$$
language plpgsql;
```

Call this function.

```
SELECT get_count();
 get_count
-----------
      2106
(1 row)

SELECT get_count() FROM t_src;
 get_count
-----------
      1032
(1 row)
```

Analysis:

This function specifies the **SHIPPABLE** attribute. When a plan is generated, the function pushes it down to DNs for execution. The test table defined in the function is a hash table. Therefore, each DN has only part of the data in the table, the result returned by **select count(*) from test;** is not the result of full data in the test table. The expected result changes after **from** is added.

Solution:

Use either of the following methods (the first method is recommended):

1. Change the function to not push down: **ALTER FUNCTION get_count() not shippable;**
2. Change the table used in the function to a replication table. In this way, the full data of the table is stored on each DN. Even if the plan is pushed down to DNs for execution, the result set will be as expected.

Using the Unlogged Table

Scenario:

After an unlogged table is used and the cluster is restarted, the associated query result set is abnormal, and some data is missing in the unlogged table.

Analysis:

If **max_query_retry_times** is set to **0** and the keyword **UNLOGGED** is specified during table creation, the created table will be an unlogged table. Data written to unlogged tables is not written to the write-ahead log, which makes them considerably faster than ordinary tables. However, an unlogged table is

automatically truncated after a crash or unclean shutdown, incurring data loss risks. The contents of an unlogged table are also not replicated to standby servers. Any indexes created on an unlogged table are not automatically logged as well. If the cluster restarts unexpectedly (process restart, node fault, or cluster restart), some data in the memory is not flushed to disks in a timely manner, and some data is lost, causing the result set to be abnormal.

Solution:

The security of unlogged tables cannot be ensured if the cluster goes faulty. In most cases, unlogged tables are only used as temporary tables. If a cluster is faulty, you need to rebuild the unlogged table or back up the data and import it to the database again to ensure that the data is normal.

5.16 Which System Catalogs in GaussDB(DWS) Cannot Undergo the VACUUM FULL Operation?

From a functional perspective, **VACUUM FULL** can be performed on all GaussDB(DWS) system catalogs, which however involves using eight levels of locks, thereby blocking services related to these system catalogs.

The suggestions are based on database versions:

Version 8.1.3 or Later

- For clusters of version 8.1.3 or later, **AUTO VACUUM** is enabled by default (controlled by the **autovacuum** parameter). After you set the parameter, the system automatically performs **VACUUM FULL** on all system catalogs and row-store tables.
  - If the value of **autovacuum_max_workers** is **0**, neither on the system catalogs nor on ordinary tables will **VACUUM FULL** be automatically performed.
  - If **autovacuum** is set to **off**, **VACUUM FULL** will be automatically performed on ordinary tables, but not system catalogs.
- This applies only to row-store tables. To automatically trigger **VACUUM** for column-store tables, you need to configure intelligent scheduling tasks on the management console. For details, see **O&M plan**.

Version 8.1.1 or Earlier

1. Reforming **VACUUM FULL** on the following system catalogs affects all services. Perform this operation in an idle time window or when services are stopped.
   - **pg_statistic** (Statistics information. You are advised not to clear it because it affects service query performance.)
   - pg_attribute
   - pgxc_class
   - pg_type
   - pg_depend
   - pg_class

- pg_index
- pg_proc
- pg_partition
- pg_object
- pg_shdepend

2. The following system catalogs affect resource monitoring and table size query interfaces, but do not affect other services.
   - gs_wlm_user_resource_history
   - gs_wlm_session_info
   - gs_wlm_instance_history
   - gs_respool_resource_history
   - pg_relfilenode_size
3. Other system catalogs do not occupy space and do not need to be cleared.
4. During routine O&M, you are advised to monitor the sizes of these system catalogs, and collect statistics every week. If the space must be reclaimed, clear the space based on the sizes of the system tables.

   The statement is as follows:

   ```
   SELECT c.oid,c.relname, c.relkind, pg_relation_size(c.oid) AS size  FROM pg_class c WHERE c.relkind IN ('r') AND c.oid <16385 ORDER BY size DESC;
   ```

5.17 In Which Scenarios Will a GaussDB(DWS) Statement Be in the idle in transaction State?

When user SQL information is queried in the **PGXC_STAT_ACTIVITY** view, the **state** column in the query result sometimes shows **idle in transaction**. **idle in transaction** indicates that the backend is in a transaction, but no statement is being executed. This status indicates that a statement has been executed. Therefore, the value of query_id is 0, but the transaction has not been committed or rolled back. Statements in this state have been executed and do not occupy CPU and I/O resources, but they occupy connection resources such as connections and concurrent connections.

If a statement is in the **idle in transaction** state, rectify the fault by referring to the following common scenarios and solutions:

Scenario 1: A Transaction Is Started But Not Committed, and the Statement Is in the "idle in transaction" State

BEGIN/START TRANSACTION is manually executed to start a transaction. After statements are executed, **COMMIT/ROLLBACK** is not executed. View the **PGXC_STAT_ACTIVITY**:

```
SELECT state, query, query_id FROM pgxc_stat_activity;
```

The result shows that the statement is in the **idle in transaction** state.


```
       state        |                          query                          |      query_id
--------------------+-------------------------------------------------------------------------+--------------------
 active             |                                                         |                 0
 idle               |                                                         |                 0
 idle               |                                                         |                 0
 active             | WLM fetch collect info from data nodes                  |  73464968921613282
 active             | WLM calculate space info process                        |                 0
 active             | WLM monitor update and verify local info                |  73464968921613276
 active             | WLM arbiter sync info by CCN and CNs                    |                 0
 idle in transaction | select count(1) from t group by a order by 1 desc limit 1; |                 0
 idle               |                                                         |                 0
 active             | select state,query,query_id from pgxc_stat_activity;    |  73464968921613283
 active             |                                                         |                 0
 idle               |                                                         |                 0
 idle               |                                                         |                 0
 active             | WLM fetch collect info from data nodes                  | 145522562959541153
 active             | WLM calculate space info process                        |                 0
 active             | WLM monitor update and verify local info                | 145522562959541123
 active             | WLM arbiter sync info by CCN and CNs                    |                 0
 active             | SELECT * FROM pg_stat_activity                          |  73464968921613283
 idle               |                                                         |                 0
(19 rows)
```

Solution: Manually execute **COMMIT/ROLLBACK** on the started transaction.

Scenario 2: After a DDL Statement in a Stored Procedure Is Executed, Other Nodes of the Stored Procedure Is In the "idle in transaction" State

Create a stored procedure:

```
CREATE OR REPLACE FUNCTION public.test_sleep()
RETURNS void
LANGUAGE plpgsql
AS $$

BEGIN
   truncate t1;
   truncate t2;
   EXECUTE IMMEDIATE 'select pg_sleep(6)';
   RETURN;
END$$;
```

View the **PGXC_STAT_ACTIVITY** view:

```
SELECT coorname,pid,query_id,state,query,usename FROM pgxc_stat_activity WHERE usename='jack';
```

The result shows that **truncate t2** is in the **idle in transaction** state and **coorname** is **coordinator2**. This indicates that the statement has been executed on **cn2** and the stored procedure is executing the next statement.

```
   coorname   |       pid       |     query_id      |        state        |        query         | usename
--------------+-----------------+-------------------+---------------------+----------------------+---------
 coordinator1 | 139767124588288 | 73464968921614213 | active              | select test_sleep(); | jack
 coordinator2 | 140055318353664 |                 0 | idle in transaction | truncate t2          | jack
(2 rows)
```

Solution: This problem is caused by slow execution of the stored procedure. Wait until the execution of the stored procedure is complete. You can also optimize the statements that are executed slowly in the stored procedure.

Scenario 3: A Large Number of SAVEPOINT/RELEASE Statements Are in the "idle in transaction" State (Cluster Versions Earlier Than 8.1.0)

View the **PGXC_STAT_ACTIVITY** view:

```
SELECT coorname,pid,query_id,state,query,usename FROM pgxc_stat_activity WHERE usename='jack';
```

The result shows that the SAVEPOINT/RELEASE statement is in the **idle in transaction** state.


```
  coorname   |       pid       |     query_id      |        state        |          query          | usename
-------------+-----------------+-------------------+---------------------+-------------------------+---------
 coordinator1 | 140127877723904 | 77687093572141691 | active              | select test_sleep1(); | jack
 coordinator2 | 139773127153408 |                 0 | idle in transaction | release s1            | jack
 coordinator3 | 140193352906496 |                 0 | idle in transaction | release s1            | jack
(3 rows)
```

Solution:

The **SAVEPOINT** and **RELEASE** statements are automatically generated by the system when the stored procedure with **EXCEPTION** is executed. (In cluster versions later than 8.1.0, **SAVEPOINT** is not delivered to CNs.) GaussDB(DWS) stored procedures with **EXCEPTION** are implemented based on subtransactions, the mapping is as follows:

```
begin
   (Savepoint s1)
   DDL/DML
exception
   (Rollback to s1)
   (Release s1)
...
end
```

If there is **EXCEPTION** in a stored procedure when it is started, a subtransaction will be started. If there is and exception during the execution, the current transaction is rolled back and the exception is handled; if there is no exception, the subtransaction is committed.

This problem may occur when there are many such stored procedures and the stored procedures are nested. Similar to scenario 2, you only have to wait after the entire stored procedure is executed. If there are a large number of **RELEASE** messages, the stored procedure triggered multiple exceptions. In this case, you must re-examine the logic of the stored procedure.

5.18 How Does GaussDB(DWS) Implement Row-to-Column and Column-to-Row Conversion?

This section describes how to use SQL statements to convert rows to columns and convert columns to rows in GaussDB(DWS).

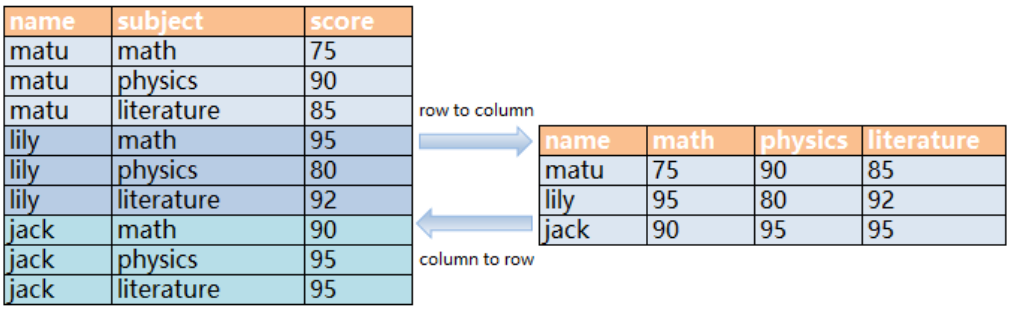
Scenario

Use a student score table as an example:

Teachers record the score of each subject of each student in a table, but students care only bout their own scores. A student needs to use row-to-column conversion to view their scores of all subjects. If the teacher of a subject wants to view the sores of all students of that subject, the teacher needs to use the column-to-row conversion.

The following figure shows the row-to-column and column-to-row conversion.

Figure 5-1 Diagram



- Rows-to-column conversion

  Convert multiple rows of data into one row, or convert one column of data into multiple columns.

- Column-to-row conversion

  Convert a row of data into multiple rows, or convert multiple columns of data into one column.

Example

- Create a row-store table **students_info**, and insert data into the table.

```
CREATE TABLE students_info(name varchar(20),subject varchar(100),score bigint) distribute by hash(name);
INSERT INTO students_info VALUES('lily','math',95);
INSERT INTO students_info VALUES('lily','physics',80);
INSERT INTO students_info VALUES('lily','literature',92);
INSERT INTO students_info VALUES('matu','math',75);
INSERT INTO students_info VALUES('matu','physics',90);
INSERT INTO students_info VALUES('matu','literature',85);
INSERT INTO students_info VALUES('jack','math',90);
INSERT INTO students_info VALUES('jack','physics',95);
INSERT INTO students_info VALUES('jack','literature',95);
```

  View information about the **students_info** table.

```
SELECT * FROM students_info;
 name |  subject   | score
------+------------+-------
 matu | math       |    75
 matu | physics    |    90
 matu | literature |    85
 lily | math       |    95
 lily | physics    |    80
 lily | literature |    92
 jack | math       |    90
 jack | physics    |    95
 jack | literature |    95
```

- Create a column-store table **students_info1**, and insert data into the table.

```
CREATE TABLE students_info1(name varchar(20), math bigint, physics bigint, literature bigint) with (orientation = column) distribute by hash(name);
INSERT INTO students_info1 VALUES('lily',95,80,92);
INSERT INTO students_info1 VALUES('matu',75,90,85);
INSERT INTO students_info1 VALUES('jack',90,95,95);
```

  View information about table **students_info1**.

```
SELECT * FROM students_info1;
 name | math | physics | literature
------+------+---------+------------
 matu |   75 |      90 |         85
```



```
 lily |   95 |      80 |          92
 jack |   90 |      95 |          95
(3 rows)
```

Static row-to-column conversion

Static row-to-column conversion requires you to manually specify the column names using the given values. If no value is given to a column, the default value **0** is assigned to the column.

```
SELECT name,
sum(case when subject='math' then score else 0 end) as math,
sum(case when subject='physics' then score else 0 end) as physics,
sum(case when subject='literature' then score else 0 end) as literature FROM students_info GROUP BY
name;
 name | math | physics | literature
------+------+---------+------------
 matu |   75 |      90 |          85
 lily |   95 |      80 |          92
 jack |   90 |      95 |          95
(3 rows)
```

Dynamic row-to-column conversion

For clusters of 8.1.2 or later, you can use **GROUP_CONCAT** to generate column-store statements.

```
SELECT group_concat(concat('sum(IF(subject = ''', subject, ''', score, 0)) AS "', name, '"'))FROM students_info;
      group_concat

---------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------
------------------------
 sum(IF(subject = 'literature', score, 0)) AS "jack",sum(IF(subject = 'literature', score, 0)) AS
"lily",sum(IF(subject = 'literature', score, 0)) AS "matu",sum(IF(subject = 'math', score, 0)) AS "jack",sum(IF
(subject = 'math', score, 0)) AS "lily",sum(IF(subject = 'math', score, 0)) AS "matu",sum(IF(subject =
'physics', score, 0)) AS "jack",sum(IF(subject = 'physics', score, 0)) AS "lily",sum(IF(subject = 'physics
', score, 0)) AS "matu"
(1 row)
```

In 8.1.1 and earlier versions, you can use **LISTAGG** to generate column-store statements.

```
SELECT listagg(concat('sum(case when subject = ''', subject, ''' then score else 0 end) AS "', subject, '"'),',')
within GROUP(ORDER BY 1)FROM (select distinct subject from students_info);
                                                                      listagg

---------------------------------------------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------
--
 sum(case when subject = 'literature' then score else 0 end) AS "literature",sum(case when subject =
'physics' then score else 0 end) AS "physics",sum(case when subject = 'math' then score else 0 end) AS
"math
"
(1 row)
```

Dynamically rebuild the view:

```
CREATE OR REPLACE FUNCTION build_view()
RETURNS VOID
LANGUAGE plpgsql
AS $$ DECLARE
sql text;
rec record;
```

```
BEGIN
sql := 'select LISTAGG(
    CONCAT( ''sum(case when subject = '''''', subject, '''''' then score else 0 end) AS '''', subject, '''''' )
    ,'','' ) within group(order by 1) from (select distinct subject from students_info);';
    EXECUTE sql INTO rec;
    sql := 'drop view if exists get_score';
    EXECUTE sql;
    sql := 'create view get_score as select name, ' || rec.LISTAGG || ' from students_info group by name';
    EXECUTE sql;
END$$;
```

Rebuild the database:

```
CALL build_view();
```

Query view:

```
SELECT * FROM get_score;
 name | literature | physics | math
------+------------+---------+------
 matu |         85 |      90 |   75
 lily |         92 |      80 |   95
 jack |         95 |      95 |   90
(3 rows)
```

Column-to-Row Conversion

Use **UNION ALL** to merge subjects (math, physics, and literature) into one column. The following is an example:

```
SELECT * FROM
(
SELECT name, 'math' AS subject, math AS score FROM students_info1
union all
SELECT name, 'physics' AS subject, physics AS score FROM students_info1
union all
SELECT name, 'literature' AS subject, literature AS score FROM students_info1
)
order by name;
 name |  subject   | score
------+------------+-------
 jack | math       |    90
 jack | physics    |    95
 jack | literature |    95
 lily | math       |    95
 lily | physics    |    80
 lily | literature |    92
 matu | math       |    75
 matu | physics    |    90
 matu | literature |    85
(9 rows)
```

5.19 What Are the Differences Between GaussDB(DWS) Unique Constraints and Unique Indexes?

- The concepts of a unique constraint and a unique index are different.

  A unique constraint specifies that the values in a column or a group of columns are all unique. If **DISTRIBUTE BY REPLICATION** is not specified, the column table that contains only unique values must contain distribution columns.

  A unique index is used to ensure the uniqueness of a field value or the value combination of multiple fields. **CREATE UNIQUE INDEX** creates a unique index.

- The functions of a unique constraint and a unique index are different.

  Constraints are used to ensure data integrity, and indexes are used to facilitate query.

- The usages of a unique constraint and a unique index are different.

  a. Both unique constraints and unique indexes can be used to ensure the uniqueness of column values which can be NULL.

  b. When a unique constraint is created, a unique index with the same name is automatically created. The index cannot be deleted separately. When the constraint is deleted, the index is automatically deleted. A unique constraint uses a unique index to ensure data uniqueness. GaussDB(DWS) row-store tables support unique constraints, but column-store tables do not.

  c. A created unique index is independent and can be deleted separately. Currently in GaussDB(DWS), unique indexes can only be created using B-Tree.

  d. If you want to have both a unique constraint and a unique index on a column, and they can be deleted separately, you can create a unique index and then a unique constraint with the same name.

  e. If a field in a table is to be used as a foreign key of another table, the field must have a unique constraint (or it is a primary key). If the field has only a unique index, an error is reported.

Example: Create a composite index for two columns, which is not required to be a unique index.

```
CREATE TABLE t (n1 number,n2 number,n3 number,PRIMARY KEY (n3));
CREATE INDEX t_idx ON t(n1,n2);
```

GaussDB (DWS) supports multiple unique indexes for a table.

```
CREATE UNIQUE INDEX u_index ON t(n3);
CREATE UNIQUE INDEX u_index1 ON t(n3);
```

You can use the index **t_idx** created in the example above to create a unique constraint **t_uk**, which is unique only on column **n1**. A unique constraint is stricter than a unique index.

```
ALTER TABLE t ADD CONSTRAINT t_uk UNIQUE USING INDEX u_index;
```

5.20 What Are the Differences Between GaussDB(DWS) Functions and Stored Procedures?

Functions and stored procedures are two common objects in database management systems. They have similarities and differences in implementing specific functions. Understanding their characteristics and application scenarios is important for properly designing the database structure and improving database performance.

Table 5-2 Differences between functions and stored procedures

Function	Stored procedures
Both can be used to implement specific functions. Both functions and stored procedures can encapsulate a series of SQL statements to complete certain specific operations.	
Both can receive input parameters and perform corresponding operations based on the parameters.	
The identifier of a function is **FUNCTION**.	The identifier of the stored procedure is **PROCEDURE**.
A function must return a specific value of the specified numeric type.	A stored procedure can have no return value, one return value, or multiple return values. You can use output parameters to return results or directly use the SELECT statement in a stored procedure to return result sets.
Functions are used to return single values, for example, a number calculation result, a string processing result, or a table.	Stored procedures are used for DML operations, for example, inserting, updating, and deleting data in batches.

- **Creating and Invoking a Function**

  Create the **emp** table and insert data into the table. The table data is as follows:

```
SELECT * FROM emp;
 empno | ename |   job    | mgr |      hiredate       |   sal   |  comm  | deptno
-------+-------+----------+-----+---------------------+---------+--------+--------
  7369 | SMITH | CLERK    | 7902 | 1980-12-17 00:00:00 |  800.00 |        |     20
  7499 | ALLEN | SALESMAN | 7698 | 1981-02-20 00:00:00 | 1600.00 | 300.00 |     30
  7566 | JONES | MANAGER  | 7839 | 1981-04-02 00:00:00 | 2975.00 |        |     20
  7521 | WARD  | SALESMAN | 7698 | 1981-02-22 00:00:00 | 1250.00 | 500.00 |     30
(4 rows)
```

  Create the **emp_comp** function to accept two numbers as input and return the calculated value.

```
CREATE OR REPLACE FUNCTION emp_comp (
    p_sal           NUMBER,
    p_comm          NUMBER
) RETURN NUMBER
IS
BEGIN
    RETURN (p_sal + NVL(p_comm, 0)) * 24;
END;
/
```

  Run the **SELECT** command to invoke the function:

```
SELECT ename "Name", sal "Salary", comm "Commission", emp_comp(sal, comm) "Total
Compensation" FROM emp;
 Name  | Salary  | Commission | Total Compensation
-------+---------+------------+--------------------
 SMITH |  800.00 |            |           19200.00
 ALLEN | 1600.00 |     300.00 |           45600.00
 JONES | 2975.00 |            |           71400.00
```



```
 WARD  | 1250.00 |     500.00 |           42000.00
(4 rows)
```

- **Creating and Invoking a Stored Procedure**

  Create the **MATCHES** table and insert data into the table. The table data is as follows:

  ```
  SELECT * FROM MATCHES;
   matchno | teamno | playerno | won | lost
  ---------+--------+----------+-----+------
        1 |      1 |        6 |   3 |    1
        7 |      1 |       57 |   3 |    0
        8 |      1 |        8 |   0 |    3
        9 |      2 |       27 |   3 |    2
       11 |      2 |      112 |   2 |    3
  (5 rows)
  ```

  Create the stored procedure **delete_matches** to delete all matches that a specified player participates in.

  ```
  CREATE PROCEDURE delete_matches(IN p_playerno INTEGER)
  AS
  BEGIN
    DELETE FROM MATCHES WHERE playerno = p_playerno;
  END;
  /
  ```

  Invoke the stored procedure **delete_matches**.

  ```
  CALL delete_matches(57);
  ```

  Query the **MATCHES** table again. The returned result indicates that the data of the player whose **playerno** is **57** has been deleted.

  ```
  SELECT * FROM MATCHES;
   matchno | teamno | playerno | won | lost
  ---------+--------+----------+-----+------
       11 |      2 |      112 |   2 |    3
        8 |      1 |        8 |   0 |    3
        1 |      1 |        6 |   3 |    1
        9 |      2 |       27 |   3 |    2
  (4 rows)
  ```

5.21 How Do I Delete Duplicate Table Data from GaussDB(DWS)?

When clearing dirty data in the database, you may retain only one piece of duplicate data. In this scenario, you can use the aggregate function or window function.

Constructing Table Data

Step 1 Create a table t_customer and insert data that contains duplicate records into the table.

```
CREATE TABLE t_customer (
  id int NOT NULL,
cust_name varchar(32) NOT NULL COMMENT' Name',
gender varchar(10) NOT NULL COMMENT' Gender',
  email varchar(32) NOT NULL COMMENT 'email',
  PRIMARY KEY (id)
) ;

INSERT INTO t_customer VALUES ('1', 'Tom', 'Male', 'high_salary@sample.com');
INSERT INTO t_customer VALUES ('2', 'Jennifer', 'Female', 'good_job@sample.com');
INSERT INTO t_customer VALUES ('3', 'Tom', 'Male', 'high_salary@sample.com');
INSERT INTO t_customer VALUES ('4', 'John', 'Male', 'good_job@sample.com');
```



```
INSERT INTO t_customer VALUES ('5', 'Jennifer', 'Female', 'good_job@sample.com');
INSERT INTO t_customer VALUES ('6', 'Tom', 'Male', 'high_salary@sample.com');
```

Step 2 Query the t_customer table.

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

```
 id | cust_name | gender |         email
----+-----------+--------+-----------------------
  1 | Tom       | Male   | high_salary@sample.com
  2 | Jennifer  | Female | good_job@sample.com
  3 | Tom       | Male   | high_salary@sample.com
  4 | John      | Male   | good_job@sample.com
  5 | Jennifer  | Female | good_job@sample.com
  6 | Tom       | Male   | high_salary@sample.com
```

----End

If the name, gender, and email of a customer are the same, the customer is regarded as a duplicate record. In the t_customer table, data whose IDs are 1, 3, and 6 is duplicate, and data whose IDs are 2 and 5 is also duplicate. Delete redundant data and retain one of them.

Method 1: Use the aggregate function **min(expr)**.

Use aggregate functions to obtain non-duplicate rows with the smallest ID through subqueries, and then use NOT IN to delete duplicate data.

Step 1 Run the following command to query the unique row with the smallest ID:

```
SELECT
   min(id) id,
   cust_name,
   gender,
   COUNT( cust_name ) count
FROM t_customer
GROUP BY cust_name,gender
ORDER BY id;
```

```
 id | cust_name | gender | count
----+-----------+--------+-------
  1 | Tom       | Male   |     3
  2 | Jennifer  | Female |     2
  4 | John      | Male   |     1
```

According to the query result, duplicate data rows whose IDs are 3, 5, and 6 are filtered out.

Step 2 Use NOT IN to filter out duplicate data rows and delete them.

```
DELETE from t_customer where id not in (
   SELECT
   min(id) id
   FROM t_customer
   GROUP BY cust_name,gender
);
```

Step 3 Query the t_customer table after duplicate data is deleted.

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

```
 id | cust_name | gender |         email
----+-----------+--------+-----------------------
  1 | Tom       | Male   | high_salary@sample.com
  2 | Jennifer  | Female | good_job@sample.com
  4 | John      | Male   | good_job@sample.com
```


The command output indicates that duplicate data has been deleted.

----End

Method 2: Use the window function row_number().

Use PARTITION BY to partition and sort columns, generate sequence number columns, and delete rows whose sequence numbers are greater than 1.

Step 1 Partition query. Sort columns by partition and generate sequence number columns.

```
SELECT
   id,
   cust_name,
   gender,
   ROW_NUMBER() OVER (PARTITION BY cust_name,gender ORDER BY id) num
FROM t_customer;
```

```
 id | cust_name | gender | num
----+-----------+--------+-----
  4 | John      | Male   |   1
  1 | Tom       | Male   |   1
  3 | Tom       | Male   |   2
  6 | Tom       | Male   |   3
  2 | Jennifer  | Female |   1
  5 | Jennifer  | Female |   2
```

According to the command output, the data in num>1 is duplicate.

Step 2 Delete the data of num>1.

```
DELETE FROM t_customer WHERE id in (
  SELECT id FROM(
   SELECT * FROM (
      SELECT ROW_NUMBER() OVER w AS row_num,id
   FROM t_customer
   WINDOW w AS (PARTITION BY cust_name,gender ORDER BY id) )
  WHERE row_num >1 )
);
```

Step 3 Query the t_customer table after duplicate data is deleted.

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

```
 id | cust_name | gender |         email
----+-----------+--------+-----------------------
  1 | Tom       | Male   | high_salary@sample.com
  2 | Jennifer  | Female | good_job@sample.com
  4 | John      | Male   | good_job@sample.com
```

----End

6 Cluster Management

6.1 How Can I Clear and Reclaim the GaussDB(DWS) Storage Space?

After you delete data stored in GaussDB(DWS) data warehouses, dirty data may be generated possibly because the disk space is not released. This results in disk space waste and deteriorates snapshot creation and restoration performance. The following describes the impact on the system and subsequent operation to clear the disk space:

Points worth mentioning during clearing and reclaiming storage space:

- Unnecessary data needs to be deleted to release the storage space.
- Frequent read and write operations may affect proper database use. Therefore, it is good practice to clear and reclaim the storage space when not in peak hours.
- The data clearing time depends on the data stored in the database.

Periodically clear dirty data to clean up and reclaim storage space. The procedure varies depending on the cluster version. The details are as follows:

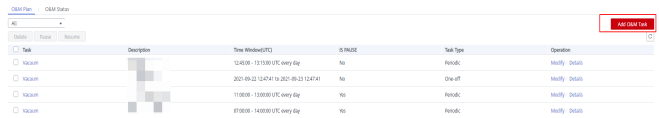
Version 8.1.3 or Later: Automatically Cleaning Using the Intelligent O&M Function on the Management Console

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

Step 2 Click the name of the target cluster.

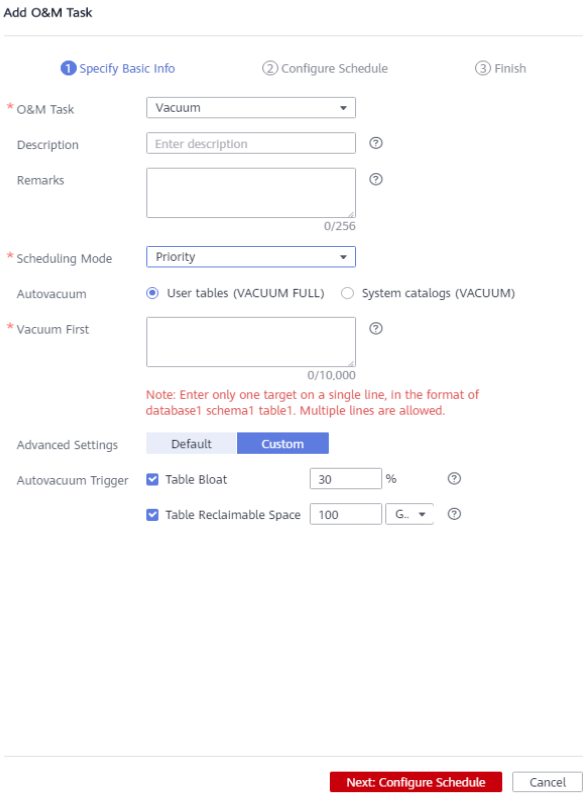
Step 3 In the navigation pane, choose **Intelligent O&M**.

Step 4 Click the **O&M Plan** tab. Click **Add O&M Task**.

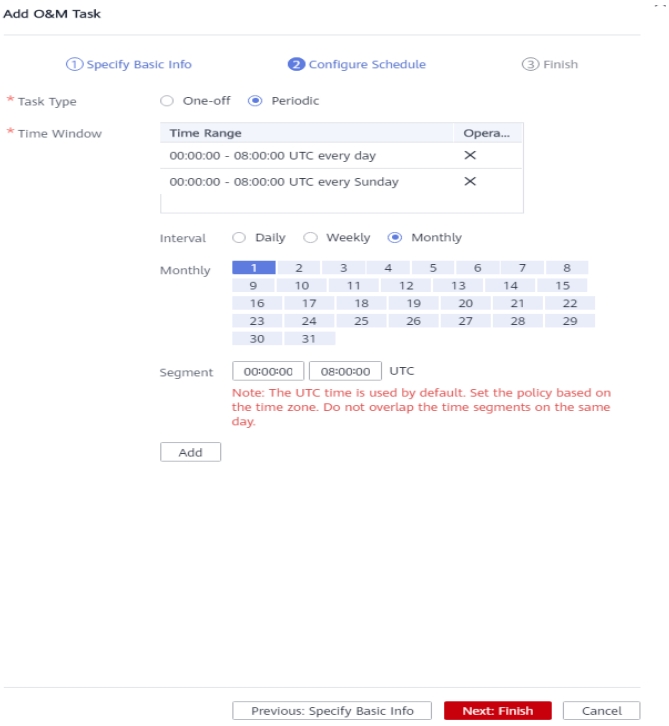


Step 5 The **Add O&M Task** page is displayed.

- Select **Vacuum** for **O&M Task**.
- Set **Scheduling Mode** to **Auto**. GaussDB(DWS) automatically scans tables that require **VACUUM** operation.
- Select **System catalogs** or **User tables** for **Autovacuum**.
  - If there are a large number of **UPDATE** and **DELETE** operations, select the **User tables**.
  - If there are a large number of **CREATE** and **DELETE** operations, select **System catalogs**.



Step 6 Click **Next: Configure Schedule** to configure the schedule and Vacuum type. You are advised to select **Periodic** for **Task Type**. The GaussDB(DWS) automatically executes VACUUM in your selected time windows.



NOTE

For automatic Vacuum O&M tasks, the system uses the **VACUUM FULL** operation to process user tables. VACUUM FULL holds a level 8 lock, which blocks other transactions. Other transactions will be in lock waiting during **VACUUM FULL** execution. After 20 minutes, a timeout error is reported. Therefore, do not perform other transactions in the configured time window.

Step 7 After confirming that the information is correct, click **Next** to complete the configuration.

----End

Version 8.1.2 or Earlier: Manually Cleaning by Running the VACUUM FULL Command

NOTICE

1. The **VACUUM FULL** operation locks a table, blocking all access to it during this period and waiting for its completion. To avoid impacting services due to table locking, schedule appropriately.
2. **VACUUM FULL** extracts valid data from the current table, reorganizes it, and removes dirty data. This process temporarily requires **additional space**, which is released after the reorganization is complete. As a result, space initially increases before decreasing. Calculate the necessary space for **VACUUM FULL** in advance using the formula: **Additional reorganization space** = **Table size** x (**1** – **Dirty page rate**).

Step 1 Connect to the database, run the following SQL statements to query large tables whose dirty page rate exceeds 30%, and sort the tables by size in descending order:

```
SELECT schemaname AS schema, relname AS table_name, n_live_tup AS analyze_count,
pg_size_pretty(pg_table_size(relid)) as table_size, dirty_page_rate
FROM PGXC_GET_STAT_ALL_TABLES
WHERE schemaName NOT IN ('pg_toast', 'pg_catalog', 'information_schema', 'cstore', 'pmk')
AND dirty_page_rate > 30
ORDER BY table_size DESC, dirty_page_rate DESC;
```

Step 2 Check whether any command output is displayed.

- If yes, perform **Step 3** for tables larger than 10 GB.
- If no, no further action is required.

Step 3 Run the **VACUUM FULL** command to clear the top 5 tables with the most dirty pages. If the maximum disk space is greater than 70%, clear the tables one by one.

```
VACUUM FULL ANALYZE schema.table_name;
```

----End

6.2 Why Does the Used Storage Capacity of GaussDB(DWS) Decrease Significantly After Scale-Out?

Cause Analysis

If you do not run the **VACUUM** command to clear and reclaim the storage space before the scale-out, the data deleted from the data warehouse may not release the occupied disk space, causing dirty data and disk waste.

During the scale-out, the system redistributes the data because the service data volume on the original nodes is significantly larger than that on the newly added nodes. When the redistribution starts, the system automatically performs **VACUUM** to free up the storage space. In this way, the used storage is reduced.

Handling Procedure

You are advised to periodically clear and reclaim the storage space by running **VACUUM FULL** to prevent data expansion.

If the used storage space is still large after you run **VACUUM FULL**, analyze whether the existing cluster flavor meets service requirements. If no, scale out the cluster.

6.3 How Is the Disk Space or Capacity of GaussDB(DWS) Calculated?

1. Total disk capacity of a GaussDB(DWS) storage-compute coupled cluster: Taking three data nodes in the cluster as an example, assume each node has a capacity of 320 GB, resulting in a total capacity of 960 GB. When 1 GB of data is stored, GaussDB(DWS) employs its replication mechanism to maintain copies of the data across two nodes, thereby utilizing 2 GB of storage space.

With additional metadata and indexing considerations, although the original dataset remains at 1 GB, the actual storage requirements exceed 2 GB upon ingestion into GaussDB(DWS). Therefore, a three-node cluster with a total capacity of 960 GB can store 480 GB data. This mechanism ensures data security. In a storage-compute decoupling scenario, disks are utilized as cache disks with capacities matching their physical sizes. There are three data nodes with decoupled storage and compute, each having a capacity of 320 GB, totaling 960 GB.

When you create a cluster on the GaussDB(DWS) console, the actual capacity of a node is displayed on the page. For example, the disk size of the storage-compute coupled **dwsx2.xlarge** node is 160 GB on the creation page. However, the actual disk size of the node is 320 GB, which is displayed as 160 GB. In this way, you can create a node based on the actual disk data. For instance, on the creation page, the **dwsx3.4U16G.4DPU** flavor of a storage-compute decoupled cluster has a specified capacity of 320 GB, and the applied disk capacity is also 320 GB. The capacity displayed on the page is the actual applied capacity.

2. Check the disk usage of a single node.

   Similarly, if the total capacity is 960 GB and there are three data nodes, the disk capacity of each node is 320 GB.

   Log in to the **DWS console** and choose **Monitoring** > **Node Monitoring** > **Overview** to view the usage of disks and other resources on each node.

   NOTE

   - The disk space shown on the node management page represents the combined capacity of all disks in the GaussDB(DWS) cluster, including system disks and data disks. On the overview page of a storage-compute coupled cluster, the displayed disk space only refers to the available space for storing table data in the cluster. Additionally, the GaussDB(DWS) cluster has backup copies of tables, which also occupy disk storage. The disk space shown on the overview page of a storage-compute coupled cluster represents the cache size, which corresponds to the actual disk space utilized.
   - If the cluster is read-only and an alarm for insufficient disk space is generated, scale out the cluster by following the instructions provided in **Scaling Out a Cluster**.

6.4 How Do I Set the Session Threshold When Creating Alarm Rules for GaussDB(DWS) in Cloud Eye?

After connecting to a database, run the following SQL statement to check the maximum number of concurrent sessions globally:

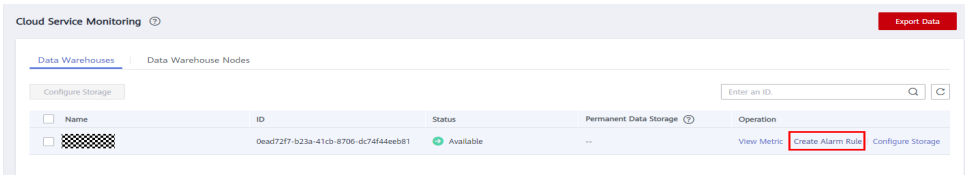
```
show max_active_statements;
```

Go to the Cloud Eye console and set the threshold to 70% to 80% of the obtained value. For example, if the value of **max_active_statements** is **80**, set the threshold to **56** (80 x 70%).

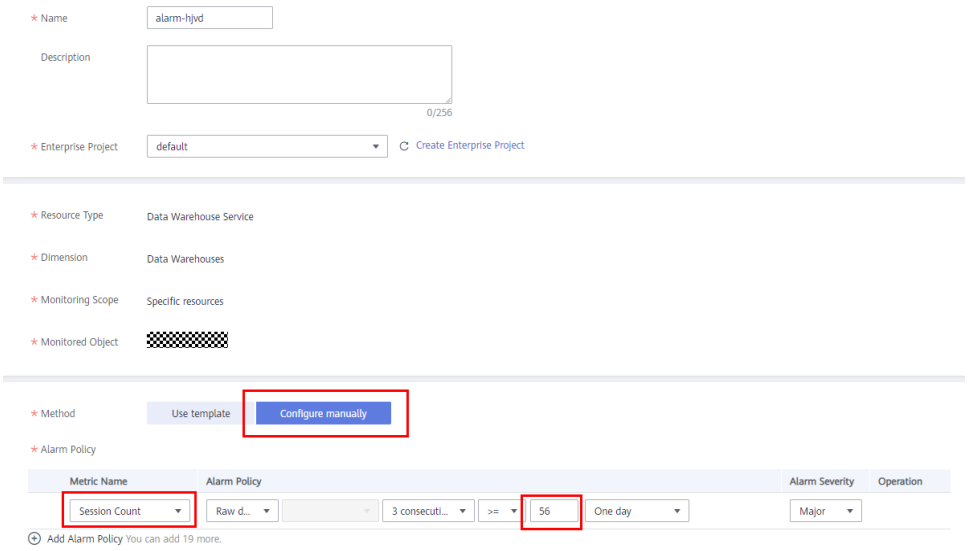
Procedure:

1. Log in to the **DWS console** and choose **Dedicated Clusters** > **Clusters**.
2. Click **View Metric** in the **Operation** column of the target cluster to go to the Cloud Eye console.

3. Click < in the upper left corner on the displayed page and click **Create Alarm Rule** of the target cluster.



4. Set **Method** to **Configure manually**, **Metric Name** to **Session Count**, **Alarm Policy** to **56**, and **Alarm Severity** to **Major**. Then click **Create**.



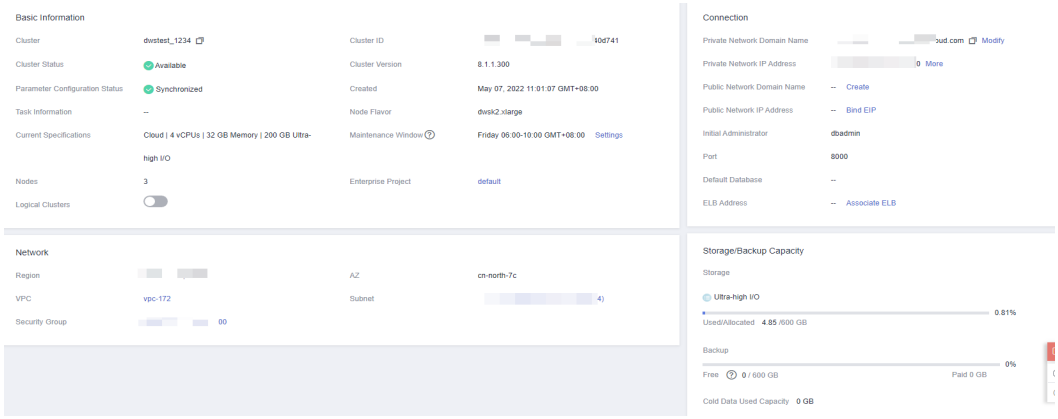
6.5 How Do I Determine Whether a GaussDB(DWS) Cluster Uses the x86 or Arm Architecture?

Procedure

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

Step 2 Choose **Dedicated Clusters** > **Clusters**. All clusters will be displayed by default.

Step 3 In the cluster list, click the name of a cluster to go to the **Cluster Information** page. In the **Basic Information** area, check the node specifications of the cluster.



Step 4 Determine the cluster architecture based on the node specifications. The following table describes the specifications.

Table 6-1 Flavor description

Node	vCPU Cores	Memory (GB)	Architecture	Type
dws2.olap.4xlarge.m6	16	128	x86	ECS/storage-compute decoupling EVS
dws2.olap.8xlarge.m6	32	256	x86	ECS/storage-compute decoupling EVS
dws2.olap.16xlarge.m6	64	512	x86	ECS/storage-compute decoupling EVS
dws2.olap.4xlarge.kc1	16	64	Arm	ECS/storage-compute decoupling EVS
dws2.olap.4xlarge.km1	16	128	Arm	ECS/storage-compute decoupling EVS
dws2.olap.6xlarge.km1	24	192	Arm	ECS/storage-compute decoupling EVS
dws2.olap.8xlarge.km1	32	256	Arm	ECS/storage-compute decoupling EVS
dws2.olap.12xlarge.km1	48	384	Arm	ECS/storage-compute decoupling EVS
dws2.m6.4xlarge.8	16	128	x86	ECS/EVS

Node	vCPU Cores	Memory (GB)	Architecture	Type
dws2.m6.8xlarge.8	32	256	x86	ECS/EVS
dws2.m6.16xlarge.8	64	512	x86	ECS/EVS
dws2.km1.4xlarge.8	16	128	Arm	ECS/EVS
dws2.km1.6xlarge.8	24	192	Arm	ECS/EVS
dws2.km1.8xlarge.8	32	256	Arm	ECS/EVS
dws2.km1.12xlarge.8	48	384	Arm	ECS/EVS
dws2.km1.xlarge	4	32	Arm	ECS/EVS
dws2.kc1.4xlarge	16	64	Arm	ECS/EVS
dws2.olap.4xlarge.i3	16	128	x86	ECS/Local passthrough
dws2.olap.8xlarge.i3	32	256	x86	ECS/Local passthrough
dws2.olap.16xlarge.i3	64	512	x86	ECS/Local passthrough
dws2.olap.4xlarge.ki1	16	64	Arm	ECS/Local passthrough
dws2.olap.8xlarge.ki1	32	128	Arm	ECS/Local passthrough
dws2.olap.16xlarge.ki1	64	228	Arm	ECS/Local passthrough
dws2.physical.ki1ne.4xlarge	128	512	Arm	BMS
dws2.physical.ki1ne.4xlarge.a	128	512	Arm	BMS
dws2.physical.c6sd.6xlarge	104	768	x86	BMS
dws2.physical.c6sd.6xlarge.7	104	768	x86	BMS
dws2.physical.c6sd.6xlarge.7.cbg	104	768	x86	BMS
dws2.physical.c6sd.6xlarge.a.7	104	768	x86	BMS
dws2.physical.io6.3xlarge.4a	104	384	x86	BMS

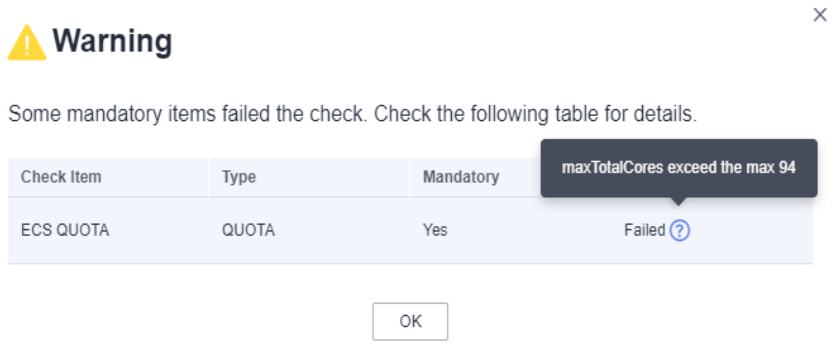
Node	vCPU Cores	Memory (GB)	Architecture	Type
dws2.physical.c6d.6xlarge.3a.cbg	88	768	x86	BMS
dws2.physical.c6sd.6xlarge.a.7.cbg	104	768	x86	BMS
dws2.physical.c6sd.6xlarge.1.cbg	104	768	x86	BMS

----End

6.6 How Do I Do If the GaussDB(DWS) Scale-Out Check Fails?

Symptom

After you click **OK** during scale-out or adding idle nodes, a warning message is displayed and you cannot go to the next step.



Cause Analysis

Before submitting a scale-out task, the system checks items such as resource quotas and IAM permissions. Abnormal items will stop scale-out tasks from being submitted to prevent scale-out failures.

Solution

- If the quota check fails, check whether the resource quota is sufficient. If the available nodes are insufficient, click **Increase Quota** to submit a service ticket to increase the node quota.
- IAM permissions: This problem occurs when a user has only an IAM account. In this case, permissions such as VPC and EVC/BMS permissions need to be assigned to the IAM account. Or, the user can use the master account to perform scaling out.

- If there are no abnormal items but the dialog box still exists, contact technical support.

6.7 How Do I Determine Whether to Add CNs to a GaussDB(DWS) Cluster or Scale Out the Cluster?

Introduction to CN Concurrency

Coordinator Node (CN) is an important component in GaussDB(DWS) that is most closely related to users. It provides external application interfaces, optimizes global execution plans, distributes the execution plans to DataNodes, and summarizes and processes execution results. A CN is an interface to external applications. The concurrency capability of the CN determines the service concurrency.

CN concurrency is determined by the following parameters:

- **max_connections**: specifies the maximum number of concurrent connections to the database. This parameter affects the concurrent processing capability of the cluster. The default value depends on the cluster specifications. For details, see **Managing Database Connections**.
- **max_active_statements**: specifies the maximum number of concurrent jobs. This parameter applies to all the jobs on one CN. The default value is **60**, which indicates a maximum of 60 jobs can run at the same time. Other jobs will be queued.

Add CNs or Scale out a Cluster?

- Insufficient connections: When a cluster is created for the first time, the default number of CNs in the cluster is 3, which can meet the customer's basic connection requirements. If the cluster has a large number of concurrent requests and the number of connections to each CN is large, or the CPU usage of a CN exceeds its capacity, you are advised to add CNs. For details, see **CNs**.
- Insufficient storage capacity and performance: If your business grows and you have higher requirements on storage capacity and performance, or the CPU of your cluster is insufficient, you are advised to scale out your cluster. For details, see **Scaling Out a Cluster**.

With the expansion of cluster nodes, more CNs are needed to meet the distribution requirements of GaussDB(DWS). In short, adding CNs does not necessarily require cluster scale-out. However, after cluster scale-out, CNs may need to be added.

6.8 How Do I Determine When to Perform Node Flavor Change, All Specification Change, Scale-Out, or Scale-In for GaussDB(DWS)?

Resizing a cluster has a great impact on your workloads. It is similar to migrating an old cluster to a new one, with changes on nodes and specifications. You are

advised to perform lightweight operations, such as scale-out, scale-in, and flavor change. The following table lists the application scenarios of the cluster modification options.

Table 6-2 Cluster modification options

Option	Scenario	Remarks
Scale-out	If your business grows and you have higher requirements on storage capacity and performance, or the CPU of your cluster is insufficient, you are advised to scale out your cluster.	-
Scale-in	During off-peak hours when a large amount of cluster capacity is idle, you can reduce the number of nodes to reduce costs.	-
Changing the Node Flavor	This option changes cluster flavors (including CPU, memory, and others) to meet service requirements. It does not change the number of nodes.	Elastic specification change is supported only for storage-compute coupled clusters that use ECSs and EVS disks. You can choose **Change node flavor** to enable elastic specification change.
Changing all specifications	You can resize your cluster when: • Your clusters are BMS clusters or they do not support flavor change. • You want to change the cluster topology instead of scale-out or scale-in which simply adds nodes or delete nodes ring by ring. • Your cluster is aged and you want to change it to a new cluster without migrating data.	Currently, only storage-compute coupled clusters are supported.

6.9 How Do I Choose Between a Small-Specification Multi-Node GaussDB(DWS) Cluster and a Large-Specification Three-Node GaussDB(DWS) Cluster with Identical CPU Cores and Memory?

- Small-flavor many-node:

  If your data volume is small and you have requirement for node scaling, but you have limited budget, you can select a small-flavor many-node cluster.

  For example, a small-flavor cluster (dwsx2.h.2xlarge.4.c6) with 8 cores and 32 GB memory can provide strong computing capabilities. The cluster has a large number of nodes and can process high concurrent requests. In this case, you only need to ensure that the network speed between nodes is normal to avoid cluster performance limitation.

- Large-flavor three-node:

  If you have a large amount of data to be processed, have high requirement on computing, and have a high budget, you can select a large-flavor three-node cluster.

  For example, a large-flavor cluster (dws2.m6.8xlarge.8) with 32 cores and 256 GB memory has faster CPU processing capability and larger memory, and can process data more quickly. However, the cluster has limited nodes, which may cause low performance in high-concurrency scenarios.

6.10 What Are the Differences Between GaussDB(DWS) Cloud SSDs and Local SSDs?

Cloud SSDs support scale-out. Therefore, you are advised to use them. The differences between cloud SSDs and local SSDs are as follows:

- **Cloud SSDs**
  - Cloud SSDs use EVS as storage media and can be scaled out as data grows. This is more flexible.
  - Cloud SSDs are not bound to the ECS flavor. Therefore, you can adjust the flavors of cloud SSDs when needed.
- **Local SSDs**
  - Local SSDs use ECS local disks as storage media. They have fixed capacity and higher performance but cannot be scaled out.
  - If the capacity is insufficient, you have to add more nodes to increase capacity. The flavors of local SSDs cannot be adjusted.

6.11 What Are the Differences Between Hot Data Storage and Cold Data Storage in GaussDB(DWS)?

The biggest difference between hot data storage and cold data storage lies in the storage media.

- Hot data is frequently queried or updated and has high requirements on access response time. It is stored on **DN data disks**.
- Cold data is not updated and is occasionally queried, and does not have high requirements on access response time. It is stored in **OBS**.

Different storage media determine the cost, performance, and application scenarios of the two storage mode, as shown in **Table 6-3**.

Table 6-3 Differences between hot and cold data storage

Storage	Read and Write	Cost	Capacity	Scenario
Hot storage	Fast	High	Fixed and restricted	This mode is applicable to scenarios where the data volume is limited and needs to be frequently read and updated.
Cold storage	Slow	Low	Large and unlimited	This mode is applicable to scenarios such as data archiving. It features low cost and large capacity.

6.12 How Do I Do If the GaussDB(DWS) Scale-In Button Is Unavailable?

Symptom

When a user performs a scale-in operation, the **Scale In** button is unavailable and the user cannot proceed to the next scale-in operation.

Possible Causes

The system verifies the cluster's eligibility for scaling in before each operation. The **Scale In** button is dimmed if the cluster does not qualify.

Solution

Check the cluster configuration information and check whether the scale-in meets the following conditions:

- The cluster consists of rings of four or five hosts each, with primary, standby, and secondary DNs deployed on them. A cluster ring is the smallest unit for scaling in, which requires at least two rings. The system removes nodes from the last ring to the first when scaling in.
- The removed nodes cannot contain the GTM, CM Server, or CN component.
- The cluster status is **Normal**, and no other task information is displayed.
- The cluster tenant account cannot be in the read-only, frozen, or restricted state.
- The cluster is not in logical cluster mode.
- A yearly/monthly cluster to be scaled in cannot be in the grace period.
- The cluster cannot have idle nodes.

7 Account Permissions

7.1 How Does GaussDB(DWS) Isolate Workloads?

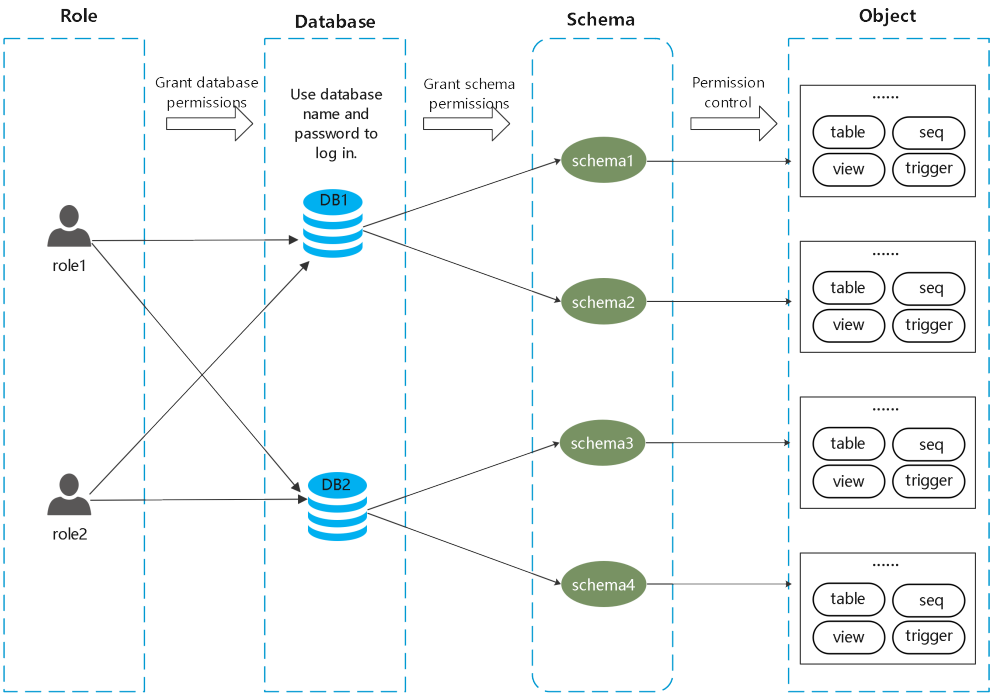
Workload Isolation

In GaussDB(DWS), you can isolate workloads through database and schema configurations. The differences are:

- Databases cannot communicate with each other and share very few resources. Their connections and permissions can be isolated.
- Schemas share more resources than databases do. User permissions on schemas and subordinate objects can be flexibly configured using the **GRANT** and **REVOKE** syntax.

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

Figure 7-1 Used for permission control.



DATABASE

A database is a physical collection of database objects. Resources of different databases are completely isolated (except some shared objects). Databases are used to isolate workloads. Objects in different databases cannot access each other. For example, objects in Database B cannot be accessed in Database A. Therefore, when logging in to a cluster, you must connect to the specified database.

SCHEMA

In a database, database objects are logically divided and isolated based on schemas.

With permission management, you can access and operate objects in different schemas in the same session. Schemas contain objects that applications may access, such as tables, indexes, data in various types, functions, and operators.

Database objects with the same name cannot exist in the same schema, but object names in different schemas can be the same.

```
gaussdb=> CREATE SCHEMA myschema;
CREATE SCHEMA
gaussdb=> CREATE SCHEMA myschema_1;
CREATE SCHEMA

gaussdb=> CREATE TABLE myschema.t1(a int, b int) DISTRIBUTE BY HASH(b);
CREATE TABLE
gaussdb=> CREATE TABLE myschema.t1(a int, b int) DISTRIBUTE BY HASH(b);
ERROR:  relation "t1" already exists
gaussdb=> CREATE TABLE myschema_1.t1(a int, b int) DISTRIBUTE BY HASH(b);
CREATE TABLE
```


Schemas logically divide workloads. These workloads are interdependent with the schemas. Therefore, if a schema contains objects, deleting it will cause errors with dependency information displayed.

```
gaussdb=> DROP SCHEMA myschema_1;
ERROR: cannot drop schema myschema_1 because other objects depend on it
Detail: table myschema_1.t1 depends on schema myschema_1
Hint: Use DROP ... CASCADE to drop the dependent objects too.
```

When a schema is deleted, the **CASCADE** option is used to delete the objects that depend on the schema.

```
gaussdb=> DROP SCHEMA myschema_1 CASCADE;
NOTICE:  drop cascades to table myschema_1.t1
gaussdb=> DROP SCHEMA
```

USER/ROLE

Users and roles are used to implement permission control on the database server (cluster). They are the owners and executors of cluster workloads and manage all object permissions in clusters. A role is not confined in a specific database. However, when it logs in to the cluster, it must explicitly specify a user name to ensure the transparency of the operation. A user's permissions to a database can be specified through permission management.

A user is the subject of permissions. Permission management is actually the process of deciding whether a user is allowed to perform operations on database objects.

Permissions Management

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

- System permission

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

  They can be specified only by the **CREATE ROLE** or **ALTER ROLE** syntax. The **SYSADMIN** permission can be granted and revoked using **GRANT ALL PRIVILEGE** and **REVOKE ALL PRIVILEGE**, respectively. System permissions cannot be inherited by a user from a role, and cannot be granted using **PUBLIC**.

- Permissions

  Grant a role's or user's permissions to one or more roles or users. In this case, every role or user can be regarded as a set of one or more database permissions.

  If **WITH ADMIN OPTION** is specified, the member can in turn grant permissions in the role to others, and revoke permissions in the role as well. If a role or user granted with certain permissions is changed or revoked, the permissions inherited from the role or user also change.

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

- Object permission

  Permissions on a database object (table, view, column, database, function, schema, or tablespace) can be granted to a role or user. The **GRANT**

command can be used to grant permissions to a user or role. These permissions granted are added to the existing ones.

Schema Isolation Example

Example 1:

By default, the owner of a schema has all permissions on objects in the schema, including the delete permission. The owner of a database has all permissions on objects in the database, including the delete permission. Therefore, you are advised to strictly control the creation of databases and schemas. Create databases and schemas as an administrator and assign related permissions to users.

Step 1 Assign the permission to create schemas in the **testdb** database to user **user_1** as user **dbadmin**.

```
testdb=> GRANT CREATE ON DATABASE testdb to user_1;
GRANT
```

Step 2 Switch to user **user_1**.

```
testdb=> SET SESSION AUTHORIZATION user_1 PASSWORD '********';
SET
```

Create a schema named **myschema_2** in the **testdb** database as **user_1**.

```
testdb=> CREATE SCHEMA myschema_2;
CREATE SCHEMA
```

Step 3 Switch to the administrator **dbadmin**.

```
testdb=> RESET SESSION AUTHORIZATION;
RESET
```

Create **table t1** in schema **myschema_2** as the administrator **dbadmin**.

```
testdb=> CREATE TABLE myschema_2.t1(a int, b int) DISTRIBUTE BY HASH(b);
CREATE TABLE
```

Step 4 Switch to user **user_1**.

```
testdb=> SET SESSION AUTHORIZATION user_1 PASSWORD '********';
SET
```

Delete table **t1** created by administrator **dbadmin** in schema **myschema_2** as user **user_1**.

```
testdb=> drop table myschema_2.t1;
DROP TABLE
```

----End

Example 2:

Due to the logical isolation of schemas, database objects need to be verified at both the schema level and the object level.

Step 1 Grant the permission on the **myschema.t1** table to **user_1**.

```
gaussdb=> GRANT SELECT ON TABLE myschema.t1 TO user_1;
GRANT
```

Step 2 Switch to user **user_1**.

```
SET SESSION AUTHORIZATION user_1 PASSWORD '********';
SET
```


Query the table **myschema.t1**.

```
gaussdb=> SELECT * FROM myschema.t1;
ERROR:  permission denied for schema myschema
LINE 1: SELECT * FROM myschema.t1;
```

Step 3 Switch to the administrator **dbadmin**.

```
gaussdb=> RESET SESSION AUTHORIZATION;
RESET
```

Grant the permission on the **myschema.t1** table to user **user_1**.

```
gaussdb=> GRANT USAGE ON SCHEMA myschema TO user_1;
GRANT
```

Step 4 Switch to user **user_1**.

```
gaussdb=> SET SESSION AUTHORIZATION user_1 PASSWORD '********';
SET
```

Query the table **myschema.t1**.

```
gaussdb=> SELECT * FROM myschema.t1;
 a | b
---+---
(0 rows)
```

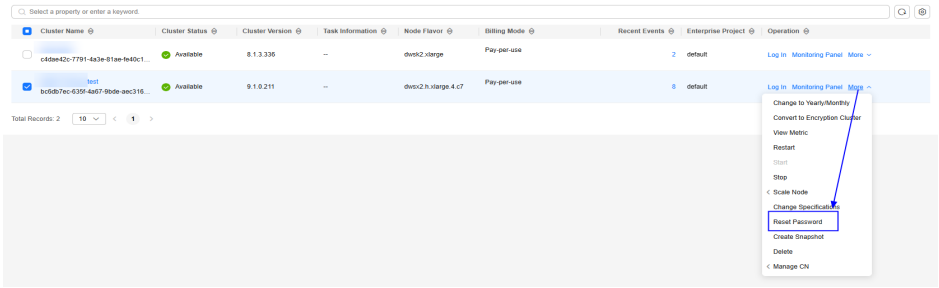
----End

7.2 How Do I Change the Password of a GaussDB(DWS) Database Account When It Expires?

Below are the methods for changing the password of a database account:

- To change the password of user **dbadmin**, log in to the **GaussDB(DWS) console**, locate the target cluster and choose **More** > **Reset Password** in the **Operation** column.

  Figure 7-2 Resetting the password of user dbadmin

- You can also connect to the database and run the **ALTER USER** command to change the password validity period of a database account (common user and administrator dbadmin).

  ```
  ALTER USER username PASSWORD EXPIRATION 90;
  ```


7.3 How Do I Grant Table Permissions to a Specified GaussDB(DWS) User?

This section describes how to grant users the SELECT, INSERT, UPDATE, or full permissions of tables to users.

Syntax

```
GRANT { { SELECT | INSERT | UPDATE | DELETE | TRUNCATE | REFERENCES | TRIGGER | ANALYZE |
ANALYSE } [, ...]
    | ALL [ PRIVILEGES ] }
  ON { [ TABLE ] table_name [, ...]
    | ALL TABLES IN SCHEMA schema_name [, ...] }
  TO { [ GROUP ] role_name | PUBLIC } [, ...]
  [ WITH GRANT OPTION ];
```

Scenario

Assume there are users **u1**, **u2**, **u3**, **u4**, and **u5** and five schemas named after these users. Their permission requirements are as follows:

- User **u2** is a read-only user and requires the SELECT permission for the **u1.t1** table.
- User **u3** requires the INSERT permission for the **u1.t1** table.
- User **u3** requires the UPDATE permission for the **u1.t1** table.
- User **u5** requires all permissions of table **u1.t1**.

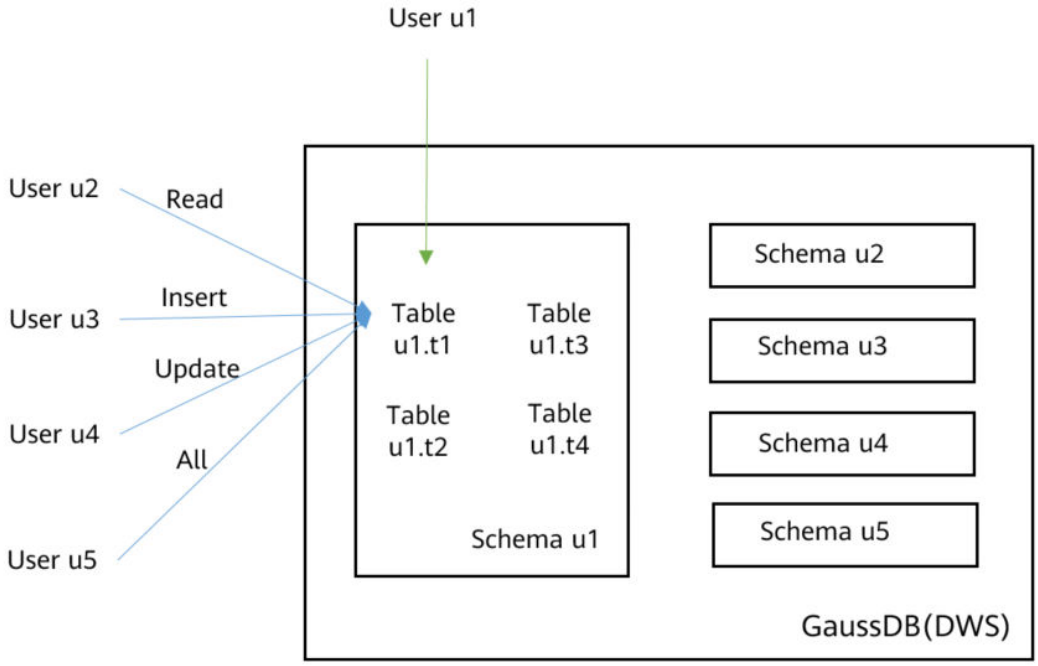


Table 7-1 Permissions of the u1.t1 table

User	Type	GRANT Statement	Query	Insert	Update	Delete
u1	Owner	-	√	√	√	√
u2	Read-only user	`GRANT SELECT ON u1.t1 TO u2;`	√	x	x	x
u3	INSERT user	`GRANT INSERT ON u1.t1 TO u3;`	x	√	x	x
u4	UPDATE user	`GRANT SELECT,UPDATE ON u1.t1 TO u4;` **NOTICE** The UPDATE permission must be granted together with the SELECT permission, or information leakage may occur.	√	x	√	x
u5	Users with all permissions	`GRANT ALL PRIVILEGES ON u1.t1 TO u5;`	√	√	√	√

Procedure

Perform the following steps to grant and verify permissions:

Step 1 Connect to your database as **dbadmin**. Run the following statements to create users **u1** to **u5**. Five schemas will be created and named after the users by default.

```
CREATE USER u1 PASSWORD '{password}';
CREATE USER u2 PASSWORD '{password}';
CREATE USER u3 PASSWORD '{password}';
CREATE USER u4 PASSWORD '{password}';
CREATE USER u5 PASSWORD '{password}';
```

Step 2 Create table **u1.t1** in schema **u1**.

```
CREATE TABLE u1.t1 (c1 int, c2 int);
```

Step 3 Insert two records to the table.


```
INSERT INTO u1.t1 VALUES (1,2);
INSERT INTO u1.t1 VALUES (1,2);
```

Step 4 Grant schema permissions to users.

```
GRANT USAGE ON SCHEMA u1 TO u2,u3,u4,u5;
```

Step 5 Grant user **u2** the permission to query the **u1.t1** table.

```
GRANT SELECT ON u1.t1 TO u2;
```

Step 6 Start a new session and connect to the database as user **u2**. Verify that user **u2** can query the **u1.t1** table but cannot write to or modify the table.

```
SELECT * FROM u1.t1;
INSERT INTO u1.t1 VALUES (1,20);
UPDATE u1.t1 SET c2 = 3 WHERE c1 =1;
```

```
gaussdb=> SELECT * FROM u1.t1;
 c1 | c2
----+----
  1 |  2
  1 |  2
(2 rows)

gaussdb=> INSERT INTO u1.t1 VALUES (1,20);
ERROR:  permission denied for relation t1
gaussdb=> UPDATE u1.t1 SET c2 = 3 WHERE c1 =1;
ERROR:  permission denied for relation t1
```

Step 7 In the session started by user **dbadmin**, grant permissions to users **u3**, **u4**, and **u5**.

```
GRANT INSERT ON u1.t1 TO u3; -- Allow u3 to insert data.
GRANT SELECT,UPDATE ON u1.t1 TO u4; -- Allow u4 to modify the table.
GRANT ALL PRIVILEGES ON u1.t1 TO u5; -- Allow u5 to query, insert, modify, and delete table data.
```

Step 8 Start a new session and connect to the database as user **u3**. Verify that user **u3** can query the **u1.t1** table but cannot query or modify the table.

```
SELECT * FROM u1.t1;
INSERT INTO u1.t1 VALUES (1,20);
UPDATE u1.t1 SET c2 = 3 WHERE c1 =1;
```

```
gaussdb=> SELECT * FROM u1.t1;
ERROR:  permission denied for relation t1
gaussdb=> INSERT INTO u1.t1 VALUES (1,20);
INSERT 0 1
gaussdb=> UPDATE u1.t1 SET c2 = 3 WHERE c1 =1;
ERROR:  permission denied for relation t1
```

Step 9 Start a new session and connect to the database as user **u4**. Verify that user **u4** can modify and query the **u1.t1** table, but cannot insert data to the table.

```
SELECT * FROM u1.t1;
INSERT INTO u1.t1 VALUES (1,20);
UPDATE u1.t1 SET c2 = 3 WHERE c1 =1;
```



```
gaussdb=> SELECT * FROM u1.t1;
 c1 | c2
----+----
  1 |  2
  1 |  2
  1 | 20
(3 rows)

gaussdb=> INSERT INTO u1.t1 VALUES (1,20);
ERROR:  permission denied for relation t1
gaussdb=> UPDATE u1.t1 SET c2 = 3 WHERE c1 =1;
UPDATE 3
```

Step 10 Start a new session and connect to the database as user **u5**. Verify that user **u5** can query, insert, modify, and delete data in the **u1.t1** table.

```
SELECT * FROM u1.t1;
INSERT INTO u1.t1 VALUES (1,20);
UPDATE u1.t1 SET c2 = 3 WHERE c1 =1;
DELETE FROM u1.t1;
```

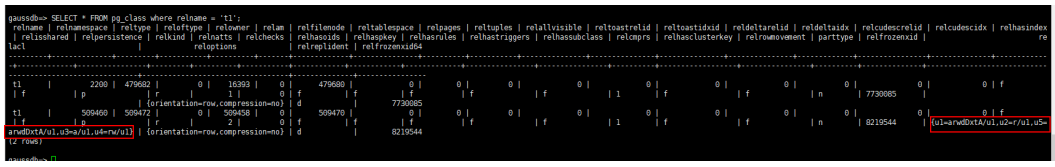
```
gaussdb=> SELECT * FROM u1.t1;
 c1 | c2
----+----
  1 |  3
  1 |  3
  1 |  3
(3 rows)

gaussdb=> INSERT INTO u1.t1 VALUES (1,20);
INSERT 0 1
gaussdb=> UPDATE u1.t1 SET c2 = 3 WHERE c1 =1;
UPDATE 4
gaussdb=> DELETE FROM u1.t1;
DELETE 4
```

Step 11 In the session started by user **dbadmin**, execute the has_table_privilege function to query user permissions.

```
SELECT * FROM pg_class WHERE relname = 't1';
```

Check the **relacl** column in the command output. *rolename*=*xxxx*/*yyyy* indicates that *rolename* has the *xxxx* permission on the table and the permission is obtained from *yyyy*.

The following figure shows the command output.



- **u1=arwdDxtA/u1** indicates that **u1** is the owner and has full permissions.
- **u2=r/u1** indicates that **u2** has the read permission.
- **u3=a/u1** indicates that **u3** has the insert permission.
- **u4=rw/u1** indicates that **u4** has the read and update permissions.
- **u5=arwdDxtA/u1** indicates that **u5** has full permissions.

----End

7.4 How Do I Grant the Permissions of a Schema to a Specified GaussDB(DWS) User?

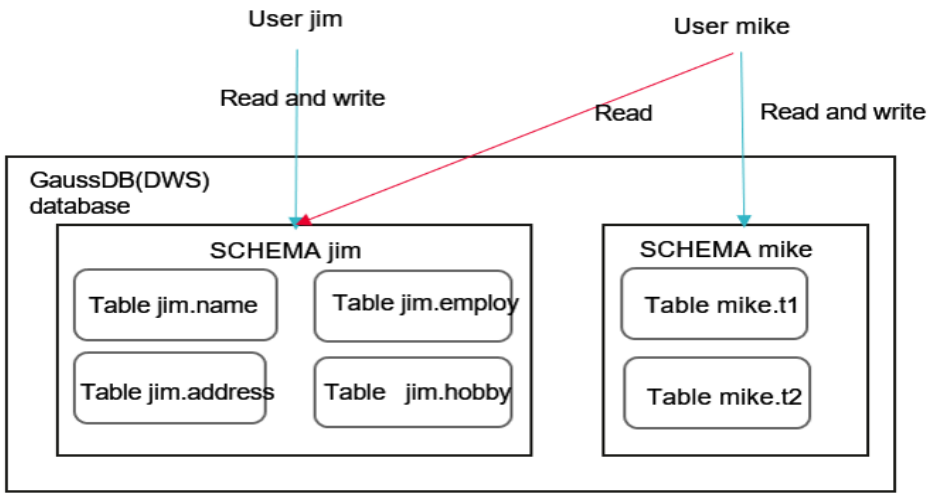
This section explains how to give query permission for schema-level permissions. If you need other permissions, see **How Do I Grant Table Permissions to a User?**

- Permission for a table in a schema
- Permission for all the tables in a schema
- Permission for tables to be created in the schema

> **CAUTION**
>
> The VACUUM, DROP, and ALTER permissions on foreign tables cannot be granted to users.

Assume that there are users **jim** and **mike**, and two schemas named after them. User **mike** needs to access tables in schema **jim**, as shown in **Figure 7-3**.

Figure 7-3 User **mike** accesses a table in SCHEMA **jim**.



Step 1 Connect to your database as **dbadmin**. Run the following statements to create users **jim** and **mike**. Two schemas will be created and named after the users by default.

```
CREATE USER jim PASSWORD '{password}';
CREATE USER mike PASSWORD '{password}';
```

Step 2 Create tables **jim.name** and **jim.address** in schema **jim**.


```
CREATE TABLE jim.name (c1 int, c2 int);
CREATE TABLE jim.address (c1 int, c2 int);
```

Step 3 Grant the access permission of schema **jim** to user **mike**.

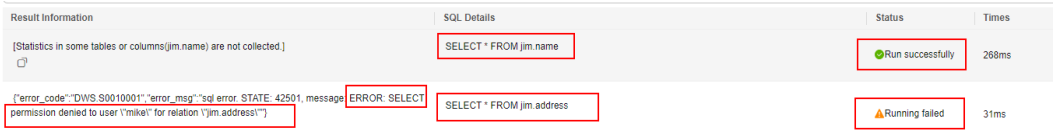
```
GRANT USAGE ON SCHEMA jim TO mike;
```

Step 4 Grant user **mike** the permission to query table **jim.name** in schema **jim**.

```
GRANT SELECT ON jim.name TO mike;
```

Step 5 Start a new session and connect to the database as user **mike**. Verify that user **mike** can query the **jim.name** table but not the **jim.address** table.

```
SELECT * FROM jim.name;
SELECT * FROM jim.address;
```

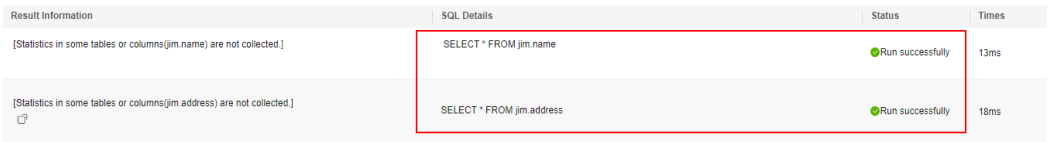


Step 6 In the session started by user **dbadmin**, grant user **mike** the permission to query all the tables in schema **jim**.

```
GRANT SELECT ON ALL TABLES IN SCHEMA jim TO mike;
```

Step 7 In the session started by user **mike**, verify that **mike** can query all tables.

```
SELECT * FROM jim.name;
SELECT * FROM jim.address;
```



Step 8 In the session started by user **dbadmin**, create table **jim.employ**.

```
CREATE TABLE jim.employ (c1 int, c2 int);
```

Step 9 In the session started by user **mike**, verify that user **mike** does not have the query permission for **jim.employ**. It indicates that user **mike** has the permission to access all the existing tables in schema **jim**, but not the tables to be created in the future.

```
SELECT * FROM jim.employ;
```

Step 10 In the session started by user **dbadmin**, grant user **mike** the permission to query the tables to be created in schema **jim**. Create table **jim.hobby**.

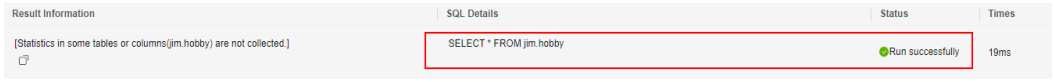
NOTE

ALTER DEFAULT PRIVILEGES is used to grant permissions on objects to be created.

```
ALTER DEFAULT PRIVILEGES FOR ROLE jim IN SCHEMA jim GRANT SELECT ON TABLES TO mike;
CREATE TABLE jim.hobby (c1 int, c2 int);
```

Step 11 In the session started by user **mike**, verify that user **mike** can access table **jim.hobby**, but does not have the permission to access **jim.employ**. To let the user access table **jim.employ**, you can grant permissions by performing **Step 4**.

```
SELECT * FROM jim.hobby;
```

----End

7.5 How Do I Create a GaussDB(DWS) Database Read-Only User?

Scenario

In service development, database administrators use schemas to classify data. For example, in the financial industry, liability data belong to schema **s1**, and asset data belong to schema **s2**.

Now you have to create a read-only user **user1** in the database. The user can access all tables (including new tables to be created in the future) in schema **s1** for daily reading, but cannot insert, modify, or delete data.

Principles

GaussDB(DWS) provides role-based user management. You need to create a read-only role **role1** and grant the role to **user1**. For details, see **Role-based Access Control**.

Procedure

Step 1 Connect to the GaussDB(DWS) database as user **dbadmin**.

Step 2 Run the following SQL statement to create role **role1**:

```
CREATE ROLE role1 PASSWORD disable;
```

Step 3 Run the following SQL statement to grant permissions to **role1**:

```
The GRANT usage ON SCHEMA s1 TO role1; -- grants the access permission to schema s1.
GRANT select ON ALL TABLES IN SCHEMA s1 TO role1;    --grants the query permission on all tables in schema s1.
ALTER DEFAULT PRIVILEGES FOR USER tom IN SCHEMA s1 GRANT select ON TABLES TO role1; -- grants schema s1 the permission to create tables. tom is the owner of schema s1.
```

Step 4 Run the following SQL statement to grant the role **role1** to the actual user **user1**:

```
GRANT role1 TO user1;
```

Step 5 Grant read-only access to user1 for a foreign table in schema **s1**.

```
ALTER USER user1 USEFT;
```

Without proper permissions, querying the foreign table as a read-only user will result in the error message "ERROR: permission denied to select from foreign table in security mode."

Step 6 Read all table data in schema **s1** as read-only user **user1**.

----End

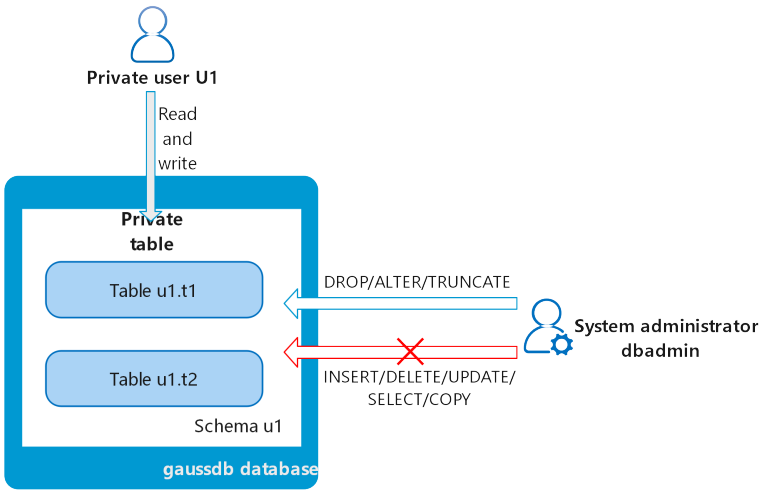
7.6 How Do I Create Private Users and Tables in a GaussDB(DWS) Database?

Scenario

The system administrator **dbadmin** has the permission to access tables created by common users by default. When **Separation of Permissions** is enabled, the administrator **dbadmin** does not have the permission to access tables of common users or perform control operations (DROP, ALTER, and TRUNCATE).

If a private user and a private table (table created by the private user) need to be created, and the private table can be accessed only by the private user and the system administrator **dbadmin** and other common users do not have the permission to access the table (INSERT, DELETE, UPDATE, SELECT, and COPY). However, the system administrator **dbadmin** sometimes need to perform the DROP, ALTER, or TRUNCATE operations without authorization from the private user. In this case, you can create a user (private user) with the INDEPENDENT attribute.

Figure 7-4 Private users



Principles

This function is implemented by creating a user with the INDEPENDENT attribute.

INDEPENDENT | NOINDEPENDENT defines private and independent roles. For a role with the **INDEPENDENT** attribute, administrators' rights to control and access this role are separated. Specific rules are as follows:

- Administrators have no rights to add, delete, query, modify, copy, or authorize the corresponding table objects without the authorization from the INDEPENDENT role.
- Administrators have no rights to modify the inheritance relationship of the INDEPENDENT role without the authorization from this role.

- Administrators have no rights to modify the owner of the table objects for the INDEPENDENT role.
- Administrators have no rights to change the database password of the INDEPENDENT role. The INDEPENDENT role must manage its own password, which cannot be reset if lost.
- The **SYSADMIN** attribute of a user cannot be changed to the **INDEPENDENT** attribute.

Procedure

Step 1 Connect to the GaussDB(DWS) database as user **dbadmin**.

Step 2 Run the following SQL statement to create private user **u1**:

```
CREATE USER u1 WITH INDEPENDENT IDENTIFIED BY 'password';
```

Step 3 Switch to user **u1**, create the table **test**, and insert data into the table.

```
CREATE TABLE test (id INT, name VARCHAR(20));
INSERT INTO test VALUES (1, 'joe');
INSERT INTO test VALUES (2, 'jim');
```

Step 4 Switch to user **dbadmin** and run the following SQL statement to check whether user **dbadmin** can access the private table **test** created by private user **u1**:

```
SELECT * FROM u1.test;
```

The query result indicates that the user **dbadmin** does not have the access permission. This means the private user and private table are created successfully.

```
gaussdb=> SELECT * FROM u1.test;
ERROR:  SELECT permission denied to user "dbadmin" for relation "u1.test"
```

Step 5 Run the **DROP** statement as user **dbadmin** to delete the table **test**.

```
DROP TABLE u1.test;
```

```
gaussdb=> drop table u1.test;
DROP TABLE
```

----End

7.7 How Do I Revoke the CONNECT ON DATABASE Permission of a User on GaussDB(DWS)?

Scenario

In a service, the permission of user **u1** to connect to a database needs to be revoked. After the **REVOKE CONNECT ON DATABASE *gaussdb* FROM u1;** command is executed successfully, user **u1** can still connect to the database. This means the revocation does not take effect.

Cause Analysis

If you run the **REVOKE CONNECT ON DATABASE gaussdb from u1** command to revoke the permissions of user **u1**, the revocation does not take effect because the

CONNECT permission of the database is granted to **PUBLIC**. Therefore, you need to specify **PUBLIC**.

- GaussDB(DWS) provides an implicitly defined group **PUBLIC** that contains all roles. By default, all new users and roles have the permissions of **PUBLIC**. To revoke permissions of **PUBLIC** from a user or role, or re-grant these permissions to them, add the **PUBLIC** keyword in the **REVOKE** or **GRANT** statement.
- GaussDB(DWS) grants the permissions on certain types of objects to **PUBLIC**. By default, permissions on tables, columns, sequences, foreign data sources, foreign servers, schemas, and tablespaces are not granted to **PUBLIC**, but the following permissions are granted to **PUBLIC**;
  - **CONNECT** permission of a database
  - **CREATE TEMP TABLE** permission of a database
  - **EXECUTE** permission of a function
  - **USAGE** permission for languages and data types (including domains)
- An object owner can revoke the default permissions granted to **PUBLIC** and grant permissions to other users as needed.

Example Operations

Run the following command to revoke the permission for user **u1** to access database **gaussdb**:

Step 1 Connect to the GaussDB(DWS) database **gaussdb**.

```
gsql -d gaussdb -p 8000 -h 192.168.x.xx -U dbadmin -W password -r
gaussdb=>
```

Step 2 Create user **u1**.

```
gaussdb=> CREATE USER u1 IDENTIFIED BY 'xxxxxxxx';
```

Step 3 Verify that user **u1** can access GaussDB.

```
gsql -d gaussdb -p 8000 -h 192.168.x.xx -U u1 -W password -r
gaussdb=>
```

Step 4 Connect to database **gaussdb** as administrator **dbadmin** and run the REVOKE command to revoke the **connect on database** permission of user **public**.

```
gsql -d gaussdb -h 192.168.x.xx -U dbadmin -p 8000 -r
gaussdb=> REVOKE CONNECT ON DATABASE gaussdb FROM public;
REVOKE
```

Step 5 Verify the result. Use **u1** to connect to the database. If the following information is displayed, the **connect on database** permission of user **u1** has been revoked successfully:

```
gsql -d gaussdb -p 8000 -h 192.168.x.xx -U u1 -W password -r
gsql: FATAL:  permission denied for database "gaussdb"
DETAIL:  User does not have CONNECT privilege.
```

----End

7.8 How Do I View the Table Permissions of a GaussDB(DWS) User?

Scenario 1: Run the **information_schema.table_privileges** command to **view the table permissions of a user**. Example:

```
SELECT * FROM information_schema.table_privileges WHERE GRANTEE='user_name';
```

```
gaussdb=> SELECT * FROM information_schema.table_privileges WHERE GRANTEE='u2';
 grantor | grantee | table_catalog | table_schema | table_name | privilege_type | is_grantable | with_hierarchy
---------+---------+---------------+--------------+------------+----------------+--------------+----------------
 u2      | u2      | gaussdb       | u2           | t2         | INSERT         | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | SELECT         | YES          | YES
 u2      | u2      | gaussdb       | u2           | t2         | UPDATE         | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | DELETE         | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | TRUNCATE       | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | REFERENCES     | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | TRIGGER        | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | ANALYZE        | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | VACUUM         | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | ALTER          | YES          | NO
 u2      | u2      | gaussdb       | u2           | t2         | DROP           | YES          | NO
 u1      | u2      | gaussdb       | u1           | t1         | SELECT         | NO           | YES
(12 rows)
```

Table 7-2 table_privileges columns

Column	Data Type	Description
grantor	sql_identifier	Permission grantor
grantee	sql_identifier	Permission grantee
table_catalog	sql_identifier	Database where the table is
table_schema	sql_identifier	Schema where the table is
table_name	sql_identifier	Table name
privilege_type	character_data	Type of the granted permission. The value can be **SELECT**, **INSERT**, **UPDATE**, **DELETE**, **TRUNCATE**, **REFERENCES**, **ANALYZE**, **VACUUM**, **ALTER**, **DROP**, or **TRIGGER**.
is_grantable	yes_or_no	Indicates if the permission can be granted to other users. **YES** indicates that the permission can be granted to other users, and **NO** indicates that the permission cannot be granted to other users.
with_hierarchy	yes_or_no	Indicates if specific operations are allowed to be inherited at the table level. If the specific operation is **SELECT**, **YES** is displayed. Otherwise, **NO** is displayed.

In the preceding figure, user **u2** has all permissions of table **t2** in schema **u2** and the **SELECT** permission of table **t1** in schema **u1**.

information_schema.table_privileges can query only the permissions directly granted to the user, the **has_table_privilege()** function can query both directly

granted permissions and indirect permissions (obtained by GRANT role to user). For example:

```
CREATE TABLE t1 (c1 int);
CREATE USER u1 password '********';
CREATE USER u2 password '********';
GRANT dbadmin to u2; //Indirectly grant permissions through roles.
GRANT SELECT on t1 to u1; // Directly grant the permission.

SET ROLE u1 password '********';
SELECT * FROM public.t1; // Directly grant the permission to access the table.
 c1
----
(0 rows)

SET ROLE u2 password '********';
SELECT * FROM public.t1; // Indirectly grant the permission to access the table.
 c1
----
(0 rows)

RESET role; //Switch back to dbadmin.
SELECT * FROM information_schema.table_privileges WHERE table_name = 't1'; // Can only view direct grants.
 grantor |  grantee   | table_catalog | table_schema | table_name | privilege_type | is_grantable | with_hierarchy
---------+------------+---------------+--------------+------------+----------------+--------------+----------------
 dbadmin | u1         | gaussdb       | public       | t1         | SELECT         | NO           | YES
(1 rows)

SELECT has_table_privilege('u2', 'public.t1', 'select'); // Can view both direct and indirect grants.
 has_table_privilege
---------------------
 t
(1 row)
```

Scenario 2: To **check whether a user has permissions on a table**, perform the following steps:

Step 1 Query the **pg_class** system catalog.

```
SELECT * FROM pg_class WHERE relname = 'tablename';
```

Check the **relacl** column. The command output is shown in the following figure. For details about the permission parameters, see **Table 7-3**.

- *rolename*=*xxxx*/*yyyy*: indicates that *rolename* has the *xxxx* permission on the table and the permission is obtained from *yyyy*.
- =*xxxx*/*yyyy*: indicates that **public** has the *xxxx* permission on the table and the permission is obtained from *yyyy*.

Take the following figure as an example:

joe=arwdDxtA: indicates that user **joe** has all permissions (**ALL PRIVILEGES**).

leo=arw/joe: indicates that user **leo** has the read, write, and modify permissions, which are granted by user **joe**.

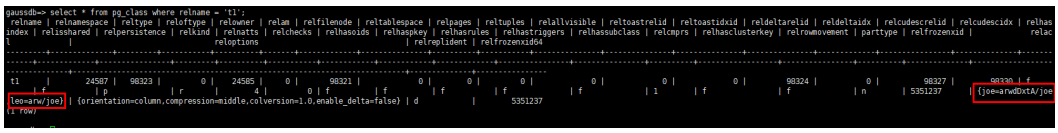


Table 7-3 Permissions parameters

Parameter	Description
r	SELECT (read)
w	UPDATE (write)
a	INSERT (insert)
d	DELETE
D	TRUNCATE
x	REFERENCES
t	TRIGGER
X	EXECUTE
U	USAGE
C	CREATE
c	CONNECT
T	TEMPORARY
A	ANALYZE|ANALYSE
arwdDxtA	ALL PRIVILEGES (for tables)
*	Actions for preceding permissions

Step 2 You can also use the **has_table_privilege** function to query user permissions on tables.

```
SELECT * FROM has_table_privilege('Username','Table_name', 'select');
```

For example, query whether user **joe** has the query permission on table **t1**.

```
SELECT * FROM has_table_privilege('joe','t1','select');
```

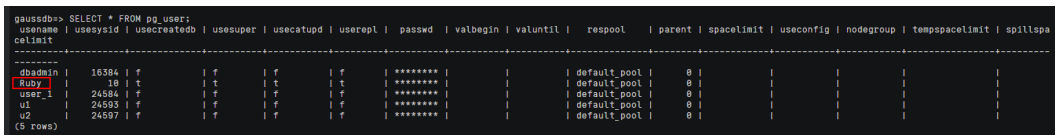
```
gaussdb=> select * from has_table_privilege('joe','t1','select');
 has_table_privilege
---------------------
 t
(1 row)
```

----End

7.9 Who Is the Ruby User in the GaussDB(DWS) Database?

When you run the **SELECT * FROM pg_user** statement to view the users in the system, you will find the **Ruby** user with extensive permissions.

User **Ruby** is an official O&M Account. After creating a GaussDB(DWS) database, a **Ruby** account is automatically generated, involving no security risks; feel free to use it.



```
gaussdb=> SELECT * FROM pg_user;
 usename | usesysid | usecreatedb | usesuper | usecatupd | userepl |  passwd  | valbegin | valuntil |   respool    | parent | spacelimit | useconfig | nodegroup | tempspacelimit | spillspa
celimit
---------+----------+-------------+----------+-----------+---------+----------+----------+----------+--------------+--------+------------+-----------+-----------+----------------+---------
 dbadmin |    16384 | f           | f        | f         | f       | ******** |          |          | default_pool |      0 |            |           |           |                |
 Ruby    |       10 | t           | t        | t         | t       | ******** |          |          | default_pool |      0 |            |           |           |                |
 user_1  |    24584 | f           | f        | f         | f       | ******** |          |          | default_pool |      0 |            |           |           |                |
 u1      |    24593 | f           | f        | f         | f       | ******** |          |          | default_pool |      0 |            |           |           |                |
 u2      |    24597 | f           | f        | f         | f       | ******** |          |          | default_pool |      0 |            |           |           |                |
(5 rows)
```


8 Database Performance

8.1 Why Is SQL Execution Slow After Using GaussDB(DWS) for a Period of Time?

After a database is used for a period of time, the table data increases as services grow, or the table data is frequently added, deleted, or modified. As a result, bloating tables and inaccurate statistics are incurred, deteriorating database performance.

You are advised to periodically run **VACUUM FULL** and **ANALYZE** on tables that are frequently added, deleted, or modified. Perform the following operations:

Step 1 By default, 100 out of 30,000 records of statistics are collected. When a large amount of data is involved, the SQL execution is unstable, which may be caused by a changed execution plan. In this case, the sampling rate needs to be adjusted for statistics. You can run **set default_statistics_target** to increase the sampling rate, which helps the optimizer generate the optimal plan.

```
gaussdb=> set default_statistics_target=-2;
SET
```

Step 2 Run **ANALYZE** again. For details, see **ANALYZE | ANALYSE**.

```
gaussdb=> ANALYZE customer_t1;
ANALYZE
```

----End

NOTE

To test whether disk fragments affect database performance, use the following function:

```
SELECT * FROM pgxc_get_stat_dirty_tables(30,100000);
```


8.2 Why Doesn't GaussDB(DWS) Perform Better Than a Single-Node Database in Extreme Scenarios?

Due to the MPP architecture limitation in GaussDB(DWS), a few PostgreSQL system methods and functions cannot be pushed down to DNs for execution. As a result, performance bottlenecks occur only on CNs.

Explanation:

- An operation can be executed concurrently only when it is logically a concurrent operation. For example, SUM performed on all DNs concurrently must centralize the final summarization on one CN. In this case, most of the summarization work has been completed on DNs, so the work on the CN is relatively lightweight.
- In some scenarios, the operation must be executed centrally on one node. For example, assigning a globally unique name to a transaction ID is implemented using the system GTM. Therefore, the GTM is also a globally unique component (active/standby). All globally unique tasks are implemented through the GTM in GaussDB(DWS), but software code is optimized to reduce this kind of tasks. Therefore, the GTM does not have much of a bottleneck. In some scenarios, GTM-Free and GTM-Lite can be implemented.
- To ensure excellent performance, services need to be slightly modified for adaptation during migration from the application development mode of the traditional single-node database to that of the parallel database, especially for the traditional stored procedure nesting of Oracle.

Solutions:

- If such a problem occurs, see the section about query performance tuning in the **GaussDB(DWS) Developer Guide**.
- Alternatively, contact technical support to modify and optimize services.

8.3 How Do I View SQL Execution Records in a Certain Period When GaussDB(DWS) Read and Write Are Blocked?

You can use the top SQL feature to view SQL statements executed in a specified period. SQL statements of the current CN or all CNs can be viewed.

Top SQL allows you to view real-time and historical SQL statements.

- For details about real-time SQL query, see **Real-Time Top SQL**.
- For details about real-time SQL query, see **Historical Top SQL**.

8.4 What is Operator Spilling in GaussDB(DWS)?

During query execution, if the cluster memory is insufficient, the database will choose to store the temporary results to the disk. When the disk storage used by

the temporary results exceeds a certain value, users will receive an alarm: "data spilling exceeds the threshold". What does spilling mean?

Operator Spilling to Disks

Any computing consumes memory space. If too much memory is consumed, the memory for running other jobs will be insufficient, causing unstable job running. Therefore, you need to limit the memory usage of query statements to ensure job running stability.

If a job running requires 500 MB memory but only 300 MB memory is allocated to it, data that is not used temporarily needs to be written to disks, and only data that is being used is retained in the memory. This is called data spilling. It is also called **operator spilling**. In addition to significantly affecting query performance, excessively large operator write-to-disk space may also cause the database to become read-only or result in a full disk. To address this, GaussDB(DWS) offers user-defined operator space limits to restrict the size of data written to disk by their operators. If the size exceeds the specified limit, an error is reported during the query, causing it to exit.

Which operators can spill?

Currently, GaussDB(DWS) supports writing six types of operators (including 10 vectorized and non-vectorized operators) to disk: **Hash(VecHashJoin)**, **Agg(VecAgg)**, **Sort(VecSort)**, **Material(VecMaterial)**, **SetOp(VecSetOp)**, and **WindowAgg (VecWindowAgg)**.

Which parameters can be used to control the operator spilling?

- **work_mem**: sets spilling threshold. Disk usage exceeding this parameter will cause operator spilling. This parameter takes effect only when the memory is not self-adaptive. (**enable_dynamic_workload**=**off**). It ensures concurrent throughput and the performance of a single query job. Therefore, you need to optimize the parameter based on the output of **Explain Performance**.
- **temp_file_limit**: limits the size of files spilled to disks. You are advised to set this parameter based on the site requirements to prevent spilled files from using up the disk space. Spilled files exceeding the value of this parameter will cause an error.

How Do I Know Whether a Statement Is Spilled to Disks?

- Check the spill files. The spill files are stored in the **base/pgsql_tmp** directory of the instance directory. The spill files are named *pgsql_tmp$queryid_$pid*. You can determine which SQL statement is spilled to the disk based on the **queryid**.
- Check the waiting view (**pgxc_thread_wait_status**). If **write file** is displayed in the waiting view, there are temporary results spilled to disks.
- Check the execution plan (**EXPLAIN PERFORMANCE**). Keywords such as **spill**, **written disk**, and **temp file num** indicates that there is an operator spilling.
- Check whether the **spill_info** column in **Real-Time Top SQL** or **Historical Top SQL** contains spill information. If this column is not empty, data has been spilled to disks on DNs. (Prerequisite: The topsql function has been enabled.)

How Do I Avoid Spilling?

When operators are spilled to disks, operator calculation data is written to disks. Compared with memory access, disk operations are slow, causing performance deterioration and query response time deterioration. Therefore, try to avoid operator spilling during query execution. You are advised to use the following methods:

- Reduce the intermediate result set: If the intermediate result set is too large, you can add filter criteria to reduce the size of the intermediate result set.
- Avoid data skew: If there is a severe data skew, spilling will occur on a DN that has a large amount of data.
- Perform **ANALYZE** in a timely manner: When the statistics are inaccurate, the number of rows may be estimated to be smaller. As a result, the plan is not optimal and data is spilled to disks.
- Perform single-point optimization: Perform optimization on single SQL statements.
- If the memory is not self-adaptive, and the intermediate result set cannot be reduced, increase the value of **work_mem** as proper.
- If the memory is self-adaptive, increase the available memory of the database as much as possible to reduce the probability of data spilling.

8.5 GaussDB(DWS) CPU Resource Isolation

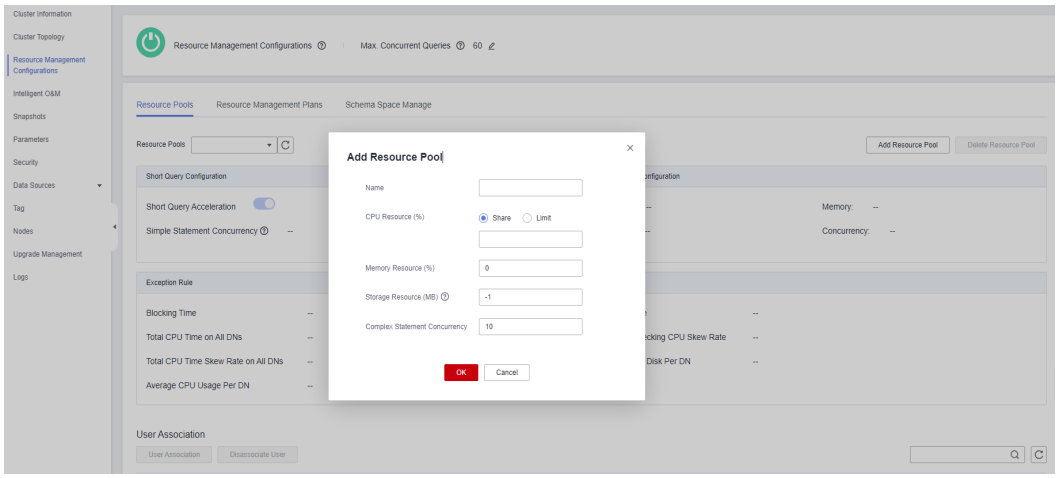
Overview of CPU Resource Management

In different service scenarios, system resources (CPU, memory, I/O, and storage resources) of the database are properly allocated to queries to ensure query performance, and service stability.

GaussDB(DWS) allows you to divide resources into different resource pools based on service requirements, with resources in separate pools being isolated from one another. Then, you can associate database users with these resource pools. When a user starts a SQL query, the query will be transferred to the resource pool associated with the user. You can specify the number of queries that can be concurrently executed in a resource pool, the upper limit of memory used for a single query, and the memory and CPU resources that can be used by a resource pool. In this way, you can limit and isolate the resources occupied by different workloads.

GaussDB(DWS) primarily utilizes cgroups to manage and control CPU resources, which involves the CPU, cpuacct, and cpuset subsystems. CPU share is implemented based on the CPU subsystem cpu.shares. The advantages of CPU share are as follows: CPU control is not triggered when the OS CPU is not fully occupied. CPU limit is implemented based on cpuset, which is a CPU subsystem used to monitor CPU resource usage.

To add a resource pool on the **GaussDB(DWS) console**, you can choose **Share** or **Limit** to manage CPU resources as needed.



CPU Share

CPU Share: Percentage of CPU time that can be used by users associated with the current resource pool to execute jobs.

The share has two meanings:

- **Share**: The CPU is shared by all Cgroups, and other Cgroups can use idle CPU resources.
- **Limit**: When the CPU is fully loaded during peak hours, Cgroups preempt CPU resources based on their limits.

CPU share is implemented based by cpu.shares and takes effect only when the CPU is fully loaded. When the CPU is idle, there is no guarantee that a Cgroup will preempt CPU resources appropriate to its quota. There can still be resource contention when the CPU is idle. Tasks in a Cgroup can use CPU resources without restriction. Although the average CPU usage may not be high, CPU resource contention may still occur at a specific time.

For example, 10 jobs are running on 10 CPUs, and one job is running on each CPU. In this case, any job request for CPU resources will be responded instantly, and there is no contention. If 20 jobs are running on 10 CPUs, the CPU usage may still not be high because the jobs do not always occupy the CPU and may wait for I/O and network resources. The CPU resources seem idle. However, if 2 or more jobs request one CPU at the same time, CPU resource contention occurs, affecting job performance.

CPU Limit

CPU Limit: specifies the percentage of the maximum number of CPU cores that can be used by a database user in the resource pool.

The limit has two meanings:

- Exclusive: Only the CPU core resources of the Cgroup are limited.
- Quota: Only the CPU resources in the allocated quota can be used. Idle CPU resources of other Cgroups cannot be preempted.

CPU limit is implemented based on cpuset.cpu. You can set a proper quota to implement absolute isolation of CPU resources between Cgroups. In this way, tasks

of different Cgroups will not affect each other. However, the absolute CPU isolation will cause idle CPU resources in a Cgroup to be wasted. Therefore, the limit cannot be too large. A larger limit may not bring a better performance.

For example, in one case, 10 jobs are running on 10 CPUs and the average CPU usage is about 5%. In another case, 10 jobs are running on 5 CPUs and the average CPU usage is about 10%. According to the preceding analysis, although the CPU usage is low when 10 jobs run on five CPUs. However, CPU resource contention still exists. Therefore, the performance of running 10 jobs on 10 CPUs is better than that of running 10 jobs on 5 CPUs. However, it is not the more CPUs, the better. If ten jobs run on 20 CPUs, at any time point, at least 10 CPUs are idle. Therefore, theoretically, running 10 jobs on 20 CPUs does not have better performance than running 10 CPUs. For a Cgroup with a concurrency of N, if the number of allocated CPUs is less than N, the job performance is better with more CPUs. However, if the number of allocated CPUs is greater than N, the job performance will not be improved with more CPUs.

Application Scenarios of CPU Resource Management

The CPU limit and CPU share both have their own advantages and disadvantages. CPU share can fully utilize CPU resources. However, resources of different Cgroups are not completely isolated, which may affect the query performance. CPU limit can implement absolute isolation of CPU resources. However, idle CPU resources will be wasted. Compared with CPU limit, CPU share has higher CPU usage and overall job throughput. Compared with CPU share, CPU limit has complete CPU isolation, which can better meet the requirements of performance-sensitive users.

If CPU contention occurs when multiple types of jobs are running in the database system, you can select different CPU resource control modes based on different scenarios.

- Scenario 1: Fully utilize CPU resources. Focus on the overall CPU throughput instead of the performance of a single type of jobs.

  Suggestion: You are advised not to isolate CPUs for individual users as any CPU management can impact overall CPU usage.

- Scenario 2: A certain degree of CPU resource contention and performance loss are allowed. When the CPU is idle, the CPU resources are fully utilized. When the CPU is fully loaded, each service type needs to use the CPU proportionally.

  Suggestion: You can use CPU share to improve the overall CPU usage while implementing CPU isolation and control when the CPUs are fully loaded.

- Scenario 3: Some jobs are sensitive to performance and CPU resource waste is allowed.

  Suggestion: You can use CPU limit to implement absolute CPU isolation between different types of jobs.

8.6 Why Do Regular GaussDB(DWS) Users Run Statements Slower Than User dbadmin?

There are three main scenarios where regular GaussDB(DWS) users experience slower execution compared to user **dbadmin**.

Scenario 1: Impact of Resource Management on Common Users

Common users often find themselves waiting in various queues, such as the global queue or the CCN queue.

1. Reasons for common users waiting in queues or global queues

   The primary reason for this queueing is the high number of active statements exceeding the maximum value set for **max_active_statements**. Administrators are exempt from queueing as they are not subject to any control measures. Modify the **max_active_statements** parameter on the **GaussDB(DWS) console**.

   a. Log in to the **GaussDB(DWS) console**.

   b. Choose **Dedicated Clusters** > **Clusters** in the navigation tree on the left.

   c. In the cluster list, find the target cluster and click the cluster name. The **Cluster Information** page is displayed.

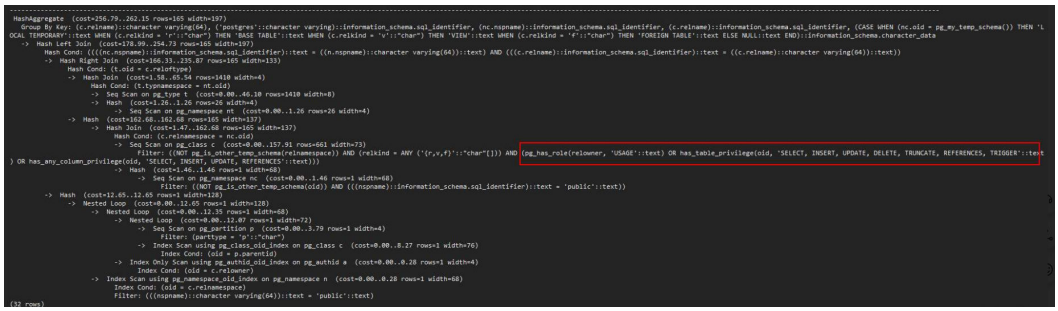
   d. Click **Parameter Modifications**, search for **max_active_statements**, modify its value, and click **Save**. After confirming that the value is correct, click **Save**.

Scenario 2: Executing OR Conditions on Common User Statements Is Time-Consuming

The **OR** conditions in the execution plans contain permission-related checks. This scenario usually occurs when the system view is used. For example, in the following SQL statement:

```
SELECT distinct(dtp.table_name),
 ta.table_catalog,
 ta.table_schema,
 ta.table_name,
 ta.table_type
from information_schema.tables ta left outer join DBA_TAB_PARTITIONS dtp
on (dtp.schema = ta.table_schema and dtp.table_name = ta.table_name)
where ta.table_schema = 'public';
```

Part of the execution plan is as follows:



In the system view, the **OR** condition is used for permission check.

```
pg_has_role(c.relowner, 'USAGE'::text) OR has_table_privilege(c.oid, 'SELECT, INSERT, UPDATE, DELETE,
TRUNCATE, REFERENCES, TRIGGER'::text) OR has_any_column_privilege(c.oid, 'SELECT, INSERT, UPDATE,
REFERENCES'::text)
```

true is always returned for **pg_has_role** of the **dbadmin** use. Therefore, the conditions after **OR** do not need to be checked.

However, the **OR** condition of common users needs to be checked one by one. If there are a large number of tables in the database, the execution time of common users is longer than that of **dbadmin**.

In this scenario, if the number of output result sets is small, you can set **set enable_hashjoin** and **set enable_seqscan** to **off**, to use the index+nestloop plan.

Scenario 3: Differences in Resource Pool Allocation for Common Users and Administrators

Check whether the resource pools corresponding to the user are the same. If they are different, check whether the tenant resources allocated to the two resource pools are different.

```
SELECt * FROM pg_user;
```

8.7 Which Factors Affect Single-Table Query Performance in GaussDB(DWS)?

GaussDB(DWS) employs the shared-nothing architecture, where data is stored in a distributed manner; consequently, the design of the distribution key, the volume of data stored in a single table, and the number of partitions impact the overall query performance of that table.

1. Distribution Key Design

   By default, GaussDB(DWS) takes the first column of the primary key as the distribution key. When you define both a primary key and a distribution key for a table, the distribution key must be a subset of the primary key. Distribution keys determine data distribution among partitions. If distribution keys are well distributed among partitions, query performance can be improved.

   If the distribution key is incorrectly selected, data skew may occur after data is imported. The usage of some disks may be much higher than that of other disks, and the cluster may become read-only in some extreme cases. Proper selection of distribution keys is critical to table query performance. In addition, proper distribution keys enable data indexes to be created and maintained more quickly.

2. Data Volume Stored in a Single Table

   The larger the amount of data stored in a single table, the poorer the query performance. If a table contains a large amount of data, you need to store the data in partitions. To convert an ordinary table to a partitioned table, you need to create a partitioned table and import data to it from the ordinary table. When you design tables, plan whether to use partitioned tables based on service requirements.

   To partition a table, comply with the following principles:

   - Use fields with obvious ranges for partitioning, for example, date or region.
   - The partition name must reflect the data characteristics of the partition. For example, its format can be Keyword+Range characteristics.
   - Set the upper limit of a partition to **MAXVALUE** to prevent data overflow.

3. Number of Partitions

   Tables and indexes can be divided into smaller and easier-to-manage units. This significantly reduces search space and improves access performance.

   The number of partitions affects the query performance. If the number of partitions is too small, the query performance may deteriorate.

   GaussDB(DWS) supports range partitioning and list partitioning. In range partitioning, records are divided and inserted into multiple partitions of a table. Each partition stores data of a specific range (ranges in different partitions do not overlap). List partitioning is only supported by clusters version 8.1.3 or later.

When designing a data warehouse, you need to consider these factors and perform experiments to determine the optimal design scheme.

8.8 How Do I Optimize a SQL Query with Many CASE WHEN Conditions?

In service queries, the **CASE WHEN** statement checks conditions. Too many unnecessary **CASE WHEN** statements in an SQL query can affect performance.

```
SELECT
  SUM(CASE WHEN a > 1 THEN 1 ELSE 0 END) AS a1,
  SUM(CASE WHEN a > 2 THEN 1 ELSE 0 END) AS a2,
  ...
FROM test
WHERE dt = '20241225';
```

In this example, the **CASE WHEN** statement must run for each branch, which increases the query time and affects performance.

GaussDB(DWS) offers these optimization policies to address this issue:

Using a Temporary Result Set or Subquery

Extract the complex **CASE WHEN** calculations into a temporary result set or subquery. This avoids repeating the same logic in the main query.

Create a subquery to calculate the intermediate result.

```
SELECT
  sub.a1,
  sub.a2
FROM (
  SELECT
    sum(case when a > 1 then 1 else 0 end) AS a1,
    sum(case when a > 2 then 1 else 0 end) AS a2
  FROM test
  WHERE dt = '20241225'
) sub;


SELECT
    SUM(case_when_a1) as a1,
    SUM(case_when_a2) as a2,
    ...
FROM (
    SELECT
        CASE WHEN a > 1 THEN 1 ELSE 0 END AS case_when_a1,
        CASE WHEN a > 2 THEN 1 ELSE 0 END AS case_when_a2,
```



```
    ...
  FROM test
  WHERE dt = '20241225'
) AS subquery;
```

Using a User-Defined Function

Encapsulate the **CASE WHEN** logic in a function. Then, call the function in your query instead of rewriting the **CASE WHEN** logic multiple times.

Create a simple function count_a_gt_value.

```
CREATE OR REPLACE FUNCTION count_a_gt_value(val INT)
RETURNS INT AS $$
DECLARE
  result INT;
BEGIN
  SELECT sum(CASE WHEN a > val THEN 1 ELSE 0 END)
    INTO result
    FROM test
    WHERE dt = '20241225';
  RETURN result;
END;
$$ LANGUAGE plpgsql;
```

Use the user-defined function count_a_gt_value for query.

```
SELECT
  count_a_gt_value(1) AS a1,
  count_a_gt_value(2) AS a2
FROM test;
```


9 Backup and Restoration

9.1 Why Is It Slow to Create a GaussDB(DWS) Automated Snapshot?

This happens when the data to be backed up is large. Automated snapshots are incremental backups, and the lower the frequency you set (for example, one week), the longer it takes. Increase backup frequency to speed up the process.

The following table lists the snapshot backup and restoration rates. (The rates are obtained from the lab test environment with local SSDs as the backup media. The rates are for reference only. The actual rate depends on your disk, network, and bandwidth resources.)

- Backup rate: 200 MB/s/DN
- Restoration rate: 125 MB/s/DN

9.2 Does a GaussDB(DWS) Snapshot Have the Same Function as an EVS Snapshot?

No.

GaussDB(DWS) snapshots are used to restore all the configurations and service data of a cluster. EVS snapshots are used to restore the service data of a data disk or system disk within a specific time period.

GaussDB(DWS) Snapshot

A GaussDB(DWS) snapshot is a full backup and an incremental backup of a data warehouse cluster at a point in time. It records the data in the current database and cluster information, including the number of nodes, node specifications, and database administrator username. Snapshots can be created manually or automatically.

When restoring data from a snapshot to a cluster, GaussDB(DWS) creates a cluster based on the cluster information recorded in the snapshot and restores database information from the snapshot data.

For more information about snapshots, see **Managing Snapshots**.

EVS snapshot

An EVS snapshot is a complete copy or image of the disk data taken at a specific time point. Snapshot is a major disaster recovery approach, and you can completely restore data of a snapshot to the time when the snapshot was created.

You can create snapshots to rapidly save the disk data at specified time points. In addition, you can use snapshots to create new disks so that the created disks will contain the snapshot data in the beginning.

You can create snapshots to rapidly save the disk data at specified time points to implement data disaster recovery.

- If data loss occurs, you can use a snapshot to completely restore the data to the time point when the snapshot was created.
- You can use snapshots to create new disks so that the created disks will contain the snapshot data.

For more information about snapshots, see **EVS Snapshots**.

